Meta-Xenakis

New Perspectives on Iannis Xenakis's Life, Work, and Legacies

Edited by Sharon Kanach and Peter Nelson

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OpenBook Publishers

https://www.openbookpublishers.com

Sharon Kanach and Peter Nelson (eds), *Meta-Xenakis: New Perspectives on Iannis Xenakis's Life, Work, and Legacies*. Cambridge, UK: Open Book Publishers, 2024, https://doi.org/10.11647/OBP.0390

Digital material and resources associated with this volume are available at https://doi.org/10.11647/OBP.0390#resources

ISBN Paperback: 978-1-80511-224-2
ISBN Hardback: 978-1-80511-225-9
ISBN Digital (PDF): 978-1-80511-226-6
ISBN Digital ebook (epub): 978-1-80511-227-3
ISBN HTML: 978-1-80511-229-7
DOI: 10.11647/OBP.0390

Cover image: Iannis Xenakis at the C.R. MacIntosh Museum, Glasgow, Scotland, 1987. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

Cover design: Jeevanjot Kaur Nagpal

With generous support from: Centre Iannis Xenakis, Xenakis Project of the Americas/The Brook Center, Université de Rouen: BQRI, IRIHS, GRHis, CÉRÉdI.

Plate 1 Iannis Xenakis, Centre Acanthes, Aix-en-Provence, France, summer 1985. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

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Notes on Contributors

Vasilis Agiomyrgianakis is an audiovisual artist, composer, and researcher. He is experienced in live coding for audiovisual performances as well as in the development of microcomputer sensor systems for artistic and academic purposes. He teaches Computer Sound Design, and he is Post-Doctoral Researcher in HAL (Hub of Art Laboratories) at the Department of Audiovisual Arts of the Ionian University, Greece. He has published papers, music and participated with his works in various conferences and festivals in Europe and Japan.

Pablo Araya, composer, holds a Doctor of Musical Arts (DMA) under the direction of Andrés Barrea (UNC-FAMAF-CONICET) and Julio Estrada (UNAM) from the National University of Córdoba (UNC). He also attended workshops and seminars by composers from Argentina, Mexico, France, and Germany with composers such as Julio Estrada, Juan C. Tolosa, Marcos Franciosi, Gabriel Valverde, Pierluigi Billone, Georges Aperghis, Brian Ferneyhough, Horacio Vaggione, Jean-Claude Risset, Mark André, Michael Maierhof, etc. He has received scholarships from the Consejo Nacional de Investigaciones Científicas y Técnicas (CONICET), the UNC Postgraduate Secretariat, the Centro de Estudios Latinoamericano de Formación Interdisciplinaria (CELFI) and the Fondo Nacional de las Artes (FNA). He has published in specialized periodicals in Argentina and Mexico. His music has been performed in Argentina, Latvia, Spain, and Germany. He currently teaches Musical Analysis at the Escuela Superior de Música José Lo Giúdice (Salta, Argentina).

Hanako Atake is a contemporary dancer/performer based in Tokyo. She started ballet in Japan at the age of three and studied various styles of dance at the London Studio Centre in England from the age of nineteen. Since 2005, she has been a member of the Tokyo-based contemporary dance company *Crewimburnny*. She has also presented her own choreographic works and performed in improvisation and butoh performances in Japan, England, and France.

Mizky Bernal is a Bolivian composer who also has training in musical direction and piano from renowned national and international teachers. She graduated in 2022 with a Bachelor degree in Music from Loyola University. She is currently pursuing a Master's degree in Sound Art at the University of Barcelona. During her career as a performer, she has participated in numerous musical events of national and international stature.

As a composer, she has been invited to collaborate with different contemporary music ensembles creating works that have been presented at several Latin American events. From 2021 to the present, she has been a part of the Ensamble Inmediato, whose work focuses on the creation and dissemination of avant-garde music.

Lise C. Bjerno is a Danish musician, conductor, and composer. In addition to her musical activities, she holds a Master's degree in Human Resource Development, a Master's in Coaching and Leadership, and provides courses and workshops in communication, innovation, sustainability, and climate change.

Inspired by natural phenomena, **Myriam Boucher** merges the organic and the synthetic in her videomusic installations, immersive projects and audiovisual performances. Her polymorphic work explores the intimate dialogue between music, sound and image, transforming everyday landscapes into fantastical, living phenomena. Elements in her pieces can move in synchronization with waves of sound, and very fluidly shift from solid to liquid, fragment to flood, plastic to plasmic. A keyboardist turned visual artist working on the real-time dialogue between music and images, Boucher initially gravitated towards classical piano, jazz and then post-rock, before learning about, and then academically pursuing electroacoustics. Her research in videomusic composition proposes a classification of image/sound relationships as a building block towards an eventual grammar of the genre. Boucher approaches video much in the same way as she did music composition, through a visual interface that sees her fleshing out digital timelines. She is an Adjunct Professor in Composition and Digital Music at the Faculté de musique of Université de Montréal. Her research-creation activities integrate musical composition, improvisation, deep listening, sound ecology, site-specific creation, immersive technologies, and cross-disciplinary arts such as cinema, visual arts, poetry, and dance within interdisciplinary groups. Her research aims to understand and analyze the mechanisms of perception and representation in audiovisual works and multidisciplinary concerts integrating sound, music, image, and performers, with the perspective that art is a practice capable of transforming reality and generating new forms of sensitive representations.

Rodolphe Bourotte is a composer/researcher. He has been writing/improvising electroacoustic and instrumental music since 1998. He studied composition with Allain Gaussin, Jean-Yves Bosseur, Jean Balissat, Paul Méfano, and electroacoustic composition at Les Ateliers UPIC. He developed various programs linking graphics and sound, notably for real-time generated scores or picture-driven probability sequences. His music is based on the assumption that we should, as humans, make the effort to create things that cannot be modeled by the computer. For more information, see https://rodolphebourotte.info/

Ramón del Buey Cañas is a Spanish researcher, with a formal background in Philosophy (BA, MA), and Environmental Humanities (MA). He holds a PhD in Philosophy from

Universidad Autónoma de Madrid. He has been a visiting scholar at Duke University from 2022 to 2023. Currently, his academic research links computation, music, and materialism. His publications include books in the Party Studies series, together with Brandon LaBelle and Víctor Aguado Machuca (Errant Bodies Press). Since 2018, he is a member of the Board of Directors of the Asociación de Música Electroacústica y Arte Sonoro de España (AMEE).

Martin Carlé lives as a musicologist, media theorist and Emacs org-mode enthusiast. His cultural objective is to leverage Literate Programming techniques as a performative methodology for experimental media arts, reproducible research and a sustainable computer literacy. While running a music recording studio and an audio consultant company, he studied systematic musicology, popular music and media history at the Humboldt-University Berlin (HUB). There he received his doctoral degree with a thesis on the epistemology of ancient Greek music theory and the respective musical notation systems. Within the frame of the German Research Society (DFG), he worked at the Helmholtz Institute for Culture Techniques and taught as assistant professor at the department of Media Studies (HUB). Ongoing international collaborations include the French ANR project "PROGRAMme." He is currently working as a Post-Doctoral Researcher in the Hub of Arts Laboratories at the Audio & Visual Arts Department of Ionian University, Corfu Greece.

Composer and musicologist specializing in "contemporary music," **Pierre Albert Castanet** is Professor Emeritus at the Université de Rouen Normandie (Musicology) and Honorary Associate Professor at the Conservatoire National Supérieur de Musique et de Danse de Paris (Analysis). Former Director of the Department of Cultural Careers (Université de Rouen Normandie), he is the Director of Musicological Collections for the publishers Michel de Maule, Basalte, Ina-GRM, Millénaire III, Les Cahiers du CIREM (International Center for Research in Musical Aesthetics). He is a member of the Academy of Sciences, Belles-lettres and Arts of Rouen, and he taught for ten years in the Doctoral program "Music and Musicology of the 20th century" (IRCAM, ENS, EHESS) in Paris. In addition to numerous lectures given in Russia, Canada, Algeria, Switzerland, Italy, Belgium, Spain, Portugal, Sweden, etc., he has also lectured for some fifteen years at the Cité de la Musique/La Philharmonie de Paris.

Erik Christensen is a Danish musicologist. He was Producer of contemporary music programs for the Danish Broadcasting Corporation from 1978–2007, and a Lecturer at the University of Copenhagen from 2007–8. He has been a Guest Lecturer at universities in the United States, Mexico, and Argentina. In 2012, he defended his PhD thesis "Music Listening, Music Therapy, Phenomenology and Neuroscience" at Aalborg University, Denmark. Currently, he is affiliated with Aalborg University, Department of Communication and Psychology as a Researcher. A list of publications is available at https://vbn.aau.dk/en/persons/115500

Renata Dalianoudi, PhD, is Associate Professor in the Department of Audiovisual Arts, Ionian University, Greece. She holds a BA in Musicology and a PhD in Ethnomusicology (Athens University and University of Vienna), with six scholarships from the State Scholarship Foundation and the Papadakis Bequest. She has also studied piano, organ, accordion, guitar, and ballet. Her works include four monographs, seventy articles and papers, four lemmas in international dictionaries, fifty-two documentaries, and over two hundred television and radio broadcasts.

Cyrille Delhaye is a musicologist and Associate Researcher of the Groupe de Recherche d'Histoire (GRHis) at the Université de Rouen-Normandie. His work focuses on electroacoustic music and *musique concrète*. He is particularly interested in the Paris school and in Pierre Henry's and Pierre Schaeffer's approaches: in 2021, he co-authored *Pierre Henry, l'oeuvre*, a catalog raisonné published by La Philharmonie de Paris (awarded the France Musique-Claude Samuel Book Award, 2022). Since 2011, he is the scientific coordinator of the Centre Iannis Xenakis's archives. For more information, see cyrilledelhaye.blogspot.com and @cyrille_delhaye.

Julio Estrada is the founder of the Musical Creation Laboratory (LACREMUS: Laboratorio de Creación Musical), first at the National School of Music (ENM: Escuela Nacional de Música) and later at the Faculty of Music (FaM: Facultad de Música), the Coordinator of the University Research Seminar on Artistic Creation (SUICREA: Seminario Universitario de Investigación en Creación Artística), and is a member of the Research Institute of Aesthetics (IIE: Instituto de Investigaciones Estéticas), all at the National Autonomous University of Mexico (UNAM: Universidad Nacional Autónoma de México). He is co-author (with Jorge Gil) of *Música y teoría de grupos finitos: 3 variables booleanas* (Music and Finite Groups Theory: 3 Boolean Variables), 1984, published by IIE-UNAM, and *MUSIIC-Win, Theory d1*, 2006, published by ENM-UNAM. He is the author of *Canto roto: Silvestre Revueltas* (Broken Chant: Silvestre Revueltas), 1st ed. 2012, 2nd ed. 2023, published by FCE (Fondo de Cultura Económica)-IIE-UNAM, *Realidad e imaginación continuas* (Continuous Imagination and Reality) (forthcoming) published by IIE-UNAM, as well as thirty-five articles in books, forty articles in academic journals, and ninety texts on Indigenous music, Mexico and Latin America, contemporary music, music and mathematics and computer science, musical aesthetics, music theory, and creative musical imagination. He is also the Editor of *La música de México* (The Music of Mexico), 1984–8, 10 volumes, published by IIE-UNAM, and is the Editorial Director of the annual magazine *PILACREMUS* (Perspectiva Interdisciplinaria del Laboratorio de Creación Musical) since 2016, published by IIE-SUICREA-UNAM. Among his musical works are: 5 *Cantos* (1973–9), 8 *yuunohui* (1983–2019), *ensemble'yuunohui* (1985–2020), *eua'on* (1980), *eua'on'ome* (1985–95), *ishini'ioni* (1984–90), *eolo'oolin* (1981–98), and the opera *Murmullos del páramo* (Murmurs of the Wasteland), libretto by J. Estrada, 1992–2006, published by Juliusedimus, based on Estrada's own research on the novel *Pedro Paramo* by Juan Rulfo: *El sonido en Rulfo: "el*

ruido ese" (The Sound in Rulfo: "that noise"), 1st ed. 1990, 2nd ed. 2008, published by IIE-UNAM. Estrada received the *Premio Universidad Nacional en Difusión y Extensión de la Cultura* (National University Prize for the Diffusion and Extension of Culture) in 2000, and the Fine Arts Medal (2016), from the Instituto Nacional de Bellas Artes y Literatura (INBAL), Mexico. He is an Emeritus Researcher of the National (Mexican) Network of Researchers (SNI: Sistema Nacional de Investigadores), a member of the Mexican Academy of Sciences (AMC: Academia Mexicana de Ciencias) and has been promoted to Officier de l'Ordre des Arts et des Lettres (France).

Nathan Friedman is a researcher, composer, and performer from Kamloops, British Columbia, Canada, currently based in Chicago. He has degrees in composition from Wesleyan University and the University of Victoria, where he studied with Paula Matthusen, Anthony Braxton, John Celona, and Wolf Edwards, and a Master's in musicology from the University of Toronto. He was a founding member of the Victoria Composers Collective, a long-time member of A Place to Listen Ensemble, and has been an Associate Composer of the Canadian Music Centre since 2016. He is currently pursuing his PhD in Music History and Theory at the University of Chicago.

Mauricio García de la Torre is a composer, researcher, and pianist. He holds a PhD in music composition from Mexico's UNAM and a Master's in Music Composition from McGill University, Canada. He graduated in piano performance from the Instituto Nacional de Bellas Artes' (INBA) Superior School of Music in Mexico. He is currently a Professor in Composition and Theory at Pan American University and the Superior School of Music. As a researcher he has studied subjects related to music cognition, phenomenology of music, physics and psychoacoustics. He is currently Editorial Director of UNAM's *PILACREMUS* periodical, Co-editor of the website www.musicaenmexico.com and founding member of the collective Transdisciplinarity, Art, and Cognition (TACo).

Oswaldo Emiddio Vasquez Hadjilyra is a Cypriot-Dominican artist and electronic musician, with a formal background in Mathematics (BSc) and Philosophy (BA, MA). He is currently a PhD candidate in the transdisciplinary program Media Arts and Sciences at Arizona State University. His research interrogates, in theory and in practice, the philosophical and aesthetic implications of treating digitality and computation under a materialist framework. In 2024, along with collaborators, he represented Cyprus in the 60th Venice Biennale.

Nickos Harizanos was born in Athens, where he studied composition, orchestration, harmony, and counterpoint in Athens from 1992 to 1999. He then continued his studies in composition at Manchester University (2000–1) and graduated with a Master's degree (MMus) in Composition. His music has been performed in thirty-four countries on all continents. He is the Secretary General of the Contemporary Music Research Center (co-founded by Iannis Xenakis) (KSYME), member of the Greek Composers' Union

(GCU) and the Hellenic Electroacoustic Music Composers Association (HELMCA) (Greece). His works are published by Schott (Germany), Tetractys (UK), Taukay (Italy), Musica Ferrum (UK). For more information, see www.nickosharizanos.com

James Harley is a Canadian composer-musician presently teaching at the University of Guelph. He obtained his Doctorate at McGill University in 1994, after spending six years (1982–8) in Europe (London, Paris, Warsaw). His music has been awarded prizes in Canada, USA, UK, France, Poland, Japan, and has been performed and broadcast around the world. Some of Harley's music is available on disc, and his scores are primarily available through the Canadian Music Centre. He composes music for acoustic forces as well as electroacoustic media, with a particular interest in multi-channel audio and soundscapes. As a researcher, Harley has written extensively on contemporary music, including two monographs: *Xenakis: His Life in Music* (2004, Routledge), *Iannis Xenakis: Kraanerg* (2015, Ashgate). As a performer, Harley has a background in jazz, and has most recently worked as an interactive computer musician.

Violinist **Conrad Harris** has performed at Ostrava Days, Darmstadt Ferrienkürse für Neue Musik, Gulbenkian Encounters of New Music, Radio France, Warsaw Autumn, and Bang on a Can. He is member of the FLUX Quartet and violin duo String Noise, and concertmaster/soloist with the S.E.M. Orchestra and Ostravská Banda. He has performed and recorded with Elliott Sharp, Robert Ashley, Alvin Lucier, David Behrman, "Blue" Gene Tyranny, Jean-Claude Risset, Rohan de Saram, and Tiny Tim. Harris has recorded several works by composer Iannis Xenakis. Recent CD releases of violin sonatas by Lejaren Hiller and John Becker are on New World Records. Upcoming recordings include works by the Sonic Arts Union and John Cage's *Freeman Etudes*. He has also recorded for Lovely, Mode, Asphodel, Vandenburg, CRI, Northern Spy, Cold Blue, New Focus, Chaikin, Infrequent Seams, and Vinyl Retentive Records. See further www.conradharris.com; www.fluxquartet.com; www.stringnoiseduo.com

Takumi Ikeda is a self-taught computer musician and composer. He appears in live performances and composes contemporary music with his programs. Many performers have featured his works. Recently he has been working on baritone and computer, trombone with nine-axis sensor, piano and soundtrack, choral pieces, pieces with video scores, and scores for improvisers. In 2016, Ikeda created the soundtrack for Kei Shichiri's film *Music as Film*, followed by a screening with live music with performers. His CDs were released in 2020 (de dicto 00) and 2022 (ftarricl-663).

Nikos Ioakeim studied musicology and philosophy in Athens, and composition in the Netherlands and Belgium. He is researching the life and work of Xenakis since 2011: he has conducted research in the composer's archives (2016–19) and has also recorded interviews with around one hundred Greek acquaintances of Xenakis, preserving their testimonies (2014–19). A monograph on the titles of the composer's musical works is under preparation. Ioakeim regularly delivers talks about Xenakis in various symposia internationally.

Jelena Janković-Beguš has been active as a researcher in the fields of musicology and cultural policy in Europe for more than twenty years, having published over thirty original scientific studies in journals and collective monographs in Serbia and abroad. She obtained her PhD degree from the Faculty of Music in Belgrade, Department of Musicology in 2022. She has edited and co-edited a number of publications of various genres. Apart from her scientific work, Janković-Beguš is an experienced cultural manager, having worked in the field of classical music production and promotion since 2002. In this field, she pursued postgraduate studies of Cultural Policy and Management at the UNESCO Chair of the University of Arts in Belgrade where she obtained a Master's degree in 2006 (joint diploma with the Université Lumière—Lyon 2, France). In 2010 she obtained a professional MA degree in the field of Management of Cultural Organizations from the Université Paris Dauphine PSL, France, where she studied as a recipient of a French Government scholarship. She is a Program Manager of the Belgrade Festival Center (CEBEF) and producer of the Belgrade Music Festival (BEMUS), and she is also active as an Expert of the European Commission for Creative Europe and Horizon Europe programs.

Diego Jiménez studied classical guitar (2006–10) under Alfredo Uribe, during these years composing his first works. In 2007 he entered the Centro de Educación Artística (CEDART) "Ignacio Mariano de las Casas" of INBA. He followed the workshop Computer Tools for Sound Creation and Production with Francisco Colasanto (2007). In 2009 he was awarded a scholarship to study jazz at the American Music Institute's Jazz Academy in Eugene, Oregon. Later he studied piano with Carmen Eloísa Sánchez and in 2011 he entered the Faculty of Music (FaM) of the National Autonomous University of Mexico (UNAM), where he formally began his studies in composition with Horacio Uribe and Lorenzo Medina. For his Bachelor's degree in Composition he studied with Mtro. Leonardo Coral, Dr. María Granillo, and Dr. Julio Estrada. He has composed chamber and orchestral music, and audiovisual media such as documentaries and feature films, among which: *Revueltas* (2018, Alfonso Jiménez), *Sobre la Muerte* (2019, Adrián Bodegas), *Tilman* (2020, Enrique Arechavala), and *Tótem* (2023, Lila Avilés). He has also served as producer and mixing and mastering engineer on albums such as *Contemporary Mexican Music for Guitar Quartet* (2021) by Cuarteto Kuikani, and *Tilman* (2023), among others. In 2021 he was awarded one of the scholarships of the Arturo Márquez Extraordinary Chair of Musical Composition. His works have been performed in Mexico, Costa Rica, Argentina, France, Colombia, and Spain.

JSEM (Japanese Society for Electronic Music) was founded in 1992 and over the past thirty years has continued its activities to propose to society a new relationship between music/art and technology, which is being renewed every day. More than 250 electroacoustic music works have been premiered at JSEM concerts. These works were initially large-scale performances using multiple computers and equipment, but have since become diverse forms of music including real-time sound processing,

acousmonium, visual music, and telematic music. In 2020, with the support of the Agency for Cultural Affairs, JSEM developed a database of these works and realized the creation of a foundation for electronic music research in Japan. In 2022, the JSEM celebrated its 30th anniversary over two nights with a diverse program of music creations, lectures, and competitions in collaboration with international organizations.

The American musician **Sharon Kanach** first went to France to study with Nadia Boulanger. Very quickly however, in 1978, her path crossed that of Iannis Xenakis, with whom she studied and collaborated closely, especially on his writings (*Arts/Sciences: Alloys; Formalized Music; Music and Architecture*…). With the publisher Pendragon Press (recently closed) she was the editor of the Xenakis Series where a total of six books were produced. In 2009, she founded the Xenakis Project of the Americas under the auspices of the Brook Center for Music Research and Documentation at the Graduate Center of City University of New York and is currently Co-president of the Centre Iannis Xenakis (CIX) based at the Université de Rouen Normandie (France), under the auspices of the research lab Groupe de Recherche d'Histoire (GRHis). Between 2013–23, she was on the Editorial Committee of *Circuit, musiques contemporaines*. In 2022, under her directorship, the CIX initiated the Meta-Xenakis Consortium to celebrate the centenary of Xenakis's birth. Kanach has been promoted to "Chevalière de l'Ordre des Arts et des Lettres" by the French Ministry of Culture.

Kuniko Kato, percussionist, studied under legendary marimbist Keiko Abe. After graduating from the Toho Gakuen School of Music in Tokyo, Japan she advanced her academic studies at Rotterdam Conservatorium under Robert Van Sice, where she graduated as the first percussionist *magna cum laude* in school's history. While in Europe she performed with the Brussels-based Ensemble Ictus and toured with them worldwide with the dance company ROSAS. She was also a member of Seiji Ozawa's Saito Kinen Orchestra for over ten years during this period. After 2002, she focused on her career as a soloist and is now recognized as one of the world's leading percussion virtuosos. Her astonishing virtuosity, exquisite musical insight, and expressive yet elegant performance style continues to attract not only audiences, but established conductors and composers. Kuniko is the only Japanese artist who has signed exclusively with UK-based LINN Records. She is renowned for her flawless technique when playing both keyboard and percussion instruments, which blends seamlessly with her profound musical intelligence. Over the past several years, Kuniko Kato has been focusing on nurturing the next generation of talent. As the Chief Executive of the NPO ARTSWORKS and its artistic director, she promotes artist incubation projects, supporting and fostering young professionals. For further information, see https://kuniko-kato.net and https://npo-artsworks.org

Nikos Kornilios lived in Paris for fifteen years (1973–89), where he studied architecture (DPLG), attended Iannis Xenakis's classes at the Université de Paris-Sorbonne and composed works of contemporary music and musical theater, which were performed in several institutions. He then returned to Greece where he devoted himself to writing and directing films of fiction. To date, he has made eleven feature-length films that have been screened and awarded in film festivals around the world.

Born in Athens, **Stella Kourmpana** holds a Bachelor of Theatrology (University of Athens), a Master's in Theater and Music Studies (Athens University and Ionian University) and a PhD in Musicology (Ionian University). Since September 2013, she has been in charge of the Athens Conservatoire Archives and since July 2022, and since November 2023 she is the Director of the Athens Conservatoire Research and Documentation Centre. She has published several articles on music, opera, theater, and literature in modern Greece and she is Chief Editor of *Neos Mousikos Hellenomnemon*, a periodical dedicated to the research of Art Music in Greece. She has taught at Ionian University (2014–17) and at the University of Ioannina (2019–21). Currently she is working as writer and co-editor of the three-volume *History of Music in Modern Greece* (2022–3, Athens Conservatoire). Since April 2023, she has been a Member of the Administrative Board of Contemporary Music Research Center (KSYME).

Guillermo Leonardini lives in La Paz (Bolivia). He has studied at the Plurinational Conservatory of Music; Loyola University; the School of Composition, 2015–16 (with a scholarship from the Fundación Hermann); with Miguel Llanque, Canela Palacios, and Sebastián Zuleta at the Casataller Art Space; and has taken composition classes with Alberto Villalpando. He has participated in various composition workshops with different teachers, including Daniel Leguizamón (Colombia), Julio Estrada (Mexico), Hugo Solís (Mexico), Peter Ablinger (Austria), among others. He has premiered numerous works, including *rumo* for the ensemble 2e2m (France); *Los otros verdes en esta* (*nuestra*) *padrera* premiered in Germany with the Recherche ensemble (Germany); and *uuuaaauauauauauuua* premiered in La Paz by the Ensamble Inmediato. Currently, he is part of the Ensamble Inmediato with which he experiments and explores the relationship between music and new media. He is studying for a Master's degree in Sound Art at the University of Barcelona.

David J. Lieberman is a University Professor at the Akademie der bildenden Künste Wien, and Associate Professor Emeritus at the University of Toronto. Architect, artist, poet, and filmmaker, David Lieberman identifies as an alchemist asserting that architecture constructs mechanisms by which to transform experience by considering the body as an empathic instrument to apprehend and to understand space. Traditional spatial composition has relied on the surfaces of resistance and reflection; space can be understood as the dissolve, and in the blur of the visual and the aural at the limits of perception and in its tactility. Current work includes explorations of the Austrian

Forests: the Birkenwald of Gustav Klimt (1862–1918) and the Jurassic spruce, the wood of choice for the string instruments of Cremona and the soundboards of pianos, as post cinematic expressions with respect for the craft of making and the spatial engagement of dance in pursuit of new architectures.

Cândido Lima is a Portuguese composer, pianist, organist, teacher, chronicler, critic, publicist, essayist, lecturer, and researcher. He studied piano, composition and aesthetics in Lisbon, Porto, and at the Université de Paris-Sorbonne with Xenakis and Michel Guiomar. He obtained his doctorate from the Sorbonne in 1983, under Xenakis's directorship. He studied orchestral conducting with Michel Tabachnik and Gilbert Amy and followed courses in electroacoustics, analysis and piano at the Université de Vincennes. He founded Grupo Musica Nova in 1973. Since the 1960s, Lima has been active in promoting contemporary music in music schools, on public television and radio, as well as in the written press, often including the work of Xenakis, even before their first personal meeting in Darmstadt in 1972. Their friendship was constant from that date until the composer's passing in 2001. *A-MÈR-ES* (1978–9), *Oceanos* (1978–9), *Manta* (2004), *Músicas de Villaiana* (2008–9), are some of his diverse and multifaceted works for orchestra, voices, and multimedia, among chamber music, electronic music, computer music, mixed music. Besides his activity as a composer, Lima has written many texts, both published and unpublished.

Henning Lohner is a German-American composer, filmmaker, and digital media artist. Lohner's creative output embraces diverse fields within the audiovisual arts. He has collaborated extensively with artists such as Karlheinz Stockhausen, Karl Lagerfeld, Louis Malle, Gerhard Richter, Frank Zappa, Dennis Hopper, and John Cage. Since 1996 Henning Lohner has been a member of the Remote Control film composers' group founded by Hans Zimmer. Lohner's documentary *Ninth November Night* was shortlisted for the Academy Awards (the Oscars) in 2005. His active images media artwork, *Silences*, has been screened, exhibited, and acquired by museums such as SFMoMA, the Centre Pompidou, the Louvre, the German National Academy of Art, the Venice Biennale, and many others. Iannis Xenakis became Lohner's life-long mentor in 1985. Since then, Lohner has published numerous articles on the composer's work, including initiating and contributing to the first German language monograph on the composer, as Volume 54/55 of the series *Musik-Konzepte* (1987).

Composer, Associate Professor, Department of Audio and Visual arts, Ionian University, Greece, **Apostolos Loufopoulos**, PhD, studied at Ionian University and City University in London. His research interest focuses on nature and sound composition. He writes music for theater, installations, as well as purely electroacoustic music. His composition and research projects have been presented at world-renowned festivals and conferences for the last twenty-three years. International prizes include competitions such as Ars Electronica, Bourges, Noroit, Metamorphoses, Space of Sound, Franco Evangelisti,

Musica Nova, SCRIME, I. Xenakis, D. Dragatakis. His discography includes releases from Ina-GRM, Musiques and Recherches, Ionian University, CyberArts, Touch Records, and personal releases. His scores have been published by S. Zerboni (Milan) and Just Flutes (London). He is a founding member of the ESSIM (Hellenic Electroacoustic Music Composers Association) and the Society of Acoustic Ecology.

Andrew Lucia is a Minneapolis-based multimedia artist, designer and academic, and is a Co-founding Partner of the creative collaborative, LUCITO. Formally trained in architecture, Lucia's practice is one that is informed by this disciplinary approach to cultural production fusing historic reference, perception, and experience through spatial-material practice and its representation. His work comprises a focused inquiry into the world of matter, its organization and affect through image, projection design, installation, land art, and architecture, including numerous collaborations with composers and sound artists. Lucia is currently an invited Visiting Critic at Cornell University, College of Architecture, Art, and Planning (AAP), and has held the positions of Visiting Critic at the University of Pennsylvania Weitzman School of Design (2019–21, 2024); Visiting Scholar at the Azrieli School of Architecture and Urbanism, Carleton University (Spring 2018); Visiting Lecturer and Critic at Cornell University, AAP (2011–15); and was a member of the Faculty in visual studies at the University of Pennsylvania, School of Design (2008–11). From 2015–17 Lucia held the position of Cass Gilbert Visiting Assistant Professor in the School of Architecture, College of Design, University of Minnesota, during which he realized the extensive research and design project *A Catalog of Difference*. He has been nominated for the United States Artist Fellowship and the Civitella Ranieri Prize for Architecture. Lucia received his Master of Architecture from the University of Pennsylvania (2008) and his BA in Architecture from the University of Minnesota (2001).

Mikhail Malt is a researcher, composer, computer music designer. Having a twofold training, scientific and musical (engineer, composer, and music conductor), he started out his musical career in Brazil as both flutist and orchestral conductor, having conducted youth orchestras for almost ten years. He has a PhD from the Ecole des Hautes Etudes en Sciences Sociales and an HDR (Habilitation à Diriger des recherches) degree. Currently, he is a Researcher at IRCAM in the Représentations Musicales team (UMR 9912—STMS) and Associate Director of Research at the Institute for Research in Musicology (IReMus—UMR 8223), Sorbonne Université. His actual research and creative work are based on generative music models, creative systems, representation epistemology, and listening strategies.

Bill Manaris is a computer science and algorithmic arts researcher, educator, and musician. He is Professor of Computer Science, and Director of the Computing in the Arts program at the College of Charleston, USA. He works in the intersection of computer science (including artificial intelligence, big data, and human-computer

interaction) with computer music and art. His lab explores interaction design, modeling of aesthetics and creativity, sound spatialization, and telematics. With his students, he designs systems for computer-aided analysis, composition, and performance in music and art. He studied computer science and music at the University of New Orleans and holds MSc and PhD degrees in Computer Science from the Center for Advanced Computer Studies, University of Louisiana. Manaris has published a textbook on Computer Music and Creative Programming, and is co-developer of the JythonMusic environment (http://jythonmusic.org). For more information, see http://manaris.org

Fabrice Marandola is an Associate Professor of Percussion and Contemporary Music at the Schulich School of Music of McGill University (Montreal). Previously, he was a Professor of Percussion at the conservatories of Angers and Grenoble in France, a pedagogy instructor at the Conservatoire de Paris, and an Invited Professor at the Crane School of Music (State University of New York (SUNY) at Potsdam, NY). A founding member of Canadian percussion ensemble Sixtrum, he has an active career on the New Music scene, commissioning, performing, and recording new works for solo and chamber ensembles. Marandola holds a PhD in ethnomusicology from Paris IV-Sorbonne and has conducted in-depth field research in Cameroon. He was the Director of the Centre for Interdisciplinary Research in Music Media and Technology of Montreal (CIRMMT) between 2020–4. In 2015–16, Marandola was Senior Research Chair at Sorbonne-Universités to lead a multidisciplinary research project on Musical Gesture (Geste-Acoustique-Musique).

Hari Marini, PhD, is Associate Professor of Performance and Intermediality in the Department of Audio and Visual Arts at Ionian University, and Artistic Director of the PartSuspended artist collective (www.partsuspended.com) which fosters performances, live art, installations, writing, and collaborations with artists from a variety of disciplines. Her research focuses on social and material contexts and conditions of performance and their social and political effects. Hari's research outputs have been published in leading academic journals, such as *European Journal of Women's Studies, Contemporary Theatre Review, Performance Research, Journal of Greek Media and Culture*, and in the edited book *Dramatic Architectures: Theatre and Performing Arts in Motion* (CEAA/ESAP 2021). Hari's artistic practice, writing, and practice-based research focus on poetics of spaces, performative architecture, and women's writing. Her creative writing and video-work have been published in journals and poetry collections such as *Tears in the Fence, Interim: A Journal of Poetry & Poetics*, and on the performingborders platform. Her bilingual book (Greek-English), 28 *Διαδρομές της/28 Paths of Her*, was published by AKAKIA Publications in 2019.

Brigitte Métra created her architectural studio in 2003 (Métra + Associés). There, she is developing her own architecture, having built a performance hall in Dole, an 84,000 m2 multifunctional urban unit in Paris (bus center, offices of the Ministry of the Interior,

Middle School, Kindergarten), a neurosurgical implant unit in Besançon, apartment buildings in Nantes and Nanterre, as well as office buildings in Paris and Besançon. In association with Les Ateliers Jean Nouvel, Métra + Associés delivered a theater in Perpignan and the concert hall of La Philharmonie de Paris as associate architect for its conception and construction. Creation and poetry, harmony between culture and nature are the vectors of Brigitte Métra's architecture. She has been promoted to Chevalière de l'Ordre National de la Légion d'honneur by the French Grand Chancery, and Officier de l'Ordre des Arts et des Lettres by the French Ministry of Culture. She is also a full member of the French Académie d'Architecture. https://brigittemetra.com/

Mauricio Arturo Meza Ruiz is a musical creator whose process embodies the figures of composer, guitarist, improviser, interactivity designer, curator, and researcher. His catalog reveals a spectrum of artistic activity that encompasses chamber music, electroacoustic music, installation, software, performance, improvisation, chrono-videography, and the series of flow-interactive devices Salto Cuántico de Grafito. He is a PhD candidate in Musical Creation and New Technologies, in the framework of a co-tutelage program between the National Autonomous University of Mexico (UNAM), the Laboratory of Musical Creation (LACREMUS), Sorbonne-Universités, the Institute for Research in Musicology (IReMus), and the Laboratory of Science and Technology of Music and Sound (STMS Lab—IRCAM).

Mikako Mizuno is a composer and musicologist, with a PhD in engineering focusing on the "Concept of Space in the Contemporary Music." Her writings mostly concern electroacoustic music, cultural exchange between France and Japan, music theory, and compositional theory. Her works have been premiered in several European countries and in the USA as well as at ISEA2000 and 2002, ISCM2003,2010,2024, EMS2010 Shanghai, ICMC2017, 2018, 2019, 2021,2022, 2023, Musicacoustica2010, ACMP2011, 2012, 2013, 2018, WOCMAT2013,2018, NIME2021 etc. She worked at Nagoya City University from 1997 to 2024, teaching sound design and music information theory. She is now teaching composition and musicology at Nagoya College of Music. She is the President of the Japanese Society for Electronic Music (JSEM).

The British composer and music scholar **Peter Nelson** is Professor Emeritus of Music and Technology at the University of Edinburgh, where he established the electronic and computer music studios and led a research group in music and artificial intelligence. He met Iannis Xenakis in 1986 and became an associate of Xenakis's computer music studio Les Ateliers UPIC between 1987 and 1991, touring and teaching with the Atelier and composing a number of works for UPIC. He has published book chapters and articles on a number of topics including music and technology, and rhythm. Between 1992 and 2022 he was Editor of the international journal *Contemporary Music Review*, published by Routledge. He was awarded an honorary doctorate by the National and Kapodistrian University of Athens in 2024.

Iakovos Panagopoulos, PhD, is an award-winning Greek film director and scriptwriter developing academic research in media and film practice. He is an Assistant Professor at the Department of Audio and Visual Arts, Ionian University. His field is: "Film Production Specializing in Creating Audiovisual Narratives." Among his film works are the titles *Flickering Souls Set Alight* (2019) and *Allimonò* (2020). Among his publications are the titles "Returning to Your Roots: Use of Mobile Shooting in an Ethnomediaology case study with the Tejon Native American Tribe in California" (Frames Cinema Journal, 2021) and, in collaboration with Ioannis Deligiannis, "How to Establish Film Practice Research and Evidence Impact in the Greek Academic Environment?" (The International Journal of Creative Media Practice, 2022). Currently he is a collaborator in UK-based StoryLab Network and a Faculty Member in the Interactive Arts Lab at the Department of Audio and Visual Arts of Ionian University.

Dana Papachristou is an art theorist and sound artist focusing on the combination of arts with the use of new media and interactivity. Her studies include music, musicology, and media studies. She holds a PhD from Paris 8-Vincennes-St. Denis and the Ionian University in Aesthetics of New Media Arts. She has been involved in interdisciplinary research projects on contemporary music, sound composition and the relationship between sound and other artistic forms, and has participated in many visual, sound, and geo-locative projects. She is a founding member of Akoo.o artistic team, in which she works on the composition of sound/audio walks using new geo-locative media technologies. She is also the Director of the research center To Aesthate, which operates as a platform for artistic production and creation. She is currently teaching in the Department of Culture, Creative Media and Industries at the University of Thessaly, and was a Visiting Scholar at the California Institute of the Arts (CalArts) in the academic year 2021–2. She is a Post-Doctoral Researcher at the Ionian University, in the PEARL Research Lab, focusing on performance, body and machine interaction through motion sensors and live coding.

Eunice Pérez is a composer and graduated from the National Conservatory of Music of Mexico in 2021. In 2018 she joined the Musical Creation Laboratory (LACREMUS) taught by Julio Estrada at the Institute of Aesthetic Research at UNAM. Her works have been presented in Mexico and Canada. She is currently part of the Proyecto Ars Nova, a project for the creation, collaboration and reflection of contemporary music.

Guy Pimienta, architect (DPLG in 1983 from the Beaux-Arts, Paris), whose final thesis focused on the links between art and architecture. Aesthetics represents the center of his interests, as does literature. Close links have formed between his practice as an architect and his interest in art. This persistent link that unites art and architecture is based on drawing as a tool of thought. His first articles were devoted to artists and architects: Johan Otto Spreckelsen, Georges Rousse, Santiago Calatrava, Enric Mirallès,

Christian de Portzamparc. Authors like Walter Benjamin, Edmond Jabès, Georges Perec, Meyer Shapiro have been decisive in his approach to what space can be. He co-founded the Dédale architecture studio in 1990 with Roland Baroin, where they develop public facilities and also scenographies. On the sidelines of their activity as architects, they founded, in 2009, Peuplier Éditions, with the intention of maintaining close links with and between artists and writers. Their "L'œuvre en main" collection of published boxes currently includes twelve titles.

Thanos Polymeneas-Liontiris is a composer, performer, and educator. His practice comprises computer-aided compositions, interactive audiovisual installations, and performances, immersive audiowalks, improvisation, generative intermedia performances, music for dance and theater. He obtained a BA in Double Bass, and a BA in Electronic Music and Composition from Rotterdam Conservatoire, while following courses at the Institute of Sonology (Royal Conservatoire of The Hague) and at IRCAM. Furthermore, he obtained two MA degrees, both with distinction, one in Art and Technology from the Polytechnic University of Valencia, and one in Creative Education from Falmouth University. In 2019 he completed his PhD at University of Sussex with a CHASE-AHRC scholarship. His dissertation "IM-Medea: Posthumansim and Remediation in Music-theatre," was ranked by the Leonardo Abstract Service 2020 (MIT Press), among the twenty most relevant PhD studies situated on the intersection between art, science, and technology. He has been working in higher education since 2011, at Falmouth University, University of Sussex, University of Brighton, Ionian University, and National and Kapodistrian University of Athens. He has been a Fellow of the UK Higher Education Academy (FHEA) since 2012.

Raphael Radna is a composer and computer music researcher working in acousmatic music, mixed music, computer-assisted composition, spatial audio, and creative music software development. He presents music and research worldwide in such venues as the International Computer Music Conference, the International Conference on Digital Audio Effects, the San Francisco Tape Music Festival, the SEAMUS National Conference, the New York City Electroacoustic Music Festival, and the Visiones Sonoras Festival of Music and New Technologies. He has collaborated with acclaimed artists such as Onix Ensemble, Erin McKibben, Antonina Styczeń, Shanna Pranaitis, HOCKET, and the Isaura String Quartet. His music technology work includes the Space Control spatialization software, the Xenos stochastic synthesizer, and projects for prominent developers Arturia and Cycling '74. Radna holds a BA *cum laude* in Music from Vassar College, an MFA in Electronic Music and Recording Media from Mills College, and an MSc in Media Arts and Technology from the University of California, Santa Barbara (UCSB), where he is a PhD candidate in Music Composition studying with João Pedro Oliveira and Curtis Roads.

Curtis Roads is Professor Emeritus in Media Arts and Technology (MAT) and in Music Composition at the University of California, Santa Barbara (UCSB), where he was also Associate Director of the Center for Research in Electronic Art Technology (CREATE). He studied electronic music and computer music composition at the California Institute of the Arts and the University of California, San Diego and received a Doctorate from the Université de Paris 8. He was Editor and Associate Editor of *Computer Music Journal* (The MIT Press) from 1978 to 2000 and co-founded the International Computer Music Association (ICMA) in 1979. His music set *Flicker Tone Pulse* (2019) was published on DVD by Schott/Wergo. His album *POINT LINE CLOUD* was re-issued on the Presto!? label in 2019. His book *Composing Electronic Music: A New Aesthetic* was published in 2015 by Oxford University Press. His newest book is *The Computer Music Tutorial*, Second Edition (2023, The MIT Press).

Ambrosio Salvador Rodríguez Lara studied music composition at the Faculty of Music of the National Autonomous University of Mexico (UNAM). At the same university, he now teaches classes in harmony, counterpoint, musical analysis, and composition for undergraduates and graduate students. His compositional interests include the use of spatialization with acoustic instruments, the interaction of acoustic instruments and electroacoustic media, and the use of textures of microtonal instruments. He has also developed a series of pieces with diverse resources from the family of recorders.

Judith Romero Porras obtained a BA in Classical Music at the Conservatory of Music of the State of Puebla, Mexico. In France, she obtained the same degree in Music and Musicology at Université de Paris-Sorbonne. On returning to Mexico, she took up her previous post as a teacher of ear training, piano, and French. In 2010, she received a scholarship from the Ministry of Education of the State of Puebla to begin a MA in Musicology at the Université de Paris-Sorbonne. Her work concerned the construction of a musical identity in Mexico in the twentieth century. Then, under the supervision of Marc Battier and Julio Estrada, she obtained a double PhD from Sorbonne-Université and from the National Autonomous University of Mexico (UNAM). Her current research relates to the French composer and artistic engineer Jean-Étienne Marie and his relationship with Mexican composers in the second half of the twentieth century, and the evolution of Mexican music and the introduction of new techniques of composition in the 1960s.

Takehito Shimazu studied composition with Sesshu Kai in Tokyo, with Isang Yun at Hochschule der Künste (HdK) Berlin, and others. He studied and produced electronic and computer music at the electronic studio of the Technical University of Berlin (TU-Studio Berlin), and at IRCAM, Les Ateliers UPIC, and at Ina-GRM in Paris. His compositions have been selected several times and played at the International Society of Contemporary Music (ISCM), at the International Computer Music Conference (ICMC), and at many other festivals in Asia and Europe. Shimazu was the chairman

of the music committee for ICMC'93 in Tokyo. He has been invited as lecturer, composer, and as the representative of Japanese composers at Japan-German Institute in Berlin, at Georgia University, Saarbrücken Music-Fest, Dresden Music-Fest, by the New York Philharmonic Orchestra, among others. Currently, he is Professor Emeritus of Fukushima University in Japan. His scores are published by Breitkopf and Härtel and F. Hofmaister in Germany. His CDs include *CCMIX Paris* (mode 98/99, New York, 2001); *30 jahre inventionen VII* (Edition RZ, Berlin, 2012).

Marko Slavíček is a composer and an architect from Zagreb, Croatia. During his music and architecture studies at the University of Zagreb, he attended several composition seminars abroad with renowned composers such as Nigel Osborne, Heiner Goebbels, and Philippe Manoury. He further specialized in spectral music in the class of Tristan Murail at the Mozarteum University of Salzburg. He is currently doing doctoral research on Iannis Xenakis at the Technical University of Berlin under the supervision of Professor Stefan Weinzierl. His interests include aesthetics, acoustics, and spatial music.

Benny Sluchin studied at the Tel-Aviv Conservatory and at the Jerusalem Music Academy, parallel to pursuing a degree in Mathematics and Philosophy at the University of Tel-Aviv. He joined the Israel Philharmonic Orchestra and was engaged as co-soloist for the Jerusalem Radio Symphony Orchestra. A member of the Ensemble Intercontemporain since 1976, he has premiered numerous works and recorded *Keren* by Iannis Xenakis, *Sequenza V* by Luciano Berio, in addition to nineteenth- and twentieth-century works for trombone. As a Doctor of Mathematics, Sluchin is involved in acoustic research at IRCAM. Passionate about teaching, he edited *Brass Urtext*, a series of original texts on teaching brass instruments. He published *Le trombone à travers les âges* (2001, Buchet-Chastel) with Raymond Lapie. Two of his books have been awarded the Sacem Prize for pedagogic publications: *Contemporary Trombone Excerpts* (1996, EME Editions) and *Jeu et chant simultanés sur les cuivres* (1995, EME Editions). His written publication on brass mutes is a benchmark and his research on Computer Assisted Interpretation has been the object of several presentations and scientific publications. As an application to his research, Sluchin has released several recordings of John Cage's music. His film *Iannis Xenakis, Le dépassement de soi*, was released in 2015 by Mode Records (Mode 284). In 2024 Sluchin received "A Lifetime Achievement Award" from the International Trombone Association "in recognition of his lifelong commitment to the trombone and a career that has reflected commitment to excellence and achievement."

Hugo Solís is an academic and electronic artist focused on the creative and aesthetic possibilities resulting from the intersection between sound, digital technologies, and interactivity. He has exhibited works and given concerts in Mexico, Japan, Ireland,

the United States, Spain, Brazil, Italy, Korea, and Portugal. He regularly participates in specialized activities in the field of electronic art. He is currently a member of the National System of Researchers level I and the National System of Creators. He has received support, scholarships, and recognition from FONCA, UNAM, TELMEX, MIT, University of Washington, DXARTS, IMEB-Bourges, Centro Multimedia, Transitio_MX, and Leonardo, among others. His installations have been presented in various galleries, exhibitions, and festivals, including Jack Straw Sound Gallery, MacLeod Residence, Transitio_MX, Sonorities, Fonca XX Años, Kirkland Art Center, and Laboratorio Arte Alameda. He is a full-time Professor and Head of the Department of Arts and Humanities at the Universidad Autónoma Metropolitana. From 2013 to 2015, he was a full-time Professor at Tecnológico de Monterrey. During the last years, he has dedicated himself to teaching digital creativity. His book, *The Process in Digital Art Production*, was published by UAM editions in 2019. He completed a Doctorate in Digital Art and Experimental Media at the University of Washington, a DEA in Computer Science at Pompeu Fabra University, a Master of Arts and Sciences at the Media Laboratory of the Massachusetts Institute of Technology (MIT), and a BA at the National School of Music of the UNAM. For more information, see http://hugosolis.net

Ronald Squibbs is Associate Professor of Music Theory at the University of Connecticut. He has published on the music of Xenakis for *Perspectives of New Music, Contemporary Music Review*, Pendragon Press, Brepols, and ZKM. In addition to his work on Xenakis, he has given conference presentations on the music of Joji Yuasa, Dane Rudhyar, John Luther Adams, and others. Active as a performer, he has recorded piano music by Yuasa and Rudhyar for Aucourant Records and by Peter Garland for Cold Blue Music. Samples of his work may be found at https://ronsquibbs.academia.edu

Yoshihisa Suzuki, percussionist and composer, was born in Yokohama, Japan in 1975. He majored in Percussion at Showa University of Music (1994–8) and studied Composition at the Institute of Advanced Media Art and Sciences (IAMAS, 2002–5). His major works include *Ring, Quartet* (2003) *Chromatist* (2004), *Marimba Pleasure* (2008). He received the ARS Electronica (Linz, Austria) 2006 digital music Honorary Mention. He is a member of the Japanese Society for Electronic Music (JSEM) and president of the Japanese Society for Sonic Arts (JSSA).

Imri Talgam is a pianist and composer based in the Netherlands and a specialist in performance of twentieth-century and contemporary music. Since winning first prize in the Concours de piano d'Orléans (France) in 2014, Talgam appeared as soloist around the world, including with Ensemble Intercontemporain and Ensemble Modern, and worked with composers including Boulez, Lachenmann, Poppe, Unsuk Chin, and Eötvös. His recordings include a CD centered on the music of Nancarrow, including transcriptions of his player-piano studies. As a researcher, he worked on cognition-informed strategies for performance of rhythmically complex music. After finishing his

doctorate at the CUNY Graduate Center, he was a Post-Doctoral Researcher and lecturer at McGill University's Schulich School of Music. Talgam is also a composer of computer music, which he studied at the institute of Sonology in the Hague. His work combines microsound and sound spatialization techniques with algorithmic composition and generative strategies. For more information, see www.imritalgam.com.

Dominic Thibault is a studio-based electronic music composer, improviser, coder, and instrument creator, whether digital, acoustic, or both. He was recently appointed Assistant Professor at Université de Montréal to pursue research in Musiques Numériques. His research-creation takes shape in the studio and ranges from fixed-media composition to improvisation with feedback processes. Co-director of the Laboratoire Formes·Ondes, Thibault is an experienced teacher, an active member of the Observatoire interdisciplinaire de création et de recherche en musique (OICRM) and Center for Interdisciplinary Research in Music Media and Technology (CIRMMT) research centers.

Panayotis Tournikiotis is now a Professor Emeritus at the National Technical University of Athens, where he taught Theory of Architecture for more than thirty years. He studied architecture, urban planning, geography and philosophy in Athens and Paris. His research focuses on critical theory and history, and the way understanding the past contributes to the interdisciplinary formation of design strategies in architecture and urban planning. He has published and edited books, including *Adolf Loos* (1991, Éditions Macula), *The Parthenon and Its Impact in Modern Times* (1996, Melissa), *The Historiography of Modern Architecture* (1999, MIT Press), *Architecture in Modern Times* (2006, Futura), and *The Diagonal of Le Corbusier* (2010, Ekkremes). He organized many architectural events and actively participates in institutional boards and committees. Le Corbusier's relationship with Greece and his collaboration with Greek architects and engineers in Paris is an ongoing chapter in his most recent research. He is the president of the European Architectural History Network (EAHN).

Katerina Tsioukra studied at the Department of Music Studies at Ionian University in Corfu, Greece. She obtained her Master's degree in Neohellenic Music History and currently is a Doctoral candidate at the same university. Her research interests lie primarily in the area of the post-war music history in Greece. Since 2018, she collaborates both with the Contemporary Music Research Center (KSYME) and the Center of Research and Documentation of the Athens Conservatoire in their educational and research activities. She is an Alexander S. Onassis Public Benefit Foundation Scholar.

Anton Vishio is Associate Professor in the Faculty of Music of the University of Toronto where he teaches courses in music theory and skills; previously he taught at William Paterson University. His work has focused on the analysis of late twentieth-century music, as well as text-music relationships; he has published articles on the music of Brian Cherney, Jo Kondo, and Charles Wuorinen. He is currently working on

analysis of *Quanta* by Priaulx Rainier, a study of polyrhythms, and a study of songs by Rabindranath Tagore.

Aram Yardumian is Associate Professor of Anthropology at Bryn Athyn College, Pennsylvania, USA, and is the author of *Iannis Xenakis's Persepolis*, published in early 2023 as part of Bloomsbury's 33 1/3 series. He is also the author of *Listen: Jeph Jerman in Conversation*, published by Errant Bodies in late 2022, and the Swedish-language book *Ögonblickets Oändlighet: Samtal med Tommie Haglund* (2022, Themis), as well as numerous academic papers.

Yin Yu is a multidisciplinary artist, designer, and engineer. Her research investigates the potential of interactive multimedia environments and the intersection of architecture, music, and emerging technologies. Her practice covers a broad spectrum, including furniture, architecture, interactive multimedia, wearable design, and art installation. Underlying every aspect of her work is her deep commitment to investigating the social and physical interactions between human beings and the built spaces and redesigning the human-made environment through new media technologies. She has a Bachelor of Science in Electronic Engineering, a Master of Science in Information Technology, a Master of Science in Interior Architecture, and a Ph.D. in Media Arts and Technologies. She has won several prestigious awards, and her work has been published and exhibited internationally, such as the Computer-Human Interaction (CHI) conference (US), the Haptic and Audio Interaction Design (HAID) workshop (FR), the Wearable Technology Exhibition (ES), and the Expanded Animation Symposium at Ars Electronica (AT). Yu joined the School of Art and Design at San Diego State University (SDSU) as Assistant Professor in 2022, and in 2023, she received the "Dean's Award for Achievement in Research Scholarship Creative Activity" from SDSU.

Iannis Zannos has a background in music composition, ethnomusicology, and interactive performance. He has worked as Director of the Music Technology and Documentation section at the State Institute for Music Research (SIM) in Berlin, Germany, and Research Director at the Center for Research for Electronic Art Technology (CREATE) at the University of California, Santa Barbara (UCSB). He teaches audio and interactive media arts at the Department of Audio and Visual Arts of the Ionian University, Corfu, Greece. Since 2018 he focuses on telematic dance performance with a series of works between Greece, Japan, and other countries.

Acknowledgements

The editors owe a huge debt of gratitude to Open Book Publishers and their entire team; in particular to managing director Alessandra Tosi who first encouraged us to submit this ambitious project, to Adèle Kreager, whose lightning speed replies to each and every query have created a new benchmark for editorial process, to Rupert Gatti, whose legal acumen has been a reassuring force, and to the anonymous peer reviewers for their diligent commentaries and suggestions which have been indispensable for us and our authors. We wish to thank also all of the support staff at OBP who have been attentively responsive to making such a complex volume a reality with ease and elegance.

As our respective biographies show, we each have editorial experience that spans decades, yet *Meta-Xenakis* is the most ambitious project either of us has ever undertaken. It also represents our first project together as co-editors, and our first project ever of conceiving an entire volume in e-book format, where we are able to share not only scholarly chapters but also research-based creative work from some of our colleagues and contributors. Our most sincere thanks to OBP for enabling us to embark on this adventure and its exponential learning curve. Collectively, we all share a profound belief in the necessity to generate and promote top quality Open Access research to the broadest possible public, and we are grateful to our colleagues at OBP for their commitment to supporting such publications at the highest level of production.

Of course, we must acknowledge the generous financial support from the Université de Rouen Normandie (BQRI, GHRis, IRIHS, CÉRÉdI) from the Xenakis Project of the Americas/Brook Center of CUNY, as well as from the Centre Iannis Xenakis (CIX). Neither the Meta-Xenakis project, nor this volume would have been possible without all of this support.

Sharon Kanach and Peter Nelson

Plate 2 Iannis Xenakis at a coffee break in Glasgow, Scotland, May 1987. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

Preface

The Meta-Xenakis Team Leaders

> […] one can create a fantastic network of optimistic and pacifistic art throughout the world. Never before has such a thing been feasible. Today it is.[1]

The year 2022 marked the centenary of the birth of Iannis Xenakis (1922), a true polymath, who left indelible traces with his own works in music and architecture as well as in his pioneering polytopes in the second half of the twentieth century.[2] His visionary production, focused on the perspective of the arts and sciences as an alloy, continues to inspire artists today.

In the spirit of Xenakis's optimism expressed in the epigraph above, beginning in 2020, the Centre Iannis Xenakis (CIX) at the Université de Rouen Normandie, France, and the KSYME (Contemporary Music Research Center) at the Athens Conservatoire, Greece, began brainstorming common events to celebrate the centenary of the composer, architect, theoretician, philosopher, and founder of their respective institutions. These events were scheduled to take place in 2022, and characterized as modest but meaningful, as many of us had had close ties with the composer over many years.[3] Soon after though, we were joined by another former close collaborator and friend of Xenakis, our Mexican colleague Julio Estrada and his SUICREA research laboratory.[4] In turn, Julio enlisted some of his former students and we swiftly partnered with our colleagues at the Nagoya City University, in Japan.[5] It only made sense then to invite the Xenakis Project of the Americas (XPA) to participate as well, to make it a truly global manifestation.[6] Our jointly organized Meta-Xenakis Consortium, spanning five

1 Xenakis and Kanach, 2008, p. 255. The original text, published posthumously, dates from 1974, a half a century ago!

2 "Polytope," from the Greek *poly-*, or "several," and *-topos*, "space." In the mathematical literature, the term 'polytope' has come generally to mean different overlapping sets of objects. In Xenakis's creative output, his five realized (and several unrealized) polytopes were all works where music, space, light, and architecture (or landscape, for his outdoor polytopes) were combined to create an immersive environment. For more information on his polytopes, see Xenakis 2008, Part Four.

3 *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/; *KYSME*, http://www.ksyme.org/

4 *SUICREA*, http://suicrea.unam.mx

5 *Nagoya*, https://www.nagoya-cu.ac.jp/sda/english/

6 "Xenakis Project of the Americas," *The Brook Center*, https://brookcenter.gc.cuny.edu/projects/xenakis-project-of-the-americas/

https://doi.org/10.11647/OBP.0390.00

countries and three continents, was therefore founded by several of Iannis Xenakis's former students, collaborators, and dedicatees.[7]

Our common, ambitious goal became to create a truly transcontinental celebration of the life, work, and multiple legacies—both philosophic and artistic—of the true Renaissance man who was Iannis Xenakis. The main partners collaborated actively with other local artists, scholars, and institutions in each region, which resulted in multiple concerts, educational workshops, masterclasses, exhibitions, public lectures, a brand-new feature-length documentary film, as well as open calls and composition competitions, several of which are documented under the Sustainable Resources section in this volume.

One of the highlights of our events, thanks to the resources of post-pandemic interconnectivity, was the Meta-Xenakis Global Symposium, a forty-one-hour non-stop marathon (true to the Xenakian spirit of *dépassement de soi*) that took place between the morning of 30 September (in France) and the evening of 1 October 2022 (in Mexico) as a distributed collaboration between participants located in the five countries, in hybrid mode and live-streamed.

We are all delighted to share with a broader public these highlights of a truly unforgettable and transformational experience. And a special thank-you to all of the artists, scholars, and friends for their shared enthusiasms, as well to as all the Meta-Xenakis Consortium members and Associate Partners.[8]

References

XENAKIS, Iannis (2008), *Music and Architecture: Architectural Projects, Texts, and Realizations*, translated, compiled and presented by Sharon Kanach, Hillsdale, New York, Pendragon Press.

7 *Meta-Xenakis*, https://meta-xenakis.org. Two committees were founded to brainstorm and put to execution all the Meta-Xenakis events. The **Scientific and Artistic Committee** comprised (local coordinators in bold): **Rodolphe Bourotte**, Angelica Cathariou, Juan Ignacio del Cueto, Cyrille Delhaye, Athanassios Economou, **Julio Estrada**, Teresa Frenk, Kiyoshi Furukawa, Nickos Harizanos, James Harley, Robert Hasegawa, Nikos Ioakeim, Toshie Kakinuma, **Sharon Kanach**, Kuniko Kato, David Lieberman, Apostolos Loufopoulos, Barbara Mackenzie, Stephanie Merakos, Mikako Mizuno, Marcos Novak, Lorenda Ramou, Curtis Roads, Evis Sammoutis, Ryosuke Shiina, Takehito Shimazu, Gabriella Spanó, Daniel Teige, Olga Touloumi, Nikos Tsouchlos, Panos Vlagopoulos, Jean-Noël von der Weid†, **Haris Xanthoudakis†**. The **Organizational Committee** comprised: Hubertus von Amelunxen, Marianna Anastasiou, **Pierre Albert Castanet**, Carla Delfos, Laurence Descubes, **Itzíar Fadrique**, Fabienne Fendrich, **Conrad Harris**, Ai Higashikawa, Jonathan Katz, **Stella Kourmpana**, Keita Matsumiya, Costas Mantzoros, Stephanie Merakos, **Mikako Mizuno**, Vivane Monel-Villa, Takeshi Mukaikuchi, Yoshihiko Nonomura, Benny Sluchin, Michèle Smith, Hugo Solís, Gabriella Spanó, Yoshihisa Suzuki, Katerina Tsioukra, Valia Vraka, Haris Xanthoudakis†. The Meta-Xenakis Team Leaders were Stella Kourmpana (Greece), Mikako Mizuno (Japan), Julio Estrada (Mexico), Barbara Mackenzie (USA), Sharon Kanach (France).

8 "About," *Meta-Xenakis*, https://meta-xenakis.org/about/

Introduction: Meta-Xenakis

Peter Nelson and Sharon Kanach

One hundred years (more or less) since the birth of Iannis Xenakis (1922–2001) and we are still getting to grips with the legacy of one of the key creative figures of the twentieth century, a figure who not only sprang indelibly from the traumas and energies of that century but also put its foundational concepts into question.[1] In his central account of the wartime experiences that defined the trajectory of his life, as well as through his own representation of himself as an "ancient" rather than a "modern," Xenakis encountered history as a crucial and exemplary element within his creative thought and artistic process: both his own, personal history, and the history which places Greek thought and culture at the center of European identity.[2] Xenakis's concern with modernity—with the modernism that represents the core energies that drove the century's preoccupations, from world wars to millennium—is clear in his work for the architect Le Corbusier (1887–1965), and in his ground-breaking researches with computers and digital technologies, and yet: the questioning that lies behind his creative impulse comes from another source, an ancient source as he himself expressed it, and that questioning blows apart the notion of the modern, and its Eurological orientation, in unique ways that are still being assessed.[3]

This volume is an attempt to register the impact of the questions Xenakis posed as much as the impact of the work he achieved. In that sense, it is not so much a celebration as a progress report. If the scale and ambition of the projects he inaugurated seem modern in their all-embracing vision and intransigent surfaces, the core of their conception has weathered in the realities of the current era to reveal a complexity and intricacy that speak to many different concerns and situations, across cultures,

1 In the recent exhibition at the Philharmonie de Paris, "Révolutions Xenakis," two passports were showcased: one dating from 1933 indicating his year of birth as 1921, and another one, dating from 1937 indicating 1922. See also Solomos, 2022, p. 34.

2 In an interview with Richard Steinitz at the Huddersfield Festival in 1987, Xenakis stated quite clearly: "I brought myself up into the ancient Greek tradition, that's for sure," Huddersfield Festival, 21st November 1987 at 2:15 PM. Transcribed by PN. For Xenakis's account of his wartime experience, see Xenakis, 1992, p. 8–9.

3 In a published interview with Bálint András Varga he says, "I felt I was born too late—I had missed two millennia" (Varga, 1996, p. 15). For an account of the concepts of the Eurological and the Afrological, see Lewis, 2002.

 https://doi.org/10.11647/OBP.0390.01

and across disciplines. As the notion of our planet as the locus of an inter-planetary, exploratory, and fundamentally acquisitive human enterprise has given way to the sense of a planet that is fragile, lonely, and in danger precisely from that human acquisitiveness, so the overarching ambition of all-encompassing schemas has evolved to the recognition that actions are fraught and uncertain, local and situated, even as they have global consequences. And Xenakis's own, explicit vision attempted to navigate the consequences and uncertainties inherent in the forces of existence, with a concern for both the local and the global.

One clear example of this vision is Xenakis's first project intended to celebrate the inauguration of the Centre Pompidou in Paris (the Beaubourg Center, inaugurated in 1977 as the pinnacle of the cultural legacy of President Georges Pompidou (1911–74)). This was a plan for a *Polytope Mondial*, envisioned as a worldwide, planetary celebration. Xenakis boldly stated:

> The time has come to bridge the arts across oceans, between continents and among countries. Why not weave together the population of the earth through the arts, by establishing a new, direct contact that overcomes the barriers of language, politics, parochialism, racism, chauvinism?

Today this "weaving together" is possible, though Xenakis's vision of "the arts" is remote from the populist notions of digital Neoliberalism. Penned in March 1974, the project specification seems like an encapsulation of Modernist ambition:

> Within such a project, the most advanced scientific research can be combined with the most prophetic artistic forms. Yet both can remain powerful abstractions closely related to cosmic phenomena with immediate effect on the imagination of the most humble man and child of all races and religions.[4]

And yet, in Xenakis's own work, "cosmic phenomena" and "imagination" are the twin poles of a view of art that transgresses cultural boundaries, while acknowledging culture as a phenomenon like any other; as both physical and metaphysical.[5] For him, the physical phenomena, that can be penetrated by scientific imagination, are entwined with cultural phenomena, that can be penetrated by the creative imagination, within a context of forces both elemental and political. As a work like *Evryali* for piano (1973) draws on ancient Greek thought and imagery to reflect on the human encounter with the abstract forces of creation, so works like *À l'île de Gorée* for harpsichord and ensemble (1986), with its harpsichord reflecting the music of the kora, and *Okho* for three djembes and large drum (1989) face up to the political and cultural forces

4 Xenakis, 2008, p. 247–8.

5 Xenakis writes, "The universes of music—classical, contemporary, pop. folk. traditional. avant-garde, etc.—seem to form units in themselves, sometimes closed, sometimes interpenetrating. They present amazing diversities, rich in new creations but also fossilizations, ruins, wastes, all in continuous formation and transformation like the clouds, so differentiated and ephemeral." Xenakis, 1985b, p. 172.

that shaped the Afrodiasporic experience that haunts Europe.[6] Xenakis, always a political radical under the surface, reflected similarly on other cultural formations, understanding, from his "ancient" perspective, that the power struggles of life—in all its forms—and the substances and forces that create and support that life, are deeply implicated in one another. This meta-view of culture and science allowed him to form a vast series of works that totally confounded the Eurological, Enlightened perspectives which formed the basis of the "avant-garde" art-worlds around him.

To mark the centenary of Xenakis's birth, the Centre Iannis Xenakis (CIX), an independent not-for-profit association hosted at the Université de Rouen Normandie (France), initiated a unique, international consortium, mainly composed of his former students, performers, dedicatees, and collaborators, from five countries and three continents: France, Greece, Japan, New York, and Mexico: META-XENAKIS.[7] The team's shared goal was to create a truly transcontinental celebration of his life and work, as well as initiating a reassessment of his artistic and philosophical legacy. In all, around eighty events (concerts, exhibitions, workshops, public lectures, masterclasses, composition competitions) took place around the globe under the Meta-Xenakis banner, culminating in a forty-one-hour non-stop marathon symposium (see Appendix). This volume consists of both written texts and digital resources of various sorts, including audio, visual images, videos, computer software, and a virtual exhibition, as well as a selection of our marathon's papers, reconstituted as considered contributions to Xenakis scholarship. Its aim is not only to shed new light on the life and work of Xenakis, as an exemplar of a particular sort of creative spirit, but also to report on new work inspired by his legacy, and to support the interdisciplinary impetus of the insights and initiatives by which Xenakis set in train a host of creative and investigative projects. Each of the eight Sections presents a pole in a constellation of viewpoints that supports a broad and inclusive view of creativity as lived by Xenakis himself, and as it lives on in the projects that continue to take the example of his work, the questions that he formulated, and the insights that he conceptualized as foundational. Throughout the book, beginning with its cover, between Sections, and occasionally as part of individual author's Figures, the reader's experience will gain human insight on Xenakis, through the thoughtful lens of Henning Lohner (b. 1961). From their initial meeting in 1985 until Xenakis's passing in 2001, the two cultivated

6 The island of Gorée, off the coast of Senegal, was the largest collection and embarkation center for the slave trade between the fifteenth and nineteenth centuries. Xenakis dedicates this work to those "who, forcibly taken from their lands into appalling slavery, have managed to win for themselves leading positions in some of the 'civilised' countries to which they had been deported. It is homage also to the black heros and victims of apartheid in South-Africa, last bastion of a hysterical racism" (Xenakis, 1988, title page). *Okho* was "a commission from the Festival d'automne à Paris and the Caisse des Dépôts et Consignations, with the support of the Government of France on the occasion of the celebration of the bicentenary of the French Revolution," a circumstance in which this instrumentation, as well as the actual musical materials, could be seen as at least a challenge to received views. See Xenakis, 1989, title page.

7 *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/; *Meta-Xenakis*, https://meta-xenakis.org

a deep complicity and bond which is documented in this selection of photos. In 2013, Lohner generously bequeathed his entire collection of his unique photos and footage of their friendship to the CIX, and we are grateful to Henning for graciously allowing us to include these images here.

To begin the volume, James Harley, one of the key figures in contemporary Xenakis scholarship, reflects on meta-materiality as an emblem of the diversity and interdisciplinarity of Xenakis's worldview. This short introductory essay surveys the life, work, and legacy of Xenakis, pointing out key aspects of Xenakis's thought and creative motivation, as an initial focus for those already familiar with Xenakis, and as a compact introduction for those who are not.

The first Section, *Xenakis before Xenakis*, presents new information and insights on the early years of Xenakis's life. As personal history, this period was not only formative for Xenakis in the usual sense, but also inflicted an indelible mark physically, politically, emotionally, and intellectually that radically informed the whole of his later existence. And yet, beside the traumas of war, injury, and exile, a life was lived whose richness and focus equally informed the course of what was to come. Thus, Nikos Ioakeim examines Xenakis's rarely mentioned theater studies during the years of the Nazi Occupation of Greece during the early 1940s. He traces some of the composer's friendships from that time and the ways in which political affinities—cemented by those friendships—intersected with a notion of ancient Greece based on her dramas and theater, and raised the thorny question of Greek language, so pivotal to Greece's identity as a modern nation. In particular, Ioakeim provides new insights through his documentary investigation of the contact between Xenakis and the philologist, writer, and man of the theater Vassilis Rotas (1889–1977) and his Theatriko Spoudastirio (Theater Studio). By uncovering the evidence of Xenakis's early engagement with theater, conceived by Rotas as a political focus for the critical reinvention of Greek culture, this text sheds important light on a hitherto underexplored aspect of the composer's early life.

Stella Kourmpana, the archivist of the Athens Conservatoire, and a member of the board of the Contemporary Music Research Center, KSYME (Κέντρο Σύγχρονης Μουσικής Έρευνας) in Athens, provides context for the presentation of the text, from the KSYME archive, of a crucial letter that Xenakis sent to the first president of the new Greek state, Konstantinos Karamanlis (1907–98), after the fall of the military dictatorship in 1974. Kourmpana explores briefly the feelings of loss and exile experienced by Greeks, like Xenakis, who were banished during the post-war years, and presents for the first time, both in its original and in translation, the letter Xenakis wrote to Karamanlis offering his services to the new Greece, and proposing KSYME, founded in association with his friends Stefanos Vassiliades (1933–2004) and John G. Papaioannou (1915–2000), as an international center for music research. The text of the letter shows both the plans and the emotions of a man whose relationship with his country and his culture was both deep and problematic.

The next Section, *Xenakis without Borders*, examines the reception of Xenakis's work and ideas internationally, and as a response to his own travels to Germany, Japan, and Indonesia. As a Greek brought up in the radically multicultural environment of Braïla, a Danube port in a historically contested region of Romania, and steeped by inclination in the pre-Christian ethos of ancient Greek culture, Xenakis's instincts were fundamentally open and inclusive: this is what makes the planetary vision of the *Polytope Mondial* affirmative rather than imperialist in its implications, and what makes his musical vision so communicative, despite its radical dimensions.

Marko Slavíček considers the experience of Xenakis as an occasional participant in the cultural life of Cold-War Berlin, particularly as a Deutscher Akademischer Austauschdienst (DAAD) visiting composer from 1963–4. Perceived as an artist at the leading edge of the Modernist avant-garde, Xenakis caught the attention of the Congress for Cultural Freedom, a Cold War enterprise inspired and funded by the US Central Intelligence Agency (CIA) and Slavíček traces the institutional and personal connections that led to the invitation from the DAAD, as well as the impact that Xenakis's presence and work had on the cultural life of the city.[8] He also traces the personal effects of an exile within an exile, as Xenakis's solitary visit to the city was experienced.

Jelena Janković-Beguš documents the reception of Xenakis's music in Serbia, a country that occupied a sort of liminal space in post-war Europe. She also demonstrates the central role of broadcasting in the formation of cultural perspective, through the efforts of Radio Belgrade Third Programme to disseminate a broad and international range of contemporary music that regularly included the work of Xenakis. Janković-Beguš surveys the generally negative critical response to broadcasts and performances of Xenakis's work, exposing the cultural politics that play out a set of tensions between the national and the international within the collective psyche of a culture that perceives itself as being on the peripheries of larger forces.

Finally, Mikako Mizuno presents a historical account of those Japanese musicians who have established a performance tradition for the work of Xenakis. In particular, the pianists Yuji Takahashi (b. 1938) and Aki Takahashi (b. 1944) are pioneers who worked with many of the key figures of the European and American avant-garde. Their advocacy of the music of Xenakis was important because their cultural background allowed them to approach Xenakis's radical style without the barriers encountered by European performers. Mizuno relates how the engagement with Xenakis's music that they established has continued into the present, particularly among pianists and percussionists. Her account of the performances by percussionist Yasuko Miyamoto shows the creativity engendered by an intercultural approach to works that are, in their conception, partly outside culture.

8 See Saunders, 1999.

In the Section *New Contexts for Understanding Xenakis*, we develop a theme, already evident in Xenakis's own work from the earliest period, concerned with fundamental research into the philosophical, scientific, and technological underpinnings of music and sound, within a holistic understanding of art as an encounter with the cosmos. This theme connects deeply with Xenakis's study of ancient Greek culture, and with his sense that his own work continued, in some way, to view the world with the same preoccupations and priorities as the ancients. Xenakis imagined this theme as concerning an "alloy" of art and science, where the re-mixing of these two is in some sense a putting-back-together of strands of thought that already existed together in ancient times, and only really became separated out as a consequence of the project of Enlightenment.[9] Nevertheless, Xenakis's own research made use of modern technologies of computing and computer modeling, not just as a method of shortcutting tedious calculations but as a method of exploring the phenomenological foundations of the physical occurrence of sound as much as the signifying processes of art.

Ronald Squibbs investigates the history and operation of Xenakis's Free Stochastic Music program, his first attempt at a generalized method of calculating the probabilistic processes that underpinned individual, experimental musical works, in a series created between 1956 and 1962 and labelled with the prefix ST. Squibbs probes the mechanisms of the program in order to show the tendencies and tolerances of the calculations, and he recalculates some of Xenakis's data in order to show the connection between the output of the program and the finished score. This allows a view of the experimental nature of Xenakis's original insight, that events in the world are probabilistic by nature, and that the processes of change are meaningful. It also demonstrates how Xenakis's experimental approach is capable of generating further insights, concerning both his own works and the processes of change in general.

Pierre Albert Castanet considers these same probabilistic processes from a philosophical perspective, as Xenakis also did. If the calculations of actual probabilities result in data, useful in the process of artistic creation, the initial insights relate to pre-Socratic notions of flux and evolution, of continuity and discontinuity that underpin our encounter with existence itself. Castanet traces the creative struggle that Xenakis experienced in trying to theorize an artistic process from these philosophical beginnings, as a way to make things clearer, rather than as some hermetic origin for artistic inspiration.

Ramón del Buey Cañas and Oswaldo Emiddio Vasquez Hadjilyra delve deeply into the discussion of materialism, taking Xenakis's own theoretical writings as a starting point. What becomes apparent here, if it was not apparent already, is that the philosophical and theoretical aspects of Xenakis's thought are themselves real and profound strands of research, with their own implications and discoveries, not merely emblems of an artistic concern with ancient culture. Xenakis's rejection of certain

9 See Xenakis, 1985a.

conceptual frames, such as the analysis of waveforms based on the theories of Jean-Baptiste Joseph Fourier (1768–1830), for example, speaks to a radical project of building from first principles. Del Buey Cañas and Vasquez Hadjilyra investigate the notion of "pedesis," as "partly unpredictable motion in matter," in order to demonstrate how real-time computing, as implemented in the UPIC (Unité Polyagogique et Informatique de CEMAMu (Centre d'Études de Mathématique et Automatique Musicales)) system, is not simply a trick of convenience, enabled by technical advance, but a principled outcome of dialectical thinking.[10]

Just as del Buey Cañas and Vasquez Hadjilyra show Xenakis's thought prefiguring certain critical strands in current Science and Technology Studies, in dialogue with the writings of Abraham Moles (1920–92) and Isabelle Stengers (b. 1949), so Nathan Friedman pursues Xenakis's aesthetic stance through the analysis proposed by Jean-François Lyotard (1924–98) in his exploration of the postmodern sublime. In his self-avowed stance of being an "ancient" rather than a "modern" Xenakis has always been an outlier in the narratives of modernism. Friedman explores Lyotard's invocation of the "inhuman," a notion that critiques the Enlightenment project of the intelligent individual, tracing its resonances in ancient thought, in order to uncover the radical ethics of Xenakis's art: an ethics that produces an art, in the words of Milan Kundera (1929–2023), "washed clean of affective filth, stripped of sentimental barbarity."[11]

Judith Romero Porras continues the theme of "building from first principles" in her consideration of microtonality. Through the figure of Jean-Étienne Marie (1917–89), she also documents the connection between Xenakis and the culture of Mexico which is, incidentally, one of the important strands of this publication. Marie, as a composer influenced by the work of the Mexican Julián Carillo (1875–1965), and as a technologist and collaborator for performances of Xenakis's work, was ideally placed to effect a cross-fertilization between Xenakis's formulation of non-standard scales through the theory of sieves (*cribles*) and the microtonal practice that arose in Carillo's music. Romero Porras shows how Marie's analysis places culturally specific scalic practices as exemplars within the principled theoretical constructions of Xenakis.

Pablo Araya explores the meaningfulness of the statistical processes at the heart of Xenakis's work through a detailed consideration of the nature of analogy. This goes to the center of the art-science "alloy," which proposes, as a foundational insight, that the trajectories of natural events, as described by the paradigms of science, are susceptible to creative manifestation. Can metaphoric or analogical processes effect some solid amalgam of perceptual forces, effectively combining different views of a phenomenon? Or can art only ever hope to resemble phenomena as a copy? Araya

10 Computerized Polyagogic Compendium of the CEMAMu—where "polyagogic" is a sort of plural of pedagogic (cf. Varga, 1996, p. 121). The Center for Studies in Mathematics and Automation of Music was founded in 1972 at CNET—Centre de Recherche et Développement de France Télécom (Center for Research and Development of France Telecom), Issy-les-Moulineaux, France, with grants from the French Ministry of Culture.

11 Kundera, 2010, p. 78.

considers a number of theoretical foundations for analogy, comparing them to Xenakis's own theoretical writing, and showing how analogy can be the engine of a "creative-constructive" perception.

Mauricio García de la Torre continues the investigation of the apprehension of the meaningful processes at the heart of Xenakis's work by considering the phenomenology of perception. This is, above all, a phenomenology of energy. García de la Torre investigates acoustic energy in particular, as theorized by Julio Estrada in terms of what he calls "macrotimbre." As García de la Torre shows, the energetic quality of Xenakis's work is evident, not just in its statistical trajectories, but also in its use of the *glissando*/diagonal as a primary material, and he demonstrates this by taking analytical examples from a selection of Xenakis's key early works. This exposes the physicality of Xenakis's music, as structures formed by "the regulation of energetic factors of change and conflict."

Ambrosio Salvador Rodríguez Lara concludes this Section by extending the discussion of energetic processes to consider the use of spatial trajectories in music, using Xenakis's work *Persephassa* for six percussion (1969) as an example. Rodríguez Lara connects Xenakis's theoretical discussions with work by Henry Cowell (1897–1965) and Conlon Nancarrow (1912–97), showing how space projects out of the geometrical configuration of pitch on specific instruments. He shows the continuing power and relevance of these concepts by discussing their practical application and development in his own work, arguing that the expressive potential of the inclusion of space within the gamut of musical materials is ripe for further research and exploration.

The Section *New Perspectives on Xenakis's Works* concentrates its focus on individual examples from Xenakis's output, taking different approaches to uncover significant insights into the history, provenance, and implications of Xenakis's heterogeneous approach to creativity. Xenakis's music continues to be widely performed, even though many of his works have a scale and ambition that make them difficult to replicate. The historical performances of many works, like *Persepolis*, have had significant, complex, and continuing impact, even when the exact circumstances and details of those performances have been hard to uncover. The cutting-edge nature of some of Xenakis's methods, and the pressure under which performances were put together, have meant that materials did not often survive in ways that were easy to access. It is only now that some archival resources are beginning to yield details that shed new and important light on spectacles that are fast receding into history.

Thus, Cyrille Delhaye probes the archives of the CIX housed at the Université de Rouen Normandie, to uncover the history of Les Ateliers UPIC, the organization originally set up by Xenakis in 1985 to promote the UPIC computer music system he developed from the 1970s through the 1990s. Delhaye outlines the materials and provenance of the archive, before exploring in detail the documentation relating to the work *Taurhiphanie* (1987), which was the first of Xenakis's works to use the real-time

possibility of the UPIC system. This work is still widely performed as an electroacoustic piece, but its origins were as a spectacle, designed for the arena at Arles, involving multiple live elements including bulls (*taur*..) and horses (..*hiphanie*). Delhaye explores Xenakis's use of "live elements," one of the foundations of his creative impulse, and demonstrates the crucial importance of archival materials in bringing the impact of such spectacles into the present.

Similarly, Mikhail Malt and Benny Sluchin investigate the rarely performed works of Xenakis that took game theory as their inspiration. In particular, they concentrate on two works for double orchestra, *Duel* (1959) and *Stratégie* (1962), using computer simulation to make an exhaustive study of the strategic possibilities inherent in the rules that Xenakis devised as the basis for the performances of these works, that pitted orchestras and conductors against one another in a sort of combat. Because of the complexity of the possible outcomes, computer modeling gives Malt and Sluchin a unique insight into the dynamics of the system Xenakis invented, as well as into the consequences of that system for actual performances.

Anton Vishio considers the monumental electroacoustic work *La Légende d'Eer* whose definitive format has only recently been reconstructed from archival materials.[12] The title, of course, refers to the writing of Plato (428/427 or 424/423–348 BCE), a constant in Xenakis's background, and in particular the notion of recurrence which lies behind the archetypal arch-form in music. Taking the work of James Hepokoski and Warren Darcy as a starting point, and considering a range of literary sources, Vishio explores the energetic and metaphoric elements of recurrence in order to reflect on the richness of experience that Xenakis evokes.

Mikako Mizuno is concerned once again with archives, in this case the reports of Sansei Engineering who were the contractors for the one of the pavilions (*Tekkhokan*) for Osaka World's Fair in 1970, sponsored by the Iron and Steel Institute of Japan, for which Xenakis created the electroacoustic work *Hibiki-Hana-Ma* (1969–70). Mizuno charts the progress of the discussions and agreements during the preparations for the event, and shows how the artistic conceptions, which were architectural/spatial in their origins, put pressure on both the technical and the artistic realization which provoked a mixture of innovation and compromise. She explores the ways in which artistic and philosophical speculation come up against the technical possibilities of a particular industrial paradigm: in this case a Western, techno-industrial regime within the context of a Japanese ethos of post-war rapprochement, demonstrating that technology requires acts of translation between cultures as it tries to turn concept into reality. This view of the *bricolage* that determines eventual, practical outcomes from principled beginnings reveals a characteristic of Xenakis's work, its cross-disciplinarity and conceptual sophistication.[13]

12 See for example Friedl, 2015, and also Reinhold Friedl, "Xenakis's Legend," https://www.reinhold-friedl.de/xenakiss-legend-

13 See Xenakis, 1979.

Erik Christensen and Lise C. Bjerno continue the phenomenological thread, begun in the texts of Araya and García de la Torre, by taking a data-driven, descriptive approach to the investigation of the sound world of Xenakis's early work, *Pithoprakta* (1955–6). This is one of the first of Xenakis's works to use his insight that stochastic processes, that is processes of change within the randomness of the distribution of events, lie behind all of the phenomena of life, from political demonstrations to thunderstorms. Using questionnaire responses, Christensen and Bjerno interrogate the consequences of listening, revealing the affective layer that arises from the experience of musical events that, in their conception, seek to confound an associative aesthetic response by attempting a direct modeling of reality.

Imri Talgam takes phenomenology a stage further by examining the ways in which Xenakis's processes of stochastic change come to be notated for performance, using the standard music notation of Western practice. Particularly in his early works, Xenakis's scores tend to be accurate transcriptions of calculations of probabilities that defy traditional rhythmic and metric structures. Talgam shows how the notational practice that Xenakis developed sets up phenomenological turbulence for the performer, in its relation of concept to experience, that can only be calmed by the re-transcription of passages in order to create more substantial, albeit perceptually near-accurate relationships between parts. He takes the piano piece *Mists* as an example, to show how different notational decisions lead to different trade-offs in the phenomenological mappings between eye (notation), hand (in performance), and ear.

This Section ends with Mauricio Arturo Meza Ruiz's exploration of the sonic imaginary of UPIC, through a comparison between the first work for UPIC, Xenakis's *Mycènes Alpha* (1978), and *eua'on* (1980), by his friend and colleague, the Mexican composer Julio Estrada. The discussion centers on the presence in both sound and drawing of the physicality of the hand, which is a key element of UPIC's operation. This leads Meza to conduct what he calls a "tracealogical" analysis of the two works, showing how the graphic elements that constitute the sonic structures inhabit fundamentally different dynamic-expressive worlds, each of which contains graphic traces of the body involved in their making. Meza proposes that these traces develop from different terrains of creativity, distinguishing the active and the re-active as twin but opposing energies at the heart of UPIC's potential.

The Section *Xenakis and Architecture* provides some glimpses into what was a major part of Xenakis's creative life, though it remains relatively unexplored.[14] Xenakis worked as both a structural engineer and architect at the architectural studio run by the Swiss/French artist known as Le Corbusier, participating in many of the defining projects of architectural modernism, including Chandigarh, the convent of La Tourette, and, most significantly for Xenakis's creative reputation, the Philips Pavilion at the Brussels World's Fair of 1958. And yet, the concern with space and spatial form, with

14 But see Xenakis, 2008.

materials and methods of construction, design and the physical acts of drawing were constants in all of Xenakis's work, of whatever provenance or genre. The architectural spirit, creating forms for living, informed everything he did.

Brigitte Métra, herself a renowned architect, whose firm Métra + associés was co-responsible with Jean Nouvel for the extraordinary new Philharmonie de Paris, reflects on Xenakis's architectural principles as she considers the ways in which space, sound, and material forms interact to create buildings that enable the life of music in new and socially flexible ways. She finds, in Xenakis's writing, surprising resonances with contemporary concerns for form, space, and function, that have, in a sense, got themselves into the blood of architecture after the modern.

Guy Pimienta confronts head on the relationship between Xenakis and Le Corbusier, engaged at such a critical and formative point in Xenakis's life after his injury and his flight from the Civil War in Greece. Le Corbusier's studio was the refuge from which Xenakis constructed the beginnings of his creative life. Pimienta documents the contrasting visions and preoccupations of each man, showing how they intersected and diverged. He charts the growing realization on the part of Xenakis that the music he loved and the architecture he practiced both faced the same creative problems. The turning point in this realization was the co-inspiration of the design for the construction of the Philips Pavilion and the score for the orchestral work *Metastasis*.[15] After that, Xenakis never looked back, and, as Pimienta shows, the break with Le Corbusier, as confronting as it was, marked the real beginning of Xenakis's creative life, formed on the hard ground (*sol dur*) of a difficult apprenticeship.

To end this brief Section, Panayotis Tournikiotis considers in greater depth Xenakis's training as a structural engineer, detailing the design work that Xenakis carried out during his work on various projects for Le Corbusier's studio. Tournikiotis includes in his discussion important photographic evidence from the various buildings on which Xenakis was employed. He also considers the design challenges posed by the various architectural briefs and traces the creative solutions that Xenakis proposed. The detail of these solutions: the use of space and color, the diagonal basis of the hyperbolic paraboloids that created many of Xenakis's forms, his visionary use of light and trajectories of movement through built spaces, all point to preoccupations and creative reference points that continued to permeate all of Xenakis's output, particularly evident in the series of polytopes, invented and constructed by Xenakis between 1967 and 1987 (whether realized or not). Xenakis continued his architectural work throughout his life, although only a small number of domestic projects were eventually built. Nonetheless, as Tournikiotis points out, Xenakis's multidisciplinary

15 Throughout this volume, we shall refer to Xenakis's breakout work as "*Metastasis*." In the Xenakian community, there is an ongoing debate about how to spell it: "*Metastaseis*" (implying the plural) or even, "*Metastassis*" (as it appears on one of the composer's manuscripts of the work, see Figure 29.1a in Cândido Lima's chapter). But Xenakis himself consistently wrote "*Metastasis*" in his books and in his archival notes; therefore, we have opted for this spelling.

approach—what the author refers to as the attribute of being "polytropos"—is the single defining feature of his life.

Living Testimony documents the memories and experiences of some of those who knew and worked closely with Xenakis. While always partial and personal, such testimonies provide particular sorts of insights into the thoughts, practices, and working relationships that develop between friends and colleagues. They can also get under the surface of certain stock images of a person, revealing unsuspected layers of motivation and expression, as well as disclosing something of the impact that figures like Xenakis, and the work that they produce, can have on other minds. In the case of someone born more than one hundred years ago, the testimonies of those still living provide a historical perspective that serve to record events and impressions that are already fading, and that triangulates contemporary views with the recollections of past interactions.

Nikos Kornilios is the son of one of Xenakis's comrades from the dark days of the Dekemvriana.[16] A film director, previously a composer who attended Xenakis's classes at the Sorbonne, he provides a vivid and poetic narrative that records the debt—historical, familial, intellectual, and emotional—of one artist to another.

American composer Curtis Roads is one of the pioneers of computer music, and in particular of a technique known as granular synthesis, which starts from Xenakis's critique of Fourier analysis (a mathematical strategy developed in the eighteenth century that seeks to decompose complex waveforms into a collection of simple sinusoids with related frequencies). Xenakis developed a completely different view of waveforms, based on mathematics described by Dennis Gabor (1900–79), which led him to a radical approach to the synthesis of sound used by Roads in his development of granular synthesis.[17] Roads documents his personal encounter with Xenakis and with Xenakis's theoretical writing, charting his own path through the early history of computer music, and relating the way in which his own creative journey is fundamentally indebted to Xenakis's insights.

Takehito Shimazu is a Japanese composer who attended a course in Paris in 1990, organized by Les Ateliers UPIC, as a consequence of which he wrote a number of works involving Xenakis's UPIC system. Shimazu narrates the details of his encounter with UPIC, and describes his use of the possibility of sampling, which was at that point a new development in UPIC's operation. He developed a deep understanding of UPIC and of Xenakis's intentions in the development of the system, and he reflects on its use in both composition and education, focusing on the physicality of the hand in graphic action, and the ways in which that physicality invests creative intention with a unique clarity of purpose.

The Mexican composer Julio Estrada was one of Xenakis's longtime friends and colleagues. Here, he presents for the first time two conversations he recorded, at

16 See Iatrides, 1972.
17 See Xenakis, 1992, p. 242

Xenakis's studio in Paris, in which the two composers discuss in an informal and illuminating way a range of topics of mutual interest. To follow, and based on his conversations and meetings with Xenakis, Estrada lays out a sort of spiritual and intellectual biography, recording his own impression of Xenakis's accomplishments, and noting those aspects of Xenakis's thought and work that continue to have such an impact on Estrada's own creative life. It is clear, in the passion with which Estrada writes, that there was a deep bond of affection and recognition between these two men; something to do with the "permanent aspiration to be free."

Similarly, the Portuguese composer Cândido Lima had a long and important friendship with Xenakis, a friendship made stronger by the support that Xenakis received, over many years, from the Gulbenkian Foundation in Lisbon, which commissioned a number of important works, including large orchestral works like *Cendrées* (1973) and *Dämmerschein* (1993–4). Lima recounts the beginning of his fascination with the music of Xenakis, their eventual meeting, and their subsequent encounters. This sets the scene for the transcription of portions from three interviews that Lima conducted with Xenakis, two in Xenakis's studio in Paris and one remotely. These interviews cover a range of topics, generating some fascinating dialogues between two extraordinary creative minds.

Finally in this Section, Scottish composer Peter Nelson, one of the core members of Les Ateliers UPIC in Paris during the 1980s, performs a kind of autoethnography of his experiences teaching and composing with UPIC. Taking some cues from contemporary writers in Science and Technology Studies, he attempts to critique the breadth of purpose and the operative capabilities of Xenakis's conception of the UPIC system, exploring the ways in which Xenakis's initial impulse, derived from his work in Le Corbusier's studio coupled with his desire to improve the speed and potential of mathematical modeling through the use of digital computers, found a rich seam of possibilities in UPIC's unique interface and sense of social, as well as creative purpose.

Meta-Xenakis (*or Where Do We Go from Here?*) brings us back to the vision, expressed in Xenakis's notes for his projected *Polytope Mondial*, quoted above, of a circumstance in which science and prophesy share a stage. This uncompromising view, typical of Xenakis and undoubtedly reflecting his own special history, has nevertheless proved to be an exhilarating challenge to a broad sweep of artists, scientists, technologists, educators, and others, across many cultural and geographical divides. The legacy of Xenakis, in the form of artistic output, fundamental and practice-based research projects, new concepts and technologies, and other—no less visionary—undertakings has in some sense indeed produced a *polytope mondial* of collective effort. This final Section surveys a few of the resulting and continuing projects that have taken inspiration from, and in some cases pay homage to the work and example of Iannis Xenakis.

Thus, Rodolphe Bourotte describes the features and implementation of his computer application UPISketch, a graphics-based application for audio synthesis and composition that takes inspiration from Xenakis's UPIC system. This project,

initially a joint research initiative between the University de Rouen Normandie and the European University of Cyprus within the framework of the Creative Europe Interfaces Network, shows how a rich initial concept is capable of development across all its facets, mathematical, technical, and artistic.[18] UPISketch continues to be a work in progress but is also a functioning application that is freely downloadable, and which has already been featured in a range of compositional and educational scenarios.[19]

Similarly, Benny Sluchin and Mikhail Malt describe the operation and use of the Somax2 system, a computer software developed by the Representations Musicales Team at IRCAM in Paris.[20] This is a sort of musical artificial intelligence (AI), which learns the material and structural features of a corpus of recorded audio and allows a performer to improvise freely using those materials. The software also implements some improvisational strategies, including memory of the performance as it progresses. Sluchin and Malt report on their use of this software to perform a version of Xenakis's *Keren* (1986) for solo trombone. This work demonstrates the ways in which Xenakis's call for a performative, collaborative, and creative research, based on fundamental principles, continues to drive innovative artistic expression. Applied research at its best!

Raphael Radna presents an introduction to his virtual instrument plugin Xenos, which, like UPISketch, is a direct descendent of one of Xenakis's own projects, in this case the revolutionary conception of Dynamic Stochastic Synthesis (DSS). Radna relates the historical background to his project, and introduces the fundamental concepts developed by Xenakis. He shows how contemporary computing techniques allow the development of ideas that were extremely difficult to implement using the machines of the 1970s and 1980s. His treatment of pitch, for example, refines the basic concepts of DSS, allowing new creative possibilities within a rich and original conception.

Yin Yu (with Conrad Harris) considers Xenakis's use of light in his polytopes from an architectural perspective based on contemporary techniques of 3D modeling. She discusses the ways in which light can be seen as a 'bridge' between music and architecture, and, after a detailed analysis of the ways in which Xenakis developed the structural principles of his light projections, she describes her own work, *The Shape of Light*, created in collaboration with the violinist Conrad Harris for his performances of Xenakis's works *Mikka* (1971) and *Mikka S* (1975).

Iannis Zannos and Takumi Ikeda's discussion of their work *Phoenix-Albatross* gives, like the text of Rodríguez Lara, an example of the way in which Xenakis's conceptual inventiveness continues to exert an influence on contemporary artistic research. *Phoenix-Albatross* also relates to the work of Malt and Sluchin whose computer modeling of game theory reveals the scope and tendencies within the rules that

18 Interfaces Network, "The Project," https://culture.ec.europa.eu/creative-europe/creative-europe-culture-strand/european-networks

19 Centre Iannis Xenakis, "UPISKETCH," *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/upisketch

20 IRCAM, "Musical Representations," *STMS-LAB*, https://www.stms-lab.fr/team/representations-musicales/

Xenakis devised for his works *Stratégie* and *Duel*. In this case, *Phoenix-Albatross* models the strategies used for *Duel* by utilizing them in a telematic dance performance, using live coding in SuperCollider. Like Malt and Sluchin, Takeda examines the matrices of probabilities, and in this case, devises a genetic algorithm that produces a more even-handed version of the game. The agonistic elements of Xenakis's conception are developed through the telematic, multi-site instantiation of the work, and through the use of movement to engage with the musical parameters of the game.

Thanos Polymeneas-Liontiris takes an autoethnographic approach to his discussion of his use, within his own practice as a performing bassist using feedback techniques, of DSS, one of Xenakis's most influential inventions. He describes his use of Xenakis's two GENDYN programs, as implemented in SuperCollider, with audio and coding examples that include aspects of machine learning.[21] This musical exploration of a combination of old and new techniques once again shows the ways in which the richness of Xenakis's original conceptions, alongside the openness and creative potential of his speculative approach, have proved inspirational and practically fruitful for later generations.

The architect Andrew Lucia presents a brief overview of his substantial work, *A Catalog of Difference*. This relates in significant ways to the work of Xenakis, both as musician and as architect, since the basic insight of Xenakis—that perceivable structural trajectories are founded on statistical differences—makes the notion of "difference" a key perceptual paradigm. Lucia's work tracks types and instances of difference across a range of media, noting, with Bateson, that "differences that make a difference" are the key to both perception and learning.[22] This exemplary work demonstrates the originality and prescience of Xenakis's theoretical writing, as it informs his creative impulse, and shows how the conceptual beginnings outlined there continue to lead to new insights and discoveries.

Computer scientist and musician Bill Manaris thinks through the notion of the algorithm, a fundamental element of Xenakis's practice, in order to show how the formalization of process represented by algorithmic thought raises important issues of agency and authorship. He demonstrates ways in which several of the algorithmic processes used by Xenakis are themselves capable of further creative extension, and gives examples of new, "syllogistic" outcomes that stand as separate but related artworks. This leads to a consideration of the algorithmic arts as a creative paradigm, that stems in substantial part from Xenakis's individual contribution as creator and theorist.

Hugo Solís, Mizky Bernal, Diego Jiménez, Guillermo Leonardini, and Eunice Pérez give an account of collective work undertaken within the Music Technology Group of SUICREA (University Seminar for Research in Artistic Creation) at the National

21 As Polymeneas-Liontiris points out, there are actually several GENDYN programs. These are not to be confused with Xenakis's electroacoustic work *Gendy3* (1991), which is indeed based on one of the GENDYN programs yet is distinct as a work unto itself.

22 Bateson, 1972, p. 271–2.

Autonomous University of Mexico. The project involves, once again, the extension and development of the rich seam of possibilities proposed by Xenakis's UPIC system, in this case including the extension of the two dimensions of the UPIC drawing board into three dimensions, and the investigation of the potential of the "flocking" algorithm, developed by Craig Reynolds.[23] With code examples, the authors explore not just certain conceptual elements that can be implemented within the UPIC framework, but also the creative consequences of thinking and working collectively. This presents more than an analogy with the use of the flocking algorithm, showing the ways in which creative dialogue can enrich creative possibilities in the effort towards a unified goal.

In the final contribution to this Section, Iannis Zannos, Martin Carlé, Vasilis Agiomyrgianakis, Takumi Ikeda, and Hanako Atake take Xenakis's concerns for new technologies in a necessary and contemporary direction by thinking through the implications of what they call 'frugal innovation': the development of a more sustainable and accessible approach to digital technologies. This sits within the activities of hacking, DIY, and maker cultures, and the authors give detailed technical accounts of their materials and hacks. The international collaborative performance project that forms the artistic center of this work combines dance, remote sensing, live coding, and audio processing to create a series of events that take inspiration from Xenakis's work *Kraanerg* (1967) whose program note invokes the "biological struggle between generations unfurling all over the planet, destroying existing political, social, urban, scientific, artistic, and ideological frameworks on a scale never before attempted by humanity."

As a vital addition to the texts introduced above, the digital archive *Meta-Xenakis: Sustainable Resources* includes and makes available a range of short texts, video, and audio files arising out of the events staged during the Meta-Xenakis program curated over three continents throughout 2022. These include performances of new work, and works by Xenakis, alongside demonstrations of projects like UPISketch and archive materials related to Xenakis himself.

Finally, as mentioned above, the Appendix documents the eighty or so events hosted respectively by each Meta-Xenakis team throughout the world in 2022. Several are included in the digital archive of our final Section *Meta-Xenakis: Sustainable Resources* and several links will enable readers to experience many of the other events.[24] Like the texts collected together in this volume, these resources stand not simply as a testament to the life and work of one of the twentieth century's most significant creative figures, but also as a progress report on the creative, scientific, technological, and conceptual work that continues to face up to the questions and challenges posed by this most challenging of men.

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23 Cf. Timmie Wong, "Boids" (2008), *Stanford University*, https://cs.stanford.edu/people/eroberts/courses/soco/projects/2008-09/modeling-natural-systems/boids.html

24 In the event of future Meta-Xenakis events, please visit our Additional Resources at https://doi.org/10.11647/OBP.0390#resources where they will be posted.

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Prolegomenon: Meta-materiality in the Thought and Creative Activity of Iannis Xenakis

James Harley

Iannis Xenakis (1922–2001) is primarily known as a music composer, but he was actually many things. The confluence of his various abilities and interests, what has been called his "alliages-alloys,"[1] leads to the notion of "meta-materiality." This study seeks to explore the ways in which Xenakis's multifaceted work grew out of mathematical abstraction and discipline that could be applied to a wide range of creative projects incorporating elaborate technical materials.

Xenakis possessed an enormous capacity to absorb different sorts of information, and to apply these inputs to his creative and technical work. This capacity developed during his training as an engineer and his time working for the famed architect Le Corbusier (1947–59); in his final project for Le Corbusier, the Philips Pavilion (for the 1958 World Fair in Brussels), he served as project coordinator, working with architects, engineers, construction contractors, audiovisual designers, and more.[2] Engineering is a discipline where a rigorous training in foundational knowledge such as mathematics is allied with practical applications. As a professor, and in interaction with younger composers and musicians, he invariably advised people to study mathematics. This conviction was most strongly expressed in his counsel to his own daughter Mâkhi, who rebelled against this advice to become a visual artist.[3] Reflecting on his own formation, Xenakis thought of himself as being shaped from a "mosaic of coherences."[4] He moved, conceptually, from the field of Philosophy, "Thrust towards truth, revelation. Quest in everything, interrogation, harsh criticism, active knowledge through creativity"[5] to the

1 The French term to convey the conceptual amalgam of arts-sciences, "alliages," was translated as "alloys" in English (Xenakis, 1985).

2 And, at the same time, carrying on his activities as a composer, working at the GRM (Groupe de Recherches Musicales) studios, writing substantial articles on music and architecture.

3 Xenakis, 2022.

4 Xenakis, 1971, p. viii.

5 Ibid.

https://doi.org/10.11647/OBP.0390.02

fields of the Arts (partially inferential and experimental), Sciences (of man, natural), and Physics, Mathematics, and Logic (entirely inferential and experimental).[6] He then moved on to categorizing questions (found in many fields) and from there to sorting types of solutions or procedures for solving questions, and then to examining specific compositions (examples of particular realizations, musical works).[7] Clearly, Xenakis placed music (and arts-based creative activity) within a larger, classical educational context: Trivium (primary stage)—Grammar; Logic; Rhetoric; then the Quadrivium (secondary stage)—Arithmetic (abstract); Geometry (spatial); Music (temporal); Astronomy (spatial and temporal). Later, when he had occasion to reflect on his trajectory, in particular when he presented his work and writings for a Doctorat d'État in 1976, he articulated the aesthetic/philosophical basis of his activities.[8]

> All the work I have done over the years is a sort of mosaic of hierarchical coherencies. At the hierarchy's summit I'd place philosophy... in the sense of the philosophical impulse which pushes us toward truth, revelation, research, general quest, interrogation, and harsh systematic criticism, not only in specialized fields but in all possible domains. This leads us to an ensemble of knowledge which should be active, in the sense of "doing." Not passive knowledge but knowledge which is translated into creative acts. I repeat, in all possible domains.... One can divide this coherency mosaic into three categories or three chapters. The first is the method which allows us to obtain this active knowledge through creativity—which (through theoretical demonstration) implies inference, meaning reason, logic, etc. Following these criteria, there are aspects of activity and knowledge which are partially inferential, entirely inferential and experimental, and others which remain unknown.[9]

In his "Table (mosaic) of Coherences" he lists musical compositions exemplifying "categories of questions," from indeterminism to determinism: under the heading Free Stochastic he lists *Achorripsis* (1957), *ST/10* (1962), *ST/48* (1962), *Morsima-Amorsima* (1962), *Atrées* (1963); under Markovian he lists *Analogique A + B* (1958–9), *Syrmos* (1959); under Games he lists *Duel* (1959), *Stratégie* (1962); and under Groups he lists *Akrata* (1964), *Nomos Alpha* (1966), *Nomos Gamma* (1967).[10]

Turning back to his chronology and formation as a composer, it is clear that Xenakis built on his classical schooling with advanced engineering studies (Athens Polytechnic, 1940–6), all while carrying on an interest in music and other arts (especially ancient Greek literature and architecture).[11] In the realm of Western music, exemplified by the conservatory approach to musical training (including composition), the cross-fertilization with other disciplines became quite restricted.[12] The increasingly elaborate

6 Ibid.
7 Xenakis's music is discussed comprehensively in Harley, 2004.
8 Xenakis, 1985.
9 Ibid., p. 7–8.
10 Xenakis, 1971, p. viii.
11 Xenakis's biography has been most thoroughly presented in Matossian, 1986.
12 In the conservatory model, music students study and learn in an isolated environment, usually separate from a wider university-type educational environment.

techniques being explored by composers made the music and related techniques more hermetic. For Xenakis, however, his particular educational background, carried out in Greece under the heritage of Plato, Aeschylus, etc., made it more natural for him to adapt tools and approaches from other disciplines, building on the core elements of mathematics, philosophy, etc. Xenakis found a little training in harmony and counterpoint during his years in Athens. But his main academic focus was on engineering, and the political upheavals and strife through those years made other extracurricular pursuits difficult. When he got to Paris in 1947 though, Xenakis quickly made music his main focus, beyond his "day job" in Le Corbusier's architectural studio. He sought advice and instruction from the best the city had to offer. In 1948 he approached Arthur Honegger (1892–1955) at the École Normale. He then approached Darius Milhaud (1892–1974) in 1949 at the Paris Conservatoire. Apparently not finding a good match working with these venerable but somewhat conservative composers, he then sought out Nadia Boulanger (1887–1979), most well-known as a pedagogue, who did not accept Xenakis as a student but whose assistant Annette Dieudonné (1896–1990) recommended he approach Olivier Messiaen (1908–92), who was teaching at the Paris Conservatoire. Messiaen saw something worthwhile in the fledgling composer and permitted Xenakis to audit his classes over three years, 1951–4. This period saw a remarkable development in Xenakis's scores, and a reference from Messiaen also opened the door to electroacoustic music through an apprenticeship at (what is commonly known as) the Groupe de Recherches Musicales at Radio France, where he worked in various capacities from 1955–62. This period was fruitful in many ways. For example, during this time another mentor, conductor Hermann Scherchen (1891–1966), encouraged Xenakis, among other things, to articulate his ideas in print. His first articles date from 1955: "Problems of Greek Musical Composition" and "The Crisis of Serial Music." Subsequent articles led to what became the book *Formalized Music*.

The transference of ideas from those other disciplines, especially mathematics, into music had the effect in Xenakis's work of creating highly original scores and sounds: firstly, the geometrical principles underlying hyperbolic paraboloids as they were being explored in architecture turned into webs of string *glissandi* in *Metastasis* (1953–4), and were further explored in string works such as *Syrmos* (1959). Secondly, the probability functions used in risk analysis in engineering and other disciplines were applied to generative applications in creating complex, granular "clouds" of sound in *Pithoprakta* (1955–6) for orchestra, *Concret PH* (1958) for electroacoustics, or *Analogique A & B* (1959) for strings and electroacoustics. And thirdly, his detailed understanding of computer programming led to the ST family of algorithmic instrumental works in 1962, while his familiarity with the intricacies of linking software to digital audio-oriented computer hardware led to a unique graphical-based synthesis system, the UPIC (Unité Polyagogique Informatique de CEMAMu); through this system, Xenakis created a series of electroacoustic compositions, from *Mycènes Alpha* (1978) to *Voyage*

absolu des Unari vers Andromède (1989). Further work in digital audio led to a new approach to sound synthesis: General Dynamic Synthesis (GENDYN). Preliminary work on what he also called "stochastic synthesis" provided material he incorporated into *Polytope de Cluny* (1972–4) and *La Légende d'Eer* (1978). GENDYN software led to two computer-generated works: *Gendy3* (1991) and *S.709* (1994).

Fig. 0.1 Aerial view of Xenakis's *Diatope*, Paris, 1978. Photo by Bruno Rastoin (1978). Archives of Centre Iannis Xenakis, Rastoin collection.

His engineering background also supported his ability to develop unique multimedia presentations involving digitally controlled lighting systems with hundreds of flashbulbs and laser displays guided by movable mirrors. His first involvement with such projects occurred with the Philips Pavilion in 1958; he was primarily involved in the architectural design of the pavilion and its construction, but he witnessed and supported the presentations that included hundreds of loudspeakers, lights, projected film, and sculptural elements (his musical contribution was the short electroacoustic work, *Concret PH*, intended as an interlude as people entered and exited the pavilion between performances). With the *Polytope de Montréal* (1967), he was able to create an installation that included music (originally scored for four spatially separated ensembles, but in the end projected on loudspeakers from a four-channel tape), strung cables forming designs reminiscent of the linear, geometrical *glissando* shapes used in *Metastasis*, and hundreds of programmable flashbulbs strung along the cables stretching over the five floors of the atrium space he was working with. He did not have the opportunity to create the architecture, but the installation became the

highlight of the pavilion. The *Polytope de Cluny* provided another opportunity to create an installation, this time in an historical site in Paris and with the addition of lasers. He also created polytopes for outdoor historical sites: *Persepolis* (1971) and *Polytope de Mycènes* (1978). Perhaps the epitome of Xenakis's meta-materiality is his *Diatope* (1978), a work combining architecture, music with computer-controlled spatialization, lights (flashbulbs and lasers), and a significant program text combining philosophy, history, and aesthetics.[13]

For Xenakis the polymath, it was natural to draw concepts and techniques into his creative work from various disciplines. Messiaen's advice to his extraordinary student who had very little traditional background or training in music proved prescient: "I encouraged him to use his mathematical and architectural knowledge in his own music and not to worry about melodic—harmonic—contrapuntal—rhythmic problems."[14] Of course, these elements are essential to whatever music is being created, but the techniques for handling them can come from musical traditions or from other disciplines. The meta-materiality of Xenakis's work is the core of his truly original contributions.

> The artist-conceptor will have to be knowledgeable and inventive in such varied domains as mathematics, logic, physics, chemistry, biology, genetics, paleontology (for the evolution of forms), the human sciences and history; in short, a sort of universality, but one based on, guided by and oriented toward forms and architectures. Moreover, the time has come to establish a new science of "general morphology" which would treat these forms and architectures within these diverse disciplines in their invariant aspects and the laws of their transformations which have, in some cases, existed for millions of years. The backdrop for this new science should be the real condensations of intelligence; in other words, an abstract approach, free from anecdotes of our senses and habits.[15]

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13 Xenakis's multimedia and architectural works are presented in detail in Xenakis, 2008.
14 Matossian, 1986, p. 10.
15 Xenakis, 1985, p. 3.

XENAKIS BEFORE XENAKIS

Plate 3 Iannis Xenakis in Delphi, Greece, during a seminar on his music, summer 1985. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

1. Iannis Xenakis's Theater Studies: An Unknown Aspect of the Composer's Life during the Occupation

Nikos Ioakeim

> My hardened conscience—nourished either by the flames of the Greek Resistance (which was betrayed from its conception and over the years by the Soviets, the Allies, and the Greek themselves) or by the desperate efforts of my music—alone, may guide me towards light or towards death.
>
> (Iannis Xenakis, 14 December 1971)[1]

Iannis Xenakis's music for the theater occupies a small, albeit very important part of his oeuvre: it consists of music for the staging of Aeschylus's *The Suppliants* (1964), Aeschylus's *Oresteia* (1966), Seneca's *Medea* (1967), Sophocles's *Oedipus at Colonus* (1975)—which unfortunately fell through but led to the autonomous piece *À Colone*,[2] Euripides's *Helen* (1977), and Euripides's *The Bacchae* (1993). Although Xenakis entered the theatrical field after a commission by the stage director Alexis Solomos (1918–2012) and the National Theater of Greece in 1964 and not on his own initiative, he followed a highly individual course that bore the landmarks of his lifelong interests: he worked solely on stagings of Greco-Roman tragedies; he opted for bilingual stagings, where he set the text to music in the original while the play was delivered in the language of the audience (with the exception of *The Suppliants* and *Oresteia*—although the latter was actually Ancient Greek text set to music, but during the staging it was sung in English); he composed incidental music for the theater, yet afterwards turned it into self-contained concert works in the form of choral-instrumental suites or unaccompanied choral pieces (while the original music was never revived), i.e., *Hiketides-Les Suppliants d'Eschyle* (1964), *Medea Senecae* (1967), *Oresteia* (1967), *À Colone* (1977), *À Hélène* (1977). His last theatrical feat, *Les Bacchantes d'Euripide*, was exceptionally not turned into a suite but was published in its original

1 Open letter by Xenakis to *Le Monde*, in Xenakis, 2008, p. 223–4.
2 See Ιωακείμ [Ioakeim], 2018, p. 112–13.

 https://doi.org/10.11647/OBP.0390.03

form. Furthermore, Xenakis composed another two separate works, *Kassandra* (1987) and *La Déesse Athéna* (1992), again settings of scenes from Aeschylus's *Oresteia*, which were inserted into his *Oresteia* suite. Especially concerning *Oresteia*, the fact that it was the sole work in his oeuvre that he revisited and reconsidered during his lifetime clearly shows that it played a pivotal role in his thought and artistic development.[3] This chapter investigates Xenakis's early and formative experiences of the theater in Athens during the Axis Occupation revealing the critical and recently discovered connection between Xenakis and the culturally important figure of Vassilis Rotas (1889–1977).

In later life, Xenakis made only scarce references to his theater experiences during his youth in Greece. He mentioned that he had participated in the staging of Attic and Shakespearean tragedies during his adolescent years at the Anargyrios and Korgialenios School of Spetses, but that he had never watched a professional staging of an ancient tragedy before leaving Greece in 1947 (although he had visited the Ancient Theater of Epidaurus in 1937 or 1938).[4] In 1981, he told François Delalande:

> I remember, I was maybe 20 years old, I was taking some classes, and I was asked to direct a tragedy by Aeschylus–I do not remember which one–and I imagined the whole staging with lights, not at all a classic staging. I don't think I had ever seen Aeschylus performed in the theater–it was based solely on the text. And I made a staging that consisted of lighting, lighting changes. And that was quite unexpected. It was the first time I became aware of the importance of visual phenomena as visual music.[5]

This singular remark about Xenakis actually having taken theater classes is confirmed by his biographer Nouritza Matossian, who also mentions that it was Aeschylus's *Agamemnon* that he was asked to direct, but until recently there was no other evidence about this.[6] In 2017, a Greek journalist, a friend of Xenakis during the Nazi Occupation (1941–4), published her memoirs where she confirms that they were fellow students at the Theatriko Spoudastirio (Theater Studio), a drama school that operated between

3 Next to Xenakis's work for the theater, the piece *Polla ta Dhina* (1962) for children's chorus and orchestra must also be mentioned, which, although a concert work, sets to music a stasimon from Sophocles's *Antigone*; it was conceived before the composer launched into writing incidental music, and shows his early predilection for the ancient drama.

4 See Xenakis's 28 May 1964 letter to the stage director Alexis Solomos regarding the staging of Aeschylus's *The Suppliants* with his music in the Theater of Epidaurus—Xenakis Archives, OM 11-2, ms. p. 3. N.B. that the theater hosted the staging of an ancient tragedy for the first time since Greek Antiquity in 1938, again in 1954, and it established itself as part of the Athens-Epidaurus Festival for the annual staging of ancient drama during the summer season in 1955.

5 Delalande, 1997, p. 111 [*Je me souviens, j'avais peut-être 20 ans, je suivais certains cours et on m'avait demandé de faire une mise en scène d'une tragédie d'Eschyle—je ne sais plus laquelle—et j'avais imaginé tout une mise en scène avec des lumières, pas du tout une mise en scène classique. Je crois que je n'avais jamais vu Eschyle joué au théâtre—c'était seulement d'après le texte. Et j'avais fait une mise en scène qui était faite de lumières, de changements de lumières. Et c'est tout à fait inattendu. C'était la première prise de conscience de l'importance des phénomènes visuels en tant que musique visuelle*].

6 Matossian, 2005, p. 259. Cf. Μάκης Σολωμός [Makis Solomos], 1996, p. 59. In Xenakis, 1996, p. 51, the composer mentions again that as a young man he directed a tragedy by Aeschylus (without naming which)—although, confusingly, not referring to his theater studies in Athens but to his secondary school years at Spetses.

1942–4 in Athens. The journalist recalls that the young Xenakis was one day asked to submit a paper on the scene of Cassandra from *Agamemnon* for the dramaturgy class, which he did, writing down in detail how the scene would be set according to the verses. Their teacher, the poetess Sofia Mavroidi-Papadaki (1898–1977), was impressed by the originality of his conception and requested his bibliography, causing Xenakis to admit that he had merely thought of it all by himself.[7]

It is well-known that Xenakis's youth was "kneaded" (his word) through his studies of Ancient Greek literature.[8] When setting Aeschylus's *Oresteia* to music in 1966, the composer mentioned that he studied the trilogy for the first time during the Occupation years, and that it "caused me a shock."[9] The fact that he delivered his paper on Cassandra's scene back then matches with the fact that in 1987 he set it to music as well with his work *Kassandra*; it is clearly characteristic of the man to bring into fruition decades later concepts that he visited during his youth.

The Theatriko Spoudastirio was founded by the philologist, writer, playwright, and translator Vassilis Rotas. Rotas was a remarkable figure of the Greek twentieth century: in addition to classical philology, he studied acting in his twenties at the Athens Conservatory, which hosted the only drama school in Greece at the time. Then he served in the army for nearly twenty years, and in 1927 he retired at the rank of colonel for political reasons. From then on, he devoted himself to the theater, penning and staging plays, and trying to retain a drama school, while making a living as a theater critic and translator.[10] Together with his companion, the writer Voula Damianakou (1922–2016), and after nearly fifty years of intermittent work, he managed to translate into Modern Greek the complete oeuvre of William Shakespeare (both his plays and poems)—an amazing feat which was completed in 1974 and remains exemplary, of analogous importance to the translations of August Wilhelm Schlegel (1767–1845) in German, and of Boris Pasternak (1890–1960) in Russian.[11]

Rotas was a founding member of the National Liberation Front (EAM) during the Occupation, together with two renowned Marxist literary figures, friends of his since their student years, Kostas Varnalis (1884–1974) and Markos Avgeris (1884–1973), and he had also composed the hymn of EAM.[12] Although becoming a member of the United Democratic Left (EDA) after its founding in 1951, during the 1960s Rotas was

7 Σώκου [Sokou], 2017, vol. 1, p. 258–9.

8 Bois, 1966, p. 18 [*Ma jeunesse a été pétrie de ça*].

9 See his letter of acceptance of the commission of *Oresteia* to the Ypsilanti festival's director Clara Godwin Owens on 19 December 1965: Xenakis Archives, OM 13-5-2. Thirty years later, in 1995, in an interview following a choreographed performance of his *Oresteia* in the Theater of Epidaurus, Xenakis came back to it (Xirou, 2010, at 58:23): "I had studied the *Oresteia* thoroughly when I was young, 18 years old."

10 Before founding the Theatriko Spoudastirio, Rotas had run the Laïko Theatro Athinon (Athens Theater of the People) between 1930–7.

11 Damianakou's birth year is often erroneously cited as being 1914. For Rotas's biography, see Ρώτας [Rotas], 1980, p. 8–13 and Ρώτας [Rotas], 1981, p. 7–10.

12 "Λευτεριά, πανώρια κόρη" (Liberty, Fair Maiden), words and music by V. Rotas—see Ρώτας [Rotas], 1981, p. 79 and Ρώτας [Rotas], 1982, p. 27–31, including a reprint of the score.

in constant dispute with EDA, accusing it of bureaucratic rule, democratic deficit, and dependence on the word of the Greek Communist Party (KKE) which had been outlawed in 1947, the year Xenakis fled Greece.[13] After the establishment of the military Junta in 1967, Rotas, although an elderly man, was exiled along with many others to the unpopulated island of Gyaros.[14] Until the end of his life, he, like Xenakis, remained faithful to the ideals and actions of EAM.

The Theatriko Spoudastirio was founded in early 1942 and functioned regardless of many difficulties until early 1944; by then, the United Panhellenic Organization of Youth (EPON), i.e., the youth of EAM, was gradually going underground since their Resistance activities against the Axis forces were becoming more and more critical. Rotas decided to move to the mountains, to the so-called "Free Greece" that was ruled by EAM, and there continued his theatrical activities until the liberation of Greece at the end of 1944, when he returned to Athens. In 1946 the Theatriko Spoudastirio managed to resume its activities with renewed staff until 1948.[15]

Prominent figures of Greek cultural life taught in Rotas's school during the Occupation: Rotas himself and Markos Avgeris taught creative writing and Greek literature, Sophia Mavroidi-Papadaki taught dramaturgy-dramatics, Yannis Tsarouchis (1910–89) taught scenography-history of art, stage director Giannoulis Sarantidis (1902–48) taught acting, Antonis Fokas (1889–1986) taught costume design, Thanassis Apartis (1899–1972) and Memos Makris (1913–93) taught drawing and sculpture, Simon Karas (1905–99) taught Greek traditional ("Demotic") and church ("Byzantine") music, and Miranda Voulgari-Filiakou (1921–2015) taught dance.[16]

The Theatriko Spoudastirio published its own student weekly and organized various cultural events such as theatrical performances, concerts, lectures, and parties.[17] It evidently functioned as a Resistance meeting point undercover, since it hosted hundreds of members of EPON: around five hundred students were enrolled in the school at its peak, including the painter and scenographer Nikos Georgiadis (1923–2001), Xenakis, as well as the film director Manos Zacharias (b. 1922), who was the chair of the student committee of the school, and was to become the political leader of the "Lord Byron Battalion" of the Greek People's Liberation Army (ELAS)

13 For an exhaustive account of his dispute with EDA, see Ρώτας-Δαμιανάκου [Rotas-Damianakou], 1961 and Ρώτας-Δαμιανάκου [Rotas-Damianakou], 1965.

14 For a chronicle of Rotas's exile, see his letters and diary entries in Ρώτας [Rotas], 1980, p. 44–71.

15 Ρώτας [Rotas], 1981, p. 24.

16 Note that Tsarouchis was also the teacher of Xenakis's youngest brother, the painter and architect Cosmas Xenakis (1925–1984). Interestingly, the Greek term for costume designer, *ενδυματολόγος* ("endymatologos") was invented in the early 1930s after the founding of the National Theater of Greece, especially for Antonis Fokas, due to lack of terminology, since there was no such tradition in professional theater in Modern Greece (the Aristotelian term *σκευοποιός* ("skeuopoios") probably didn't seem suitable, as it is exclusively relevant to the Attic tragedy)—see Antonis Fokas's testimony in *Φωτόπουλος* [Fotopoulos], 1990, p. 258–9. N.B. that even the role of the stage director was not yet recognized in Greek theatrical practice at the time. The Theatriko Spoudastirio was, in fact, hosted at the music school of Simon Karas, at 26 Lekka Street. See further Ρώτας [Rotas], 1981, p. 16.

17 Find reprints of material from the weekly in Ρώτας [Rotas], 1982, p. 38–59.

during the *Dekemvriana* in December 1944, where Xenakis served as an officer and was wounded on 1 January 1945.[18]

Rotas, in his fifties at the time, functioned as a role model and a symbol for the members of EPON; his 1943 lecture on traditional Greek song was packed.[19] Xenakis probably attended classes irregularly, given his studies at the Polytechnic and his participation in the Resistance—Rotas's focus, however, on discovering and preserving tradition as a source of inspiration and self-consciousness for the present certainly resounded in the young Xenakis: let's consider not only his early forays in composition up to *Metastasis*, but also the principles on which his later work developed, plus his constant urge to the Greeks after his return to Greece for the first time in 1974 to be aware of their traditions and to research them.[20]

On 24 September 1943 the "manifesto" of the Theatriko Spoudastirio was published, signed by Rotas, describing the objectives of the school and the kind of theatrical practice he dreamt of and tried to set in motion. The following statements sound very Xenakian:

> The artist [. . .] must [. . .] be apprenticed in all genres transmitted to us by the exuberant current of tradition and be scientifically qualified to acquire an all-embracing artistic perspective and experience, in order to be able to solve problems and apply living theories with the power of his cultivated talent. [. . .] The lust [of his imagination] must learn to run and fly according to laws drawn from scientific experience. The ancient Greek tradition (which in many ways has survived in our traditional folk art), the global artistic production, and the social demands of our people; these must be the contributors to such a creation. [. . .] Therefore, not only actors, but also stage directors and set designers and dancers and even composers and playwrights, must be scientifically educated. [. . .] We look to the masses, which is why our theater can only be a theater of the people. The theater of the people must offer the Greek people a 'festivity', i.e. it must be an all-embracing theater that meets their artistic and social demands.[21]

18 Σώκου [Sokou], 2017, vol. 1, p. 223. Manos Zacharias is mentioned in Ρώτας [Rotas], 1981, p. 24 and Ρώτας [Rotas], 1982, p. 37.

19 For an account of the event, see Ρώτας [Rotas], 1981, p. 16–17, 75 and Ρώτας [Rotas], 1982, p. 1. For the text of the lecture, see Ρώτας, "Το Δημοτικό τραγούδι" [Rotas, "The Demotic Song"] in Ρώτας [Rotas], 1982, p. 60–8, and in Ρώτας [Rotas], 1986, p. 266–76.

20 See especially Rotas's 13 August 1943 essay "Το ελληνικό ήθος" (The Greek Ethos) in Ρώτας [Rotas], 1986, p. 221–5. See also on p. 211–14 his 17 September 1943 essay "Ελληνικό πνεύμα" (Greek Spirit) where he reproduces and affirms relevant ideas of the writer, politician, Greek Communist Party member, and author of the ideological manifesto of EAM, Dimitris Glinos (1882–1943). For Xenakis's thoughts about tradition, see Παγκουρέλης [Pangourelis], 1977.

21 Ρώτας [Rotas], 1986, p. 263–64 [*Ο καλλιτέχνης* [...] *οφείλει* [...] *να μαθητέψει σε όλα τα είδη που μας φέρνει το πληθωρικό ρεύμα της παράδοσης και να καταρτιστεί επιστημονικά για ν' αποχτήσει καθολική γνώμη κι εμπειρία της τέχνης, για να μπορέσει με τη δύναμη του καλλιεργημένου ταλάντου του να λύσει προβλήματα και να εφαρμόσει ζωντανές θεωρίες.* [...] *Κι ο πόθος αυτός [της φαντασίας του] πρέπει νάχει μάθει να τρέχει και να πετάει με νόμους βγαλμένους από την επιστημονικήν εμπειρία. Η αρχαία ελληνική παράδοση που σε πολλά έχει επιβιώσει στη νεώτερη λαϊκή μας τέχνη, η παράδοση από την παγκόσμια παραγωγή και το κοινωνικό αίτημα του λαού μας, αυτά πρέπει να σταθούνε οι συντελεστές για μια τέτοια δημιουργία.* [...] *Πρέπει λοιπόν να μορφωθούνε επιστημονικά όχι μόνον υποκριτές, παρά και σκηνοθέτες και σκηνογράφοι και χορευτές και μάλιστα οι μουσουργοί και οι δραματικοί ποιητές.* [...] *Κι εμείς αποβλέπουμε στον*

What is remarkable in these excerpts is Rotas's insistence that the artist acquires *scientific knowledge*—not in the sense of academic education, but as an in-depth training that excludes amateurism—as well as the broadest possible perspective. What is also striking is the use of the term "all-embracing theater;" it brings to mind "total theater"/"total spectacle," which is how Xenakis characterized the ancient drama already in 1967, while contemplating on his work thus far on Aeschylus's *The Suppliants*, Seneca's *Medea* and Aeschylus's *Oresteia*.[22] The composer came back to it in 1991 with his essay "Aeschylus, A Total Theater," where he reviewed his settings of words to music and discussed his predilection for Aeschylean tragedy.[23] Of course by the notion of "total theater," Xenakis referred to the synthesis of all arts that the ancient drama requires and displays, while by his "all-embracing theater," Rotas meant something more general and "leftist" (in accordance with the spirit of the times): a theatrical practice which concerns and is relevant to everybody.

The elective affinities of the two men do not end there: starting from the 1940s, Rotas reviewed theater performances, with a special focus on the ancient drama. In his reviews he constantly criticized the approach of the National Theater of Greece, maintaining that ancient tragedy should only be presented in ancient theaters, with the actors wearing *cothurnuses* (i.e., high, thick-soled buskins meant to make them look taller) and masks, and using a particular type of speaking, acting, and moving that suited the open-air dimensions of the spectacle. In other words, he demanded specialized research into the matter, and a quasi-ritualistic approach instead of the rather realistic one that was in fashion at the time.[24]

Such ideas from Rotas coincide perfectly with the objectives stated by Xenakis to the press whenever he came to Athens to work on the staging of a tragedy—in particular, Sophocles's *Oedipus at Colonus* in 1975 and Euripides's *Helen* in 1977. In fact, during an interview the day before *Helen*'s première, Xenakis stated that his "secret desire" was to work on a tragedy in an all-embracing manner, both in terms of music and stage direction, "but there is much time and studying needed for something like that." Such a work could be realized by a group that should follow a fixed style in acting, staging, and voice-training "so that authentic performances be created, and perhaps, after two or three generations, the foundations of a high-standard art will have been laid."[25] This

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πολύν ελληνικό λαό, γι' αυτό και το θεατρό μας δεν μπορεί να είνε άλλο από λαϊκό θέατρο. Το λαϊκό θέατρο πρέπει να προσφέρει στον ελληνικό λαό 'γιορτή', δηλαδή καθολικό θέατρο, που ν' ανταποκρίνεται στο καλλιτεχνικό και κοινωνικό αίτημά του].

22 "Notice sur l'Orestie" in Xenakis, 1967.

23 "Eschyle, un théâtre total" in Xenakis, 1996, p. 49–58.

24 See especially his essays dating from 1943 to 1951: "Η Αναγέννηση της τραγωδίας" (The Rebirth of Tragedy), "Η γέννηση της τραγωδίας" (The Birth of Tragedy), "Έχει προγόνους η τραγωδία;" (Does Tragedy Have Ancestors?), "Η τραγωδία και οι παραστάσεις των αρχαίων δραμάτων" (The Tragedy and the Staging of Ancient Dramas) in Ρώτας [Rotas], 1986, p. 474–519.

25 Παγκουρέλης [Pangourelis], 1977 [*[...] ό 'κρυφός πόθος' του [...] εἶναι νά δουλέψει ὁλοκληρωμένα μιά τραγωδία, καί σάν μουσική καί σάν σκηνοθεσία, 'ἀλλά χρειάζεται πολύς χρόνος καί μελέτη γιά κάτι τέτοιο'. Μιά τέτοια δουλειά, θά μποροῦσε νά γίνει [...] ἀπό μιά ὁμάδα, πού θά ἀκολουθήσει ἕνα ὁρισμένο ὕφος στην ὑποκριτική, τή σκηνοθεσία, τή φωνητική "ὥστε νά*

was the sole instance where Xenakis revealed his intention to assume the role of stage director as well. Unfortunately, the composer never received a commission to work on an ancient tragedy in Greece again, and this idea was never set in action.

The point, however, where Xenakis's ideas deviate from Rotas's concerns language itself: Rotas considered it self-evident that the tragedies would be played translated into Modern Greek, while Xenakis, ever since his *Oresteia* in 1966, insisted on setting the text to music in the original. In accordance with the spirit of the Metapolitefsi ("regime change") in Greece after the fall of the Junta in 1974, the composer's tendency to set the tragedies in Ancient Greek was generally received as both elitist and reactionary: firstly, because performing in open air theaters during the summer months was considered a spectacle for the masses, for whom listening to Ancient Greek doomed the text to be incomprehensible; secondly, because this attitude inevitably connected itself with *the Greek language question*, a divisive political issue which had lingered on since the nineteenth century about whether the vernacular should become the official language of the Greek state, press, and education or not, and which was finally settled in favor of the vernacular in 1976, one year before the staging of Euripides's *Helen*.

Xenakis's stance was irrelevant to the question—his purposes were auditory and artistic: he believed that using the original text allowed the composer to tamper with the beauty of the language, and also created a sense of distance that was necessary for the artist as well as for the audience (especially in the case that they were native speakers) who could follow a simultaneous translation in surtitles.[26] It is true that such a cosmopolitan stance did not match with Greek politics prevalent at the time: for the Left, it was too elitist, while at the same time it questioned the Conservatives' traditional zeal to prove that Modern Greeks were the heirs of Ancient Greek civilization—how could they watch an Attic tragedy with surtitles, on equal terms with foreigners? It also annihilated in one go the very existence and flourishing of the National Theater of Greece, which, since its founding in Athens in 1931, had presented the staging of Attic tragedies in Modern Greek as the epitome of its cultural role, and had trained dozens of actors to this end.

It is not known if Rotas remembered the young Xenakis as having been among his students, or if he and Xenakis had the chance to meet again after 1974, when the composer was allowed to enter Greece, and before Rotas's death in 1977. Rotas must have been aware of Xenakis's later career, especially since one of his sons, Nikiforos Rotas (1929–2004), also became a composer of contemporary music; Vassilis Rotas's 1965 review of Aeschylus's *Agamemnon* (directed by Alexis Minotis) and *The Persians*

δημιουργηθοῦν αὐθεντικές παραστάσεις καί ἴσως ὕστερα ἀπό 2 ἤ 3 γενεές νά ὑπάρχει τό βάθρο μιᾶς τέχνης μεγάλης στάθμης].

26 Xenakis's idea about surtitles was expressed in 1975 during his collaboration with the director Alexis Minotis on the staging of Sophocles's *Oedipus at Colonus*, which finally fell through—see Ιωακείμ [Ioakeim], 2018, p. 114. It was a pioneering proposal, when one considers that it predated its international application in the field of opera by about a decade.

(directed by Karolos Koun), both set to music by Jani Christou (1926–70)[27] shows that he might have been positive towards Xenakis's music.

Be that as it may, there is a striking essay by Rotas, "Space and Time," that was published on 15 October 1943, during the Occupation:[28] apart from the remarkable fact that a man of the theater tackled such a philosophical subject at that time, amidst dark though elevating years, and provided important insights, one cannot help but wonder whether Xenakis had read it then, and how much of it is echoed forty-five years later in his 1988 essay "On Time," where he discusses the perennial conflict between Heraclitus and Parmenides with regard to time.[29] The elective affinities of the two men remain a fascinating matter that needs to be investigated further.

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27 Ρώτας, "Κρατικά θέατρα και τα νεοελληνικά έργα" [Rotas, "National Theaters and the Modern Greek Plays"] in Ρώτας [Rotas], 1986, p. 596.

28 Ρώτας, "Χώρος και χρόνος" [Rotas, "Space and Time"] in Ρώτας [Rotas], 1986, p. 241–7.

29 Xenakis, "Sur le temps" in Xenakis, 1994, p. 94–105. The essay has also found its way into "Concerning Time, Space and Music," Chapter 10 of Xenakis, 1992.

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2. Iannis Xenakis through his Letters at the KSYME Archive

Stella Kourmpana

In memory of Haris Xanthoudakis[1]

KSYME (*Κέντρο Σύγχρονης Μουσικής Έρευνας*, or Contemporary Music Research Center) was founded in 1979 by Iannis Xenakis, along with Stefanos Vassiliades (1933–2004) and John G. Papaioannou (1915–2000), and twenty-two other members, following the example of Xenakis's CEMAMu (Centre d'Études de Mathématique et Automatique Musicales; founded in 1972 in Paris). Its main founding goal was the research and development of computer-based electroacoustic music in Greece. Today, located at the premises of the Athens Conservatoire, the KSYME is an active Music Research Center and its archives host valuable chapters of Greek music heritage, and a great part of its collections is related to its main founder.

At the archives one can find a collection of twenty-three letters by Xenakis; twenty-two are addressed to Papaioannou, written during the period Xenakis was living in France and making his first steps as a composer and as an engineer and architect, and one is a later letter addressed to the then President of the Greek Republic, Konstantinos Karamanlis (1907–98), the person who gave back to Xenakis his Greek citizenship, that had been taken away in 1947. This chapter explores the content of these letters, to provide context for the first complete translation into English of the letter from Xenakis to Karamanlis, a statement and an offer that could have marked a turning point in Xenakis's life, and which show clearly the extent of Xenakis's personal and emotional commitment to Greece, and to the political and cultural renovation of Greek life that began with the fall of the military dictatorship in 1974.

The urban planner and musicologist, Papaioannou, a valued friend of contemporary music in Greece, who offered his life to promoting the work of another prominent Greek composer and pupil of Arnold Schönberg (1874–1951), Nikos Skalkottas

1 Haris Xanthoudakis (1950–2023) was a leading Greek composer and musicologist—a pupil of Xenakis in Paris and one of his collaborators in Greece—an important figure in Greek musicology, who dedicated his life to promoting Greek art music.

 https://doi.org/10.11647/OBP.0390.04

(1904–49), had realized early on the importance of the work of Xenakis and was very willing to help him in many ways. After their acquaintance in Germany during the premiere of *Metastasis* (1953–4) in 1955, Xenakis and Papaioannou became good friends. Papaioannou was one of the key people who introduced the work of Xenakis to Greece, during the years of Xenakis's exile, mainly through the organization of the "Greek Contemporary Music Weeks"[2] but also through his articles and his lectures on contemporary music. Their regular correspondence, from 1956 until 1962, reveals the evolution of Xenakis's musical thought during the period when his own creative voice was being formed: as it became known with the emblematic work *Metastasis*, his break with Le Corbusier (1887–1965) over the authorship of the Philips Pavilion,[3] the rivalry with Pierre Boulez (1925–2016), his critique of serialism, but also his relationship with Greece and his identity as a Greek composer.

Xenakis in Greece

Born in Braïla (Romania) in 1921, Iannis Xenakis and his younger brothers, Jason and Kosmas, moved to Greece in 1927, a year after the death of their mother.[4] Their father Klearchos sent them to a boarding school on the island of Spetses. It was there that the young Iannis took his first music lessons and learned to sing (Palestrina, among other things). After that boarding school experience, Xenakis moved to Athens in order to study engineering. At the same time, he studied music with the Greek composer Aristotle Kondourov (1896–1969), a student of Mikhail Ippolitov-Ivanov (1859–1935), with whom Xenakis studied harmony, counterpoint, and orchestration. The political situation in Greece during those years—while Xenakis was studying at the Athens Polytechnic (1940–7: the German Occupation, December Days (*Dekemvriana*), and the beginning of the Civil War)—played a decisive role in his personal development and in his musical formation.[5] This difficult period, during which he developed intense resistance activity, strengthened his conviction that creation was the only "path to salvation." Thus, the Occupation demonstrations in which he participated (and, in particular, the behavior of the sound carried from the front to the back of the crowd) would later serve as a source of inspiration for the composition of *Metastasis*, his first iconic work.

His youthful years in the capital would mark him in many ways. In the Battle of Athens in December 1944, in which Xenakis participated as a member of the resistance, he was wounded in the face by a shell and lost an eye. Despite his serious injury, in 1947, having just received his diploma from the Polytechnic University, he was called

2 The "Greek Contemporary Music Weeks" was a very important initiative that promoted contemporary music in Greece during the years 1966–76, by organizing concerts, but also lectures and exhibitions.

3 See further Chapter 22 in this volume.

4 As discussed in the Introduction to this volume, the question lingers as to whether Xenakis was born in 1921 or in 1922. Yet, in Greece, his birth year was consistently celebrated as being 1921.

5 For further comment on the December Days, see Chapter 28 in this volume.

up to join the National Army. Being a member of the Communist Party, at a time when communists were being persecuted in Greece, he escaped from the army and managed, via Italy, to flee to Paris. In the meantime, he was sentenced to death in absentia by a court martial and shortly afterwards stripped of his Greek citizenship.

Paris, which was then for him a kind of continuity of the ancient Greek civilization that he so admired, proved to be a hospitable place, but he never ceased to feel like a stranger. His collaboration with Le Corbusier would pave the way to recognition in the field of architecture and his apprenticeship with Olivier Messiaen (1908–92) would convince him that he could do what he wanted in music, without restrictions. France would become his second home (he was granted French citizenship in 1965) and it would not be long before he established himself as a pioneer in the world of musical.

A Young Composer in Paris

Although still at the beginning of their acquaintance, in his first letter to Papaioannou, written in Paris on 27 November 1956, Xenakis felt the need to open up to his Greek supporter and to share his feelings and thoughts with him. Thanking Papaioannou for an article he had published in the Athenian newspaper *Nea* dedicated to Xenakis's music, the composer (who had been living in exile in Paris since 1947) felt extremely moved when realizing that there were people supporting him in his homeland, since, at the same time, "Foreigners are always ungenerous with encouraging words, when not addressing compatriots."[6] As an example, he mentioned the fact that the newspaper *Figaro* wrote about five composers who won scholarships, and published a short *curriculum vitae* only for the French one, while for the other four, there was only a mention of their names. Xenakis concluded that "the French in general are chauvinists while the Germans are much more open."[7]

Concerning contemporary music, things were not easier:

> Generally, avant-garde French composers are performed in Germany, but in France no orchestra, private or public, want to perform them. Only Boulez succeeded to present contemporary works but again, choosing composers who were strictly dodecaphonic (serial) and of his own mentality.[8]

Here one can trace the marks of Xenakis's disagreement with serial music and technique, that would very soon be expressed in his study "La crise de la musique sérielle,"[9] a text that would give serious impetus to Xenakis's own compositional language.

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6 Xenakis's letter to Papaioannou, 27 November 1956 (KSYME Archive, Xenakis's Letters) [*Καὶ οἱ ξένοι εἶναι πάντοτε φειδωλοὶ στὰ ἐνθαρρυντικὰ λόγια ὅταν δὲν πρόκειται γιὰ ὁμοεθνεῖς*].

7 Ibid. [*Γενικὰ δὲ οἱ Γάλλοι εἶναι ἐθνικιστες ἐνῶ οἱ Γερμανοὶ εἶναι πολὺ πιὸ ἐλεύθεροι*].

8 Ibid. [*Γενικὰ οἱ προοδευτικοὶ Γάλλοι συνθέτες παίζονται στὴ Γερμανία ἐνῶ στὴ Γαλλία καμμιὰ ὀρχῆστρα κρατικὴ ἢ ἰδιωτικὴ δὲν τοὺς ἀναδέχεται. Μόνο ὁ Boulez κατάφερε νὰ ἀνεβάσει σύγχρονα ἔργα καὶ πάλι διαλέγοντας τοὺς συνθέτες νὰ εἶναι στενὰ δωδεκαφθογγιστὲς καὶ τῆς ἴδιας νοοτροπίας τῆς ἰδικῆς του*].

9 See Xenakis, 1955, p. 2–4.

In a letter dated 22 July 1958, we read again about the difficulties Xenakis had to face as a foreign composer in France:

> Greeks think that life in France offers great facilities. But they forget that everyday living and competition is on another level. And for a Greek, it is a double fight: a) To understand the mentality of life here, of the social relationships and values, that are different from those there [in Greece] and b) to prepare for and surpass the best, if he has any ambition (or just pride—φιλότιμο). In Paris, either you disappear and even the stones forget about you, or you are patient, you work night and day, until your work and efforts are recognized. Triumphs for a (Greek) foreigner do not exist, especially when one seeks the avant-garde. Teaching the French with a non-stop tradition of 1.000 years, or a German?[10]

Contrary to popular belief, Xenakis (like all Greeks) faced many challenges in achieving success in France, a country with a rich musical tradition. The first ten years were particularly difficult for Xenakis. He had to work very hard and wait a long time for his work to be recognized and applauded. During this period, he was mostly occupied with engineering and architecture.[11]

Xenakis and Le Corbusier—The Philips Pavilion

It is really fascinating to follow, day by day, important historical moments through Xenakis's words, right when those events were taking place. In the first letter from 1956 cited above, Xenakis mentions his involvement with the Philips Pavilion:

> The Philips Company asked Le Corbusier to create a Pavilion for the International Exposition of 1958 in Brussels. He (Le Corbusier) assigned me the architectural study and I made a pavilion without any of his instructions, or rather, against his instructions, and he finally approved it, with no changes. It is quite original. Inside he will make an 'Electronic Poem', with colored projections with the play of light and shadows and sound. For the music he will collaborate with Varèse and myself. Varèse will create music lasting 8 minutes, and me, 2 minutes.[12] It is very interesting, and I believe that it will be impressive.[13]

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10 Xenakis's letter to Papaioannou, 2 July 1958 (KSYME Archive, Xenakis's Letters) [*Οἱ Ἕλληνες νομίζουν πὼς ἡ ζωὴ στὴ Γαλλία ἔχει μεγάλες εὐκολίες. Ξεχνοῦν ὁμως ὅτι ἡ βιοπάλη καὶ ὁ συναγωνισμὸς βρίσκονται σὲ ἄλλη στάθμη. Καὶ γιὰ ἕναν Ἕλληνα εἶναι διπλὸς ὁ ἀγῶνας: α) νὰ μπῆ στὸ νόημα τῆς ἐδῶ ζωῆς, τῶν κοινωνικῶν σχέσεων καὶ ἀξιῶν ποὺ διαφέρουν ἀπ' τὶς ἐκεῖ β) νὰ ἐφοδιασθῆ καὶ νὰ ξεπεράση τοὺς καλλίτερους ἂν ἔχει φιλοδοξία (ἢ καὶ ἁπλῶς φιλότιμο). Στὸ Παρίσι ἢ χάνεσαι καὶ σὲ ξεχνοῦν καὶ οἱ πέτρες ἢ κάνεις ὑπομονὴ δουλεύοντας νύχτα μέρα ὥσπου νὰ δικαιωθοῦν ἀργὰ οἱ κόποι σου. Θρίαμβοι γιὰ ἕνα ξένο (Ἕλληνα) δὲν ὑπάρχουν, μάλιστα ὅταν ἀξιώνεις τὴν πρωτοπορεία. Νὰ διδάξεις Γάλλους μὲ συνεχόμενη παράδοση 1000 ἐτῶν, ἢ Γεμρανό;*].

11 During the years 1947–59, Xenakis worked full-time in Le Corbusier's studio.

12 That would be the piece *Concret PH* (1958).

13 Xenakis's letter to Papaioannou, 27 November 1956 (KSYME Archive, Xenakis's Letters) [*Ἡ ἑταιρεία ΦΙΛΙΠΣ πέρασε παραγγελία τοῦ Le Corbusier γιὰ νὰ φτιάξη ἕνα περίπτερο στὴ διεθνῆ ἔκθεση 1958 τῶν Βρυξελλῶν. Μοῦ ἀνέθεσε τὴν ἀρχιτεκτονικὴ μελέτη καὶ τοῦ ἔφτιαξα ἕνα περίπτερο χωρὶς καμμία ὁδηγία του, μᾶλλον παρὰ τὶς ὁδηγίες του, καὶ τὸ ἐνέκρινε τελικὰ χωρὶς καμμία*

Note here the word "interesting," a keyword for Xenakis.[14]

The next mention of the Philips Pavilion appears in a letter dated 19 April 1958, meaning two days after the inauguration of the Brussels Exposition. After discussing *Pithoprakta* (1955–6), Xenakis refers to the Pavilion:

> I am also sending you an article the Philips Company commissioned me to write about the architecture of the Pavilion that I made for Le Corbusier. You will see how and why I gave it that form. Le C[orbusier] admits my role in that, although he doesn't mind accepting the congratulations in my place. It is a fight with him and with Philips. And when it is over, I will tell you about it. Finally, Le Corbusier accepted the official title: Architecture Philips = Le Corbusier + Y. Xenakis.[15]

And of course, that "fight" between Le Corbusier and Xenakis was to be fatal to their relationship. As Xenakis mentioned many years later, they both liked and respected each other; their fight was basically a matter of generational difference.[16] Regarding the Philips Pavilion, Xenakis was very proud because, for the first time, he had the chance to create something entirely by himself, and that "something" was totally unique. And he was proud that in it he had implemented the main idea that he had also used in his first, revolutionary musical work, *Metastasis*: the goal was to try and allow movement from one point to another without disturbing the continuity. What he did with the *glissandi* in *Metastasis*, he also applied to the Pavilion, with hyperbolic paraboloids. From the very beginning, Xenakis thought like a true *homo universalis*.

Xenakis's Early Compositions

It is very interesting to see that Xenakis felt the need to discuss with Papaioannou several issues arising from his compositions; not only about the reception of his work, but also about the composition of the works themselves. It seems Xenakis had found a good conversational partner as far as contemporary music was concerned, since Papaioannou was a great analyst of music himself. When *Pithoprakta* was first performed in Southern Germany, no one seemed to have understood what Xenakis was trying to do, and they wrote that he was like "a worm made of nickel that eats the corpse."[17]

μεταβολή. Εἶναι ἀρκετὰ πρωτότυπο. Μέσα σ' αὐτὸ θὰ κάνει ὁ ἴδιος ἕνα «ἠλεκτρονικὸ ποίημα»μὲ προβολὲς ἔγρωμες, παιγνίδια φωτὸς καὶ σκιῶν καὶ ἠχοβολίες. Στὴ μουσικὴ θὰ συνεργαστῆ μὲ τὸν Varèse καὶ μ' ἐμένα. Ὁ Varèse θὰ κάνει μουσικὴ 8 λεπτῶν κ' ἐγὼ 2 λεπτῶν. Ἔχει μεγάλο ἐνδιαφέρον καὶ νομίζω πὼς θὰ κάνει κρότο].

14 See Xenakis, 2008, p. 130 ("Beautiful or Ugly").

15 Xenakis's letter to Papaioannou, 19 April 1958 (KSYME Archive, Xenakis's Letters) [*Σοῦ ἐσωκλείω ἕνα ἄρθρο ποὺ μοῦ παράγγειλε ἡ ἑτ[αιρία] Φίλιπς πάνω στὴν ἀρχιτεκτονικὴ τοῦ περιπτέρου ποὺ ἐμελέτησα γιὰ τὸν Le Corbusier. Θὰ δῆς πῶς καὶ γιατί τοῦ ἔδωσα τέτοια μορφή. Ὁ Le C[orbusier] παραδέχεται τὸν ρόλο μου ἀλλὰ δὲν τὸν ἐνοχλεῖ νὰ δέχεται τὰ συγχαρητήρια στὴν θέση μου. Εἶναι μιὰ πάλη μαζύ του καὶ μαζὺ μὲ τὴν Φίλιπς καὶ ἂν περάση θὰ στὰ διηγηθῶ. Τελικὰ ὁ Le Corbusier δέχτηκε τὸν τίτλο Architecture Philips= Le Corbusier + Y. Xenakis ἐπίσημα κλπ*].

16 Cf. "Biography" chapter in Varga, 1996, p. 7–46.

17 Xenakis's letter to Papaioannou, 19 April 1958 (KSYME Archive, Xenakis's Letters) [*μὲ παρομοίασαν μὲ σκουλῆκι ἀπὸ χρωμονικέλιο ποὺ σπαράτει τὰ πτώματα*].

This is why he felt so relieved when he read Papaioannou's analysis of the work, and he knew that he had a great interlocutor with whom he could share his thoughts. So, in a postcard dating from, most likely, 1962, he explained to Papaioannou: "I wrote an 'application' for piano: I finally discovered a 'symbolic' music, like symbolic logic."[18] The work he was referring to was, of course, *Herma*, a piece for piano he composed between 1960 and 1962, in which he "finally" found a way to parallel mathematics and music (once again, this demonstrates his holistic thinking). George Boole's (1915–64) algebra and symbolic logic formed the basis of his new compositional idea. When asked why he chose the term "symbolic music" he answered: "because sounds are symbols, they have no other meaning."[19] Xenakis believed that music does not provoke emotion. It is rather the psychological and sociological contexts that make us react emotionally to music. Xenakis wanted to create a new sound universe that would be different from any other.[20]

But what is perhaps more interesting in Xenakis's letters about his music is the connection between music and his relationship with his homeland.

Xenakis and Greece: Nostalgia and Guilt

In a letter dated 25 February 1960, Xenakis wrote to Papaioannou to ask Manos Hatzidakis (1925–94) to bring him Byzantine music and some of Hatzidakis's own compositions.[21] At the time, Xenakis was working on the music for the film *Orient-Occident* (which would be presented eventually at the Cannes Film Festival in May 1960). This project led him to listen to Radiodiffusion Télévision Française (RTF), which was playing music from Pontos.[22] Listening to this music provoked in him a great nostalgia: "I got so nostalgic. I counted the years that I stayed in France, away from Greece."[23] And that thought made him ask himself:

> What kind of music do I make? International or French? I hope the first, since Greek I cannot, although it doesn't really matter anymore. Greek ok, but only if that could stand as a model for the whole earth (tomorrow). Fortunately, art no longer has borders. But it is good when your homeland brings the best fruits.[24]

18 Xenakis's postcard to Papaioannou, undated (KSYME Archive, Xenakis's Letters) [*Ἔγραψα γιὰ πιάνο μία ἐφαρμογή. Βρῆκα ἐπὶ τέλους μίαν «συμβολικη μουσικὴ» κατὰ τὴν συμβολικὴ λογική*].

19 Cf. "Theories-Compositions" chapter in Varga, 1996, p. 72–96.

20 As Haris Xanthoudakis, a former pupil of Xenakis and collaborator, told me in a private conversation, during the Meta-Xenakis Global Symposium, in Athens on 1 October 2022.

21 A very popular Greek composer of his time.

22 Pontos is an area in today's Turkey where Greek orthodox populations used to live until their genocide during the years 1914–23.

23 Xenakis's letter to Papaioannou, 25 February 1962 (KSYME Archive, Xenakis's Letters) [*Πόση νοσταλγία μἔπιασε. Ἀναμέτρησα ξαφνικὰ τὰ χρόνια ποὺ ἔμεινα στὴ Γαλλία ἔξω ἀπ' τὴν Ἑλλάδα*].

24 Ibid. [*Τί μουσικὴ κάνω; Διεθνιστικὴ ἢ Γαλλική; Εὔχομαι τὴ πρώτη ἀφοῦ Ἑλληνικὴ δὲν μπορῶ, ἂν καὶ δὲν ἔχει πιὰ καὶ τόση σημασία σήμερα. Ἑλληνικὴ σύμφωνοι, ἀλλὰ μόνο μὲ τὴν προϋπόθεση νἆναι «δεῖγμα» σ' ὅλη τὴ γῆ (αὔριο). Ἡ τέχνη εὐτυχῶς πιὰ σήμερα δὲν ἔχει σύνορα. Ἀλλὰ καλὸ*

In 1972, Xenakis founded the CEMAMu in Paris, a research center aimed at promoting contemporary and, above all, electronic music, as well as its research, and the renewal of music education, and in 1974 he would become a professor at the Sorbonne. However, for years Xenakis was tormented by guilt for having left the country he had fought for. He felt a debt to the friends he had left behind by escaping abroad, and he felt he had to do something to repay it. "I felt I had a mission. I had to do something important to regain my right to live."[25]

But what could he do for his country that had driven him so far away? In the autumn of 1974, with the fall of the dictatorship and the restoration of democracy, thanks to the intervention of the President of the Republic, Karamanlis, Xenakis was acquitted of the charge of high treason that condemned him to death, and he regained his citizenship. He could now return home after twenty-seven years of "difficult exile," as he wrote (see below).[26] It was the moment to fulfill the debt he felt he owed. In Greece, he had some friends waiting for him who had supported him during his period of exile. One of them was Papaioannou, the person who had dedicated his life to the promotion of contemporary music in Greece, and who had made sure that Xenakis's work was known to his homeland while he was in France. Despite the challenging political situation in Greece, especially during the period of the Seven Year Dictatorship (1967–74), the musical life of the country showed impressive activity, especially in the field of avant-garde music (largely thanks to Papaioannou's activity). At the same time, the echoes of Xenakis's work in France had reached his homeland, so when he returned to Greece, with the experience of so many years and the desire to do something important for his country, he was accepted almost as a hero.

In April 1975, a group of Greek students invited Xenakis to speak about philosophy. He responded enthusiastically and gave a four-hour lecture in front of an audience that had flooded the Law School building and the surrounding streets, where loudspeakers had been installed. Xenakis was back in his homeland, and speaking on his favorite subject, ancient Greek philosophy, which was for him not only a world of inspiration but also of creation. He often said that in his youth he believed he had been born twenty-five centuries too late. He read Plato (ca. 427–348 BCE) in the original, and believed that Greekness was harmony, proportion, and light. He lived with one foot in ancient Greece and the other in modern Greece. These two moments in time were to merge in September 1978 at the *Polytope de Mycènes*. Polytope means "a mixture of many places," with the term place being taken in the general, abstract sense, as the creator himself explained, and it was an event that included music, speech, and lighting.[27] Xenakis had already presented the *Polytope de Montréal* (1967) and the *Polytope de Cluny* (1972),

εἶναι ὁ τόπος σου νὰ τρέφει τοὺς καλλίτερους καρπούς].

25 "Interludium (Confession)" chapter in Varga, 1996, p. 56.

26 Xenakis's letter to Karamanlis, 24 June 1980 (KSYME Archive, Xenakis's Letters).

27 Cf. Pierre Carré "Polytope," in Dimitris Exarchos (ed.), "A Xenakis Dictionary" (2023), *Les Amis de Xenakis*, https://www.iannis-xenakis.org/en/polytope/

and more would follow, but the one in Mycenae had something unique. Mycenae was a place of particular cultural significance both for humanity and for Xenakis himself. A Polytope at the archaeological site of Mycenae aimed at a connection between the ancient era and the modern one. The composer wanted to recall how many "peaks" there are in Greek culture, as he used to say, and, on the occasion of the presentation of the *Polytope*, to give an opportunity to create a new, modern, "peak" in the same place.

In this complex extravaganza, for which a very large number of individuals and institutions (even the Greek army) collaborated, Xenakis had as constant companions both Papaioannou and the composer Stefanos Vassiliadis, who, together with Xenakis and twenty-two other founding members, would sign, shortly after the presentation of the *Polytope*, the Statutes of KSYME. If the *Polytope de Mycènes* had been a new "peak" for Greek culture, the establishment of a center for contemporary music research would have been the springboard for the continued creation of important cultural events in Greece. Xenakis's vision was to create an institution along the lines of CEMAMu, which would promote research and music composition, with a special emphasis on technology, but also to familiarize young children and teenagers with the sounds that modern technological means can create. The basic tool of CEMAMu was a computer system for sound creation and musical composition based on the graphical representation of the sound signal, which had been first presented in Bonn in 1977 with great success and was called UPIC (Unité Polyagogique Informatique CEMAMu). Xenakis wanted to bring and disseminate a UPIC (Greek: *Polyagogia*) in Greece.[28]

But the creation of an institution does not automatically imply its operation. It needs the support—mainly financial—of the state. Thus, Xenakis decided to write a letter to the President of the Republic, Karamanlis, who had allowed his longed-for return to Greece. This letter, written in 1980, describes the vision of the operation of this new institution and, through it, the fulfillment of the debt that Xenakis would offer his country. He wanted to shift the center of gravity of his artistic and teaching activity from France (where he was a professor at the Sorbonne) to Greece, and to make the KSYME a model center among the "most advanced in the world" for "the learning of music, the synthesis and the promotion of the latest ideas and methods based on mathematics, physics, acoustics, the history of music and the latest computer technology."[29] Xenakis's role in this would be merely coordinating, with no other consideration, as he emphasized, than the pleasure of contributing to his art and his place. In other words, Xenakis, at the peak of his artistic career, longed to offer all his

28 Cf. Agostino Di Scipio, "UPIC," in Dimitris Exarchos (ed.), "A Xenakis Dictionary" (2023), *Les Amis de Xenakis*, https://www.iannis-xenakis.org/en/dictionary-upic/

29 Xenakis's letter to Karamanlis, 24 June 1980 (KSYME Archive, Xenakis's Letters) [*Αὐτὸ τὸ κέντρο θὰ προίκιζε τὴν Ἑλλάδα μὲ ἕνα μέσο πρωτότυπο, πρότυπο καὶ ἀπὸ τὰ πιὸ προχωρημένα στὸν κόσμο, γιὰ τὴν ἐκμάθηση τῆς μουσικῆς, τὴν σύνθεση καὶ τὴν προαγωγὴ τῶν τελευταίων ἰδεῶν καὶ μεθόδων ποὺ στηρίζονται στὰ μαθηματικά, τὴ φυσική, τὴν ἀκουστική, τὴν ἱστορία τῆς μουσικῆς καὶ στὴν τελευταία τεχνολογία τῶν ἠλεκτρονικῶν ὑπολογιστῶν*].

strength for the "new reconstruction of culture" in his own place:

> Dear Mr. President,
>
> Six years ago you issued a special decree that gave me back my Greek citizenship and deleted the condemnation of my youth. As a result, thanks to you, I could finally return to Greece for the first time after 27 years of hard exile, even if I spent them along with the friendly and beautiful nation of French, who honored me with the French citizenship in 1965. I owe you great favor for that.
>
> My joy was great and I was ready to help with all my strength to the new rebuilding of the culture of my homeland [...] and I was thinking that I could, if not completely, at least, partly move the base of my cultural and educational activity (I am a professor at the Sorbonne) to Greece, so that the young people and my homeland can take advantage of the quality and the experience of my whole intensive cultural activity abroad. This is why I proposed the foundation of a Center of Scientific Research on Music in Greece, following the example of the Center that I created in Paris with main financial support by the ministry of Culture in France and according to the official will of the President at the time, Georges Pompidou.
>
> This Center would offer Greece an original and a model platform, and one of the most advanced in the world, for learning music, for composing, and promoting the most recent methods, based in mathematics, physics, acoustics, the history of Music, as well as the cutting-edge technology of computers. The Center that I created in France is the fruit of the most advanced cultural-scientific concepts in music. My role would be, as in the French center, simply guiding—scientifically and artistically—without any other reward, only having the joy to help to my art and my country.[30]

30 Xenakis's letter to Karamanlis, 24 June 1980 (KSYME Archive, Xenakis's Letters) [*Κύριε Πρόεδρε,*

Πρὶν ἔξη χρόνια βγάλατε εἰδικὸ διάταγμα ποὺ μοῦ ἔδιδε πίσω τὴν ἑλληνικὴ ἰθαγένεια καὶ ἔσβυνε τὶς καταδίκες τῶν νεανικῶν μου χρόνων. Ἔτσι, χάρη σὲ σᾶς, μπόρεσα νὰ ἐπιστρέψω στὴν Ἑλλάδα, πρώτη φορὰ ὕστερα ἀπὸ 27 ἐτῶν δύσκολης ἐξορίας, ἔστω καὶ ἂν τὰ πέρασα στὸ φιλικὸ καὶ ὡραῖο ἔθνος τῶν Γάλλων, ποὺ μὲ τίμησαν τὸ 1965 μὲ τὴν Γαλλικὴ ἰθαγένεια. Σᾶς χρεωστῶ χάρη μεγάλη γι' αὐτό.

Ἡ χαρά μου ἦτο πολλὴ καὶ ἤμουν ἕτοιμος νὰ συμβάλλω μὲ τὶς δυνάμεις μου στὴν νέα ἀνοικοδόμηση τοῦ πολιτισμοῦ τοῦ τόπου μου κάτω ἀπ' τὴν σοφὴ καὶ ἀναίμακτη ὁδήγησή σας. Σκεφτόμουν, ἂν ὄχι ἐντελῶς, τουλάχιστο μερικῶς, νὰ μετατοπίσω τὸ κέντρο βάρους τῆς καλλιτεχνικῆς καὶ διδακτικῆς μου (εἶμαι καθηγητὴς στὴ Σορβόννη) δραστηριότητος στὴν Ἑλλάδα, ὥστε ἡ νεολαία καὶ ὁ τόπος νὰ ἐπωφεληθοῦν ἀπ' τὴν ποιότητα καὶ τὴν πεῖρα ὁλόκληρης τῆς ἐντατικῆς καλλιτεχνικῆς ἐπίδοσής μου στὸ ἐξωτερικό. Γι' αὐτὸ καὶ πρότεινα νὰ ἱδρυθῆ στὴν Ἀθήνα ἕνα κέντρο ἐπιστημονικῆς ἐρεύνης τῆς μουσικῆς κατὰ τὸ πρότυπο τοῦ κέντρου ποὺ ἵδρυσα στὸ Παρίσι μὲ κύρια οἰκονομικὴ ἀρωγὴ τοῦ ὑπουργείου πολιτισμοῦ τῆς Γαλλίας καὶ σύμφωνα μὲ τὴν ἐπίσημη θέληση τοῦ τότε προέδρου Ζὼρζ Πομπιδοῦ.

Αὐτὸ τὸ κέντρο θὰ προίκιζε τὴν Ἑλλάδα μὲ ἕνα μέσο πρωτότυπο, πρότυπο καὶ ἀπὸ τὰ πιὸ προχωρημένα στὸν κόσμο, γιὰ τὴν ἐκμάθηση τῆς μουσικῆς, τὴν σύνθεση καὶ τὴν προαγωγὴ τῶν τελευταίων ἰδεῶν καὶ μεθόδων ποὺ στηρίζονται στὰ μαθηματικά, τὴ φυσική, τὴν ἀκουστική, τὴν ἱστορία τῆς μουσικῆς καὶ στὴν τελευταία τεχνολογία τῶν ἠλεκτρονικῶν ὑπολογιστῶν. Αὐτὸ τὸ κέντρο, ὅπως καὶ αὐτὸ ποὺ ἵδρυσα στὴ Γαλλία, εἶναι τὸ ἄνθος τῆς πιὸ προχωρημένης καλλιτεχνικοεπιστημονικῆς σκέψης στὴ μουσική.

Ὁ ρόλος μου θὰ ἦτο, ὅπως καὶ στὸ Γαλλικὸ κέντρο, ἐντελῶς καθοδηγητικός, ἐπιστημονικὰ καὶ καλλιτεχνικά, χωρὶς ἄλλη καμμία ἀμοιβή, πλὴν τῆς χαρᾶς νὰ συμβάλλω στὴν τέχνη μου καὶ στὸν τόπο αὐτό. Θεώρησα δέ, ὅτι ὑπῆρξε εὐτυχὴς συγκυρία ἡ παρουσία σας στὴ θέση ἐκείνου ποὺ ἀποφασίζει, γνωρίζοντας ὅτι ἐκτιμᾶτε ὅπως ἀξίζει τὶς ἀνιδιοτελεῖς προσφορές.

Οὔτε ξεχνῶ βέβαια τὴν τιμὴ ποὺ μοῦ κάνατε, ἐρχόμενος στὶς Μυκῆνες καὶ μάλιστα ὅταν ἐκφράσατε δημοσία τὴν εἰλικρινῆ καὶ λίαν ἐνδιαφέρουσα κρίση σας, ποὺ ἀντάμειψε πλήρως

However, despite this selfless contribution of the "greatest contemporary musician in the world" and the "greatest artist of modern Greece," as the Athenian newspapers described him at the time, [31] the Greek state did not respond to Xenakis's invitation and the operation of KSYME was not possible before 1986. The inauguration of the association took place with the presentation of UPIC, the technical installation and maintenance of which was carried out by a professor at the Polytechnic University, Andreas Stafylopatis, while the use of this new means of musical creation was taught by Haris Xanthoudakis and Dimitris Kamarotos, who were the first Greek composers, after Xenakis, to produce works with this system. The delayed start of the KSYME and the limited interest of the state in the vision of this Greek composer did not allow, in the end, the shift of Xenakis's center of gravity and the dedication of all his energies to Greece. The KSYME continued its operation, albeit it without the inspirational guidance of its visionary founder. Despite this, Xenakis never abandoned it. He had fulfilled his debt to his country, yet he never ceased to feel like a stranger everywhere.

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τοὺς κόπους τῶν συνεργατῶν μου καὶ τοὺς ἰδικούς μου.

Σήμερα ἔρχομαι, ἴσως γιὰ τελευταία φορά, νὰ σᾶς παρακαλέσω νὰ δώσετε τὴν ὁριστικὴ ὥθηση πρὸς τὸ ὑπουργεῖο συντονισμοῦ (ἁρμόδιος ὁ κος Σουφλιᾶς) καὶ στὸ ὑπουργεῖο πολιτισμοῦ, ὥστε τὸ κέντρο ποὺ σᾶς προτείνω, νὰ ἐνταχθῆ τώρα, χωρὶς καθυστέρηση, στὸ «Πνευματικὸ Κέντρο», ἀνεξάρτητα ἀπ' τὴν ἵδρυση τῆς Μουσικῆς Ἀκαδημίας, πού, ὅταν γίνη, εὔκολο θἆναι νὰ ἐνσωματωθῆ. Τοῦτο, διότι τὸ κέντρο αὐτὸ μπορεῖ ναρχίση νὰ λειτουργεῖ ἀμέσως, χωρὶς χρονοτριβὴ (θὰ ἦτο ἴσως καὶ μιὰ εὐκαιρία ἀπαρχῆς ἐγκαταστάσεώς μου στὴν Ἑλλάδα). Ὁ κ. Κανδύλης, μὲ τὸν ὁποῖο μίλησα, εἶναι πρόθυμος νὰ σᾶς ἐνημερώση σ'αὐτὸ τὸ ζήτημα, καὶ φυσικὰ κι' ἐγώ.

Ἐλπίζοντας ὅτι αὐτή μου ἡ ἐπιστολὴ θὰ εὕρη τὴν εὐνοϊκή σας ὑποστήριξη, σᾶς παρακαλῶ νὰ δεχθῆτε τὴν ἔκφραση τοῦ βαθυτάτου σεβασμού μου].

31 Clippings at the KSYME Archive.

XENAKIS WITHOUT BORDERS

Plate 4 Iannis Xenakis en route to his 65th Birthday Concert by the BBC Scottish Symphony Orchestra, Glasgow, May 1987. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

3. Iannis Xenakis in Berlin

Marko Slavíček[1]

Early Berlin-related Engagements

Iannis Xenakis's first documented experience with Berlin was of an architectural nature and took place in the late 1950s. In this period, Xenakis worked as an engineer at the studio of a notorious modernist architect, Le Corbusier (1887–1965), in Paris. He was engaged in various tasks, both as an engineer and as an architect, which included the development of *Unité d'habitation* (housing) projects.[2] The first realized projects of the series were in Paris and Marseille[3] in the 1940s and early 1950s, while others followed in Nantes (1955), Berlin[4] (1957), Briey (1963), and Firminy (1965). Although the construction of the Berlin project took place while Xenakis still worked at the studio,[5] no indications of his possible participation have (yet) been identified.[6]

In March 1957, the West Berlin Senate initiated a prestigious international town planning competition to rehabilitate the central urban areas. Berlin was heavily damaged during the Second World War, and several internationally renowned architects participated in the competition.[7] Together with two colleagues from Le Corbusier's office, André Maisonnier (1923–2016) and Augusto Tobito Acevedo (1921–2012), Xenakis created detailed plans for the competition in January 1958. As the entries had to be anonymous, it is difficult to determine precisely which portions of the work were overseen by each draftsman. However, notes in Xenakis's handwriting

1 I would like to thank Mâkhi Xenakis, Folkmar Hein, German Academic Exchange Service (DAAD), and the Berlin Academy of Arts (AdK) for their kind help in providing me with archival material.

2 This was an influential high-density residential building design with an aim to serve the purpose of a self-sufficient smaller-scale city.

3 One of the most successful of Le Corbusier's realizations, *La Cité Radieuse* (The Radiant City), was designed in Brutalist architectural style.

4 This project was located in the Westend district, near the Olympic stadium. Today it is known as Corbusierhaus.

5 Le Corbusier terminated Xenakis's employment on September 1, 1959. Xenakis had worked at his studio since December 1947 (Turner, 2014, p. xvii).

6 Sterken, 2004, p. 295 and Xenakis, 2008, p. 308. Matossian ([1981] 2022) mentions Xenakis being involved in partial solutions to the project (p. 163).

7 For example: Alvar Aalto (1898–1976), Walter Gropius (1883–1969), and Oscar Niemeyer (1907–2012).

 https://doi.org/10.11647/OBP.0390.05

on two drawings serve to help us in identifying his contribution. The submission of Le Corbusier's studio was ultimately eliminated on the grounds that the planned buildings were too high.[8]

In the same period, Xenakis was not only occupied as an engineer but was also struggling to make a breakthrough as a young composer. Among the most influential persons in his musical development was a Berlin-born conductor, Hermann Scherchen (1891–1966), who was known to actively promote music of contemporary composers. Xenakis met Scherchen in Paris after a rehearsal of Edgard Varèse's (1883–1965) *Déserts* (1954) and also visited him in his hotel room the next morning presenting the score of his first mature orchestral work, *Metastasis* (1953–4). Although Scherchen expressed interest in conducting the piece, it was in the end premiered by an Austrian conductor, Hans Rosbaud (1895–1962) in Donaueschingen. Scherchen did, however, conduct Xenakis's future works, such as *Pithoprakta* (1955–6) in 1957, *Achorripsis* (1956–7) [9] in 1958, and *Terretektorh* (1965–6) in 1966. The two remained close until Scherchen's death in 1966.[10]

Scherchen's influence on Xenakis was not simply of a practical nature—in terms of mentoring and promoting his music—but also of a theoretical nature. The conductor organized annual conferences at his home in Gravesano, Switzerland, where he invited international experts to discuss contemporary music, electronic music, and audio and sound engineering.[11] In addition, from 1955 to 1966, Scherchen published a series of reviews titled *Gravesaner Blätter* (Gravesano Review), which covered the conferences' activities. He also invited Xenakis to participate at the conferences, thus encouraging him to formulate and articulate his ideas in writing.[12] In Gravesano, Xenakis had an opportunity to meet important figures in the sphere of the theory of information and its adaptation to the realm of aesthetics and music, such as Werner Meyer-Eppler (1913–60) and Abraham Moles (1920–92).[13] In the ninth issue of the Review, in 1957, even Le Corbusier contributed with a text on his Modulor system.[14] Throughout the period of eleven years, Xenakis wrote twelve texts for the Review. Many of these writings were later used in his first book *Musiques formelles* (Formalized Music), first published in October 1963.[15] Xenakis's texts include: "The Crisis of Serial Music" (No. 1, 1955), "Probability Theory and Music" (No. 6, 1956), "Le Corbusier's 'Electronic Poem'" (No. 9, 1957), "In Search of a Stochastic Music" (Nos. 11–12, 1958),

8 Official website of the Le Corbusier Foundation: https://www.fondationlecorbusier.fr/oeuvre-architecture/projets-urbanisme-berlin-allemagne-1958/

9 This composition, scored for an ensemble of 21 musicians, was published by Berlin-based publishing house Bote & Bock. It was the first published score by Xenakis (Turner, 2014, p. 26).

10 Xenakis [1963] 1992, p. 15, 24, 260; Varga, 1996, p. 33–40.

11 Di Scipio, 2015, p. 289.

12 Varga, 1996, p. 36.

13 Harley, 2004, p. 11.

14 This is an anthropometric system of proportions based on the golden mean. The graphic representation of Modulor appeared on the cover of this ninth edition for the first time and remained unchanged until the final twenty-ninth edition in 1966. Prior to that, the Review used a neutral cover design, deprived of any illustrations.

15 Turner, 2014, p. xviii; Di Scipio, 2015, p. 289. Xenakis also expressed his gratitude to Scherchen in the preface to the book, written in 1962 (Xenakis, [1963] 1992, p. x).

"Elements of Stochastic Music" (No. 18, 1960), "Elements of Stochastic Music (II)" (Nos. 19–20, 1960), "Elements of Stochastic Music (III)" (No. 21, 1961), "Elements of Stochastic Music (IV)" (No. 22, 1961), "Stochastic Music" (No. 23–4, 1962), "Free Stochastic Music from the Computer" (No. 26, 1965), "Concerning Le Corbusier" (Nos. 27–8, 1966), and "Towards a Philosophy of Music" (No. 29, 1966).[16]

Scherchen wanted to establish an international music center in Gravesano and had plans to build a studio there. To motivate Xenakis to pursue architecture alongside his musical endeavors, Scherchen asked him to design the auditorium. Although Xenakis began work on the project, it was abandoned after the conductor's death (Figs. 3.1–2).[17] It also appears that the two men considered compiling Xenakis's Gravesano writings and publishing them under the title *Mécanisme d'une musique* (Mechanism of Music). Xenakis enthusiastically wrote a prologue for the text, but the edition was never published.[18] In September 2017, the archives of the Berlin Academy of Arts (Akademie der Künste, or AdK) digitized all twenty-nine volumes of *Gravesaner Blätter* and made them accessible online.[19]

Alongside his music activities, Scherchen also showed interest in sound reproduction. As stereophony was not yet popular during this period, he wanted to improve music transmission and give it the sort of spatial sound effect one would otherwise experience in a concert hall. To simulate sound reflection from various locations, the conductor experimented with a spectrophone[20]—a rotating device that aimed to provide an immediate surround sound. Scherchen's innovation was to rotate the device simultaneously around the vertical and horizontal axes, an idea which he patented. The patent consisted of a tripod with a diameter of 1.5 meters with a central spherical part hosting thirty-two loudspeakers.[21] Due to the periodically varying positions of the system, one could experience a subjective sound localization and a Doppler effect. If lights were to be placed on the sphere, the rotating system would create a corresponding visual effect of Lissajous curves.

16 Apart from the first text ("The Crisis of Serial Music"), which was published in French as "La crise de la musique serielle" and the second text ("Probability Theory and Music"), which was published in German as "Wahrscheinlichtkeitstheorie und Musik," all the other texts were published in both German and English.

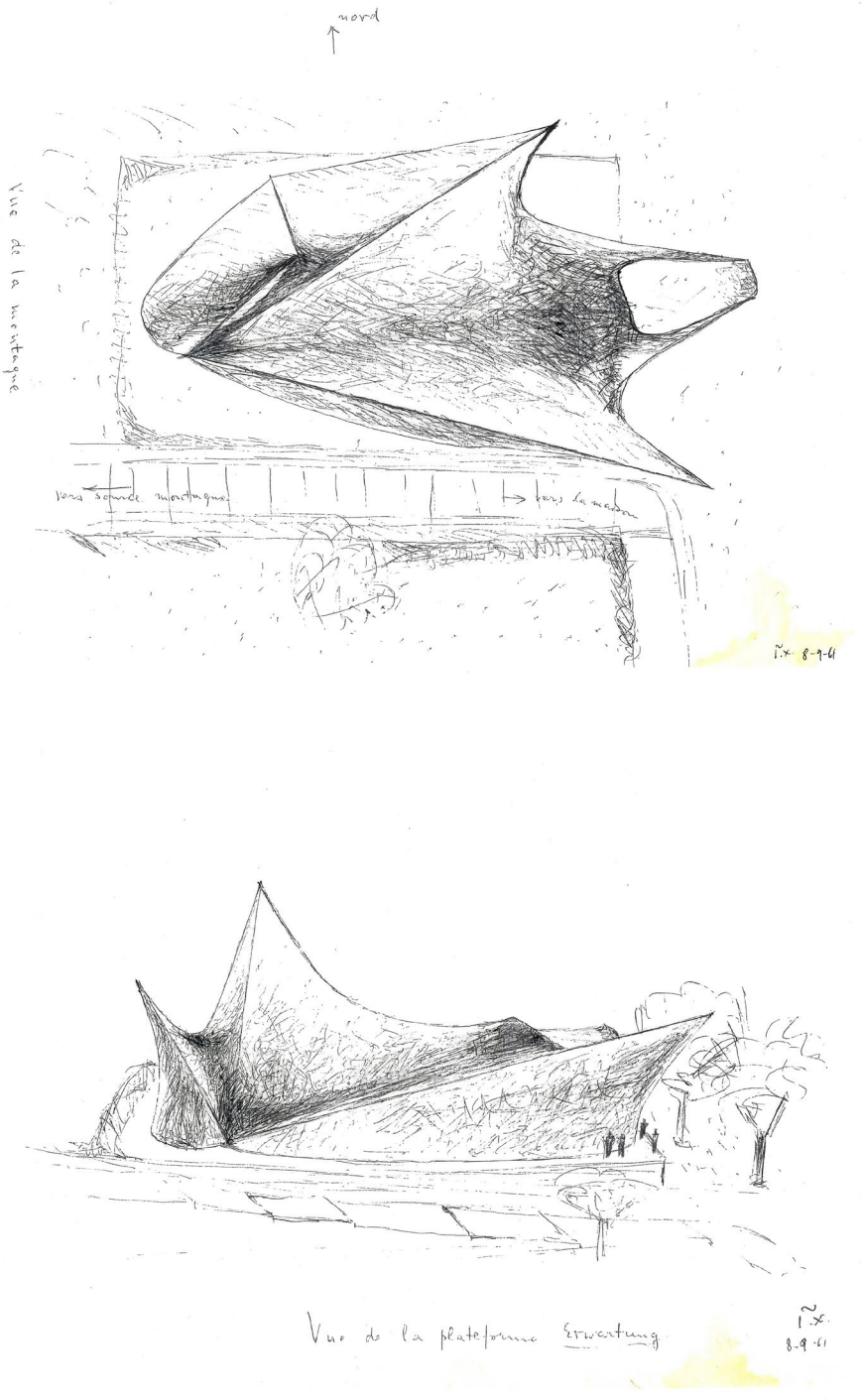
17 Varga, 1996, p. 36; Sterken, 2004, 349f. Under a working title *SCHR 100*, Xenakis sketched out the draft in the summer of 1961. He planned to further explore the hyperbolic paraboloid shapes with which he had previously worked along with Le Corbusier on the Philips Pavilion for the Brussels World's Fair in 1958. The project was most probably abandoned due to the lack of funds. The Berlin Academy of Arts archives contain three of Xenakis's sketches for the auditorium under the shelf-mark Scherchen 1442. The sketches, representing the top and perspective views of a typical Xenakian hyperbolic paraboloid structure, are dated September 8, 1961 (Figs. 3.1–2).

18 Kanach, 2003, p. 155.

19 *Akademie der Künste*, https://archiv.adk.de/bigobjekt/44596

20 This is not to be confused with a spectrophone–an instrument used in spectral analysis as an adjunct to the spectroscope.

21 The disposition of loudspeakers on a sphere follows the disposition of faces of an Archimedean solid truncated icosahedron. A prototype is well documented by Cathy van Eck at "An Active Loudspeaker by Hermann Scherchen," *Between Air and Electricity*, http://microphonesandloudspeakers.com/2017/03/10/active-loudspeaker-hermann-scherchen/



Figs. 3.1–2 Two of Xenakis's sketches for the Hermann's Scherchen's Auditorium in Gravesano, Switzerland: top view and perspective. © By kind permission of Archiv der Akademie der Künste Berlin.

In 1963, together with German scenographer Hans-Ulrich Schmückle (1916–93), Scherchen created the sound film recording *Achorripsis*, named after the eponymous piece by Xenakis that Scherchen premiered in 1958 in Buenos Aires. The five-minute film–the duration of which corresponds to that of the composition–was an experimental sound-and-light study of Scherchen's new sound system. Despite all efforts and hopes for future development, the innovation did not achieve commercial success. However, the film was later restored and presented in Berlin in 2011 (Färber 2021).[22]

The Berlin Residency (1963–4)

In the late 1950s and early 1960s, Xenakis began to be recognized as a composer. In 1957, a Russian-born American composer Nicolas Nabokov (1903–78) serving as a Secretary-General of the Congress for Cultural Freedom (CCF), supported the young Xenakis by encouraging the European Foundation for Culture to give an award to his piece *Metastasis*.[23] In April 1961, he invited Xenakis to attend the Tokyo East-West Music Encounter. And Nabokov was not the only supporter. Hans Heinz Stuckenschmidt (1901–88), a German composer and musicologist who worked at the influential Berlin newspaper *Der Tagesspiegel* and later as a professor at the Music Department of the Technical University of Berlin, invited Xenakis to Germany to give a lecture on his music. It was to be part of the series of lectures and broadcasts organized by Stuckenschmidt in 1962 and 1963, with many famous names contributing.[24] The events were transmitted live by Sender Freies Berlin (SFB) broadcasting company. Xenakis's lecture, with the title "Formalization and Axiomatization of Musical Compositions," took place on February 18, 1962, at the Berlin Congress Hall in the Tiergarten district.[25] Xenakis touched on many topics which he had already discussed in Gravesano, such as the formalization of stochastic music as an alternative to serialism. He also presented several of his musical compositions as examples of his theories, primarily *Metastasis* and *Pithoprakta*, but discussed his architectural experience as well. Between February 19 and 27, 1963, a number of reviews of Xenakis's lecture were published, namely by *Der Abend, Der Kurier, Berliner Morgenpost, Der Tag, Der Tagesspiegel, Telegraf, Die Welt, Berliner Zeitung*, and *Westfalen-Blatt*.[26] Only two weeks after the lecture at the Congress Hall, Xenakis would be invited to the city again. This time it was to take part in the Ford Foundation's[27] artist-in-residence program. Before this would take place, Xenakis

22 Färber, 2021, p. 130–3. The screening of the film was missing a long-lost soundtrack. The version with the soundtrack would be shown four years later at the festival Kontakte '15 in Berlin.

23 For the historical background of the Western efforts to support artistic movements in Europe to combat the political influence of the Soviet Union, see Saunders, [1999] 2013.

24 For example: Boris Blacher (1903–75), John Cage (1912–92), Hans Werner Henze (1926–2012), György Ligeti (1923–2006), and Luigi Nono (1924–90) (Scheubel, 2012, p. 13f).

25 Today Haus der Kulturen der Welt (House of the World's Cultures).

26 The reviews are reprinted in Scheubel, 2012, p. 200–9, together with two letters by Xenakis, addressed to Stuckenschmidt.

27 This American private foundation was founded in 1936 by industrialists Edsel and Henry Ford (see www.fordfoundation.org).

would spend a summer teaching at the Tanglewood Music Center in Massachusetts, following an invitation by renowned American composer Aaron Copland (1900–90). In September 1963, after the Tanglewood summer course and some time spent in New York, Xenakis moved to Berlin.[28] In a letter to Scherchen dated 2 October 1963, Xenakis writes that he arrived in the city three days ago.[29]

After many years engaged as an engineer, Xenakis finally had an opportunity to be financially secure working exclusively on his music. The program in question, partially funded by the Ford Foundation and partially funded by the West Berlin Senate, aimed to be given to artists of international status with the hope that they would work and reside in a post-war, isolated enclave.[30] A French historian, Indologist, and musicologist, Alain Daniélou (1907–94), participated in the same program.[31] A German-American pianist and radio presenter, Karl Haas (1913–2005), was included in the program organization and stood at Xenakis's disposal.[32] Between 13 August and 4 September 1964, during the New York City Ballet's performance at the Berlin Festival Weeks, Xenakis may have also met the influential Georgian-American ballet choreographer George Balanchine (1904–83) for the first time. Balanchine would later choreograph Xenakis's *Metastasis* and *Pithoprakta* in New York, in 1968.[33] Among composers whom Xenakis had an opportunity to meet in Berlin were John Cage[34] (1912–92) and Joel Chadabe (1938–2021). The latter remained a close friend of Xenakis and was a promoter of his music, publishing the first CD of his electronic works.[35] Despite the ideal working conditions, Xenakis lived in Berlin in extreme isolation and did not enjoy his stay. He invited his wife Françoise to join him, along with their daughter Mâkhi, to help him endure the time.[36] The family was accommodated in a large house in the Grunewald district of West Berlin (Fig. 3.3).[37] The daughter attended the French

28 Xenakis, [1963] 1992, p. 371, Varga, 1996, p. 44, Harley, 2004, p. 31, and Turner, 2014, p. xvii.

29 The Berlin Academy of Arts archives, shelf-mark Scherchen 963. The folder contains twenty-one letters and one telegram of correspondence between Scherchen and Xenakis.

30 Vagopoulou, 2007, p. 16. The program began in 1963, and throughout the following decades, the organizers invited many famous composers, among whom were Igor Stravinsky (1882–1971), Krzysztof Penderecki (1933–2020), György Ligeti, Morton Feldman (1926–87), John Cage, Arvo Pärt (b. 1935), Luigi Nono, La Monte Young (b. 1935), and Olga Neuwirth (b. 1968). It is currently called Berliner Künstlerprogramm des DAAD (The DAAD Artists-in-Berlin Program) (www.berliner-kuenstlerprogramm.de).

31 In 1967, Daniélou published Xenakis's essay "ad libitum" in his journal *World of Music*, and Xenakis cited Daniélou's *North Indian Music* in his *Formalized Music* chapter "Towards a Metamusic" (Turner, 2012, p. 103).

32 A letter from Moritz von Bomhard—the Consultant to the Ford Foundation—to Xenakis, dated 29 August 1963 (DAAD archives, Xenakis folder, p. 20).

33 Turner, 2014, p. xix.

34 In conversation with Xenakis scholar James Harley (29 June 2022). The existing photograph of the two composers together was likely taken in 1964 but this is not certain. It can be seen at the following link: www.adk.de/de/projekte/2011/cage/programm2011.htm

35 Official website of the Meta-Xenakis Global Symposium 2022: https://meta-xenakis.org. See also Chapter 45 in this volume.

36 Solomos, 1996, p. 31; Varga, 1996, p. 44; Vagopoulou, 2007, p. 16.

37 In conversation with Mâkhi Xenakis (1 June 2021). The address Winkler Str. 4, West Berlin 33—DE (today Winkler Str. 4a, 14193 Berlin) was found on the letter by Scherchen to Xenakis (The Berlin

school for a year. Xenakis described the new environment in a letter to Françoise, dated 2 October 1963:

> I am writing to you in my presidential armchair in this miniature Marienbad. Three times the area of our flat, eight rooms, ceiling four meters high, large windows with a view over the lake, bathroom, cupboards everywhere. But what am I to do in this colossal place all by myself? A kind of glass-casement overhangs the park and the lake below this facade is to the south. It is scandalous. No telephone, but soon no doubt. It is very peaceful, and the silence is deafening. When I walk through the rooms at night, I feel phantasmal shadows brushing lightly, ghostlike.[38]

Françoise, too, expressed a similar sentiment of isolation in an interview from January 1981:

> The local people resented the artists being coddled in their midst. "Why don't you take your money and spend it elsewhere?", they said. If one spoke French, it was impossible to get a seat on the bus. I preferred not to meet the Berliners as they walked through the Grunewald at night with their huge Alsatians off the lead. I once narrowly escaped being devoured by one. I was wearing a white sheepskin coat, and it was exactly that, a wolfhound trained to catch sheep. In short, none of the past was forgotten, either by them or by myself. We stayed at home and worked a lot. I wrote *Des dimanches et des dimanches*. Occasionally we met other foreign artists but with the city there was little real contact.[39]

Fig. 3.3 The house in Grunewald district of Berlin where Xenakis family was accommodated. © Photo by Marko Slavíček, 21 January 2023.

Academy of Arts archives, shelf-mark Scherchen 963), dated 8 October 1963. The house has since been reconstructed, with additions built on its sides and in the back garden (Fig. 3.3).

38 Matossian, [1985] 2022, p. 324–6.

39 Ibid.

Since 1965, the artist-in-residence program has been run by DAAD (Deutscher Akademischer Austauschdienst) [German Academic Exchange Service], the largest German academic support organization. In 2020, the DAAD digitized archive materials from the period 1963–78.[40] The Xenakis folder contains seventy-six scanned pages of personal correspondences and related materials dating from 1962 to 2011. The folder includes twenty-one scanned letters in total. Ten letters from March to August 1963 constitute the correspondence between Xenakis and Moritz von Bomhard (1908–66), Consultant of the Ford Foundation. Within the correspondence, two additional letters are enclosed: one from Xenakis to Igor B. Maslowski (1914–99) of the Philips company, dated 11 December 1962, and one from Xenakis to Prof. Dr. Ing. Fritz Winckel (1907–2000) of the Technical University of Berlin, dated 22 May 1963. Eight letters from October 1964 and November 1965 between Xenakis and Peter Nestler (1929–2022), the Head of the DAAD Artists-in-Berlin Program, are also available. An additional enclosed letter was sent by Xenakis to Dr. Wolfgang Gert Stresemann (1904–98), Intendant of the Berlin Philharmonic, on 3 July 1965.[41]

The official invitation to Xenakis was sent by von Bomhard on 3 March 1963. In the letter, we find that Nabokov was a mediator in this arrangement and that Mr. Shepard Stone, Director of International Affairs at the Ford Foundation, announced in a press conference that the foundation planned to spend eight million German marks (Deutsche Mark, or DM) on the program. If the invited artists should want to continue to teach their students, they too would be welcome in Berlin, for which they would receive a scholarship. Xenakis was offered fifteen thousand dollars and housing free of charge for the year. In further correspondence with von Bomhard, Xenakis expressed a desire to work with Winckel[42] at the electronic studio of the Technical University of Berlin.[43] Xenakis recommended three of his colleagues/students to join him in Germany: Japanese composer and pianist Yuji Takahashi (b. 1938), French composer François-Bernard Mâche (b. 1935), and Polish musicologist and composer Józef Patkowski (1929–2005).[44] Of the three, Mâche and Patkowski were not able to join the program for personal reasons.[45] Takahashi received a yearly scholarship of 2,100 dollars plus travel costs, while he needed to take care of the housing himself. Xenakis also asked for the Foundation to provide funds for Winckel but was denied.[46]

40 In conversation with the personnel of DAAD (18 November 2019).

41 The entire correspondence between Xenakis and Bomhard is in English. Enclosed letters to Maslowski and Winckel are in French. The correspondence between Xenakis and Nestler is both in English and French. The enclosed letter to Stresemann is in French, with a translation to German.

42 A letter from Xenakis to Bomhard, dated 12 March 1963 (DAAD archives, Xenakis folder, p. 38).

43 The electronic studio was located in the main building of the University, in room 1001 (see "Die Umzüge des Studio" (September 2004), *Technical University of Berlin*, https://fhein.users.ak.tu-berlin.de/Alias/Geschichte/themen/Umzuege_Neubau.html).

44 A letter from Xenakis to Bomhard, dated 10 April 1963 (DAAD archives, Xenakis folder, p. 35f).

45 A letter from Xenakis to Bomhard, dated 22 May 1963 (DAAD archives, Xenakis folder, p. 25f), and from Bomhard to Xenakis, dated 29 August 1963 (DAAD archives, Xenakis folder, p. 30).

46 A letter from Bomhard to Xenakis, dated May 30, 1963 (DAAD archives, Xenakis folder, p. 23f), and from Bomhard to Scheibe, dated 12 August 1963 (DAAD archives, Xenakis folder, p. 21f).

In the correspondence with Peter Nestler in 1965, Xenakis praised his student Takahashi and recommended his scholarship to be extended for at least one more year (Fig. 3.4).[47] Xenakis's willingness to help the young musician is evident in the following passage:

> I am anxious about his [Takahashi's] future. [...] [But] although [these] concerts are paid [to him], this money is certainly not sufficient for him and his family. [...] I can certainly affirm again my admiration for him as a pianist and in general as a musician. I think that the European possibilities will bring him to a high standard, one of the highest in the world. Much more safely than in Japan. I know that you agree with me and that your human qualities make you completely understand these considerations in my will to help this extraordinary man and give him the smallest opportunity to achieve himself. Unfortunately, there is no policy of helping young talents in France such as it is developed in Germany or in the USA, this is why I am addressing my request to you.[48]

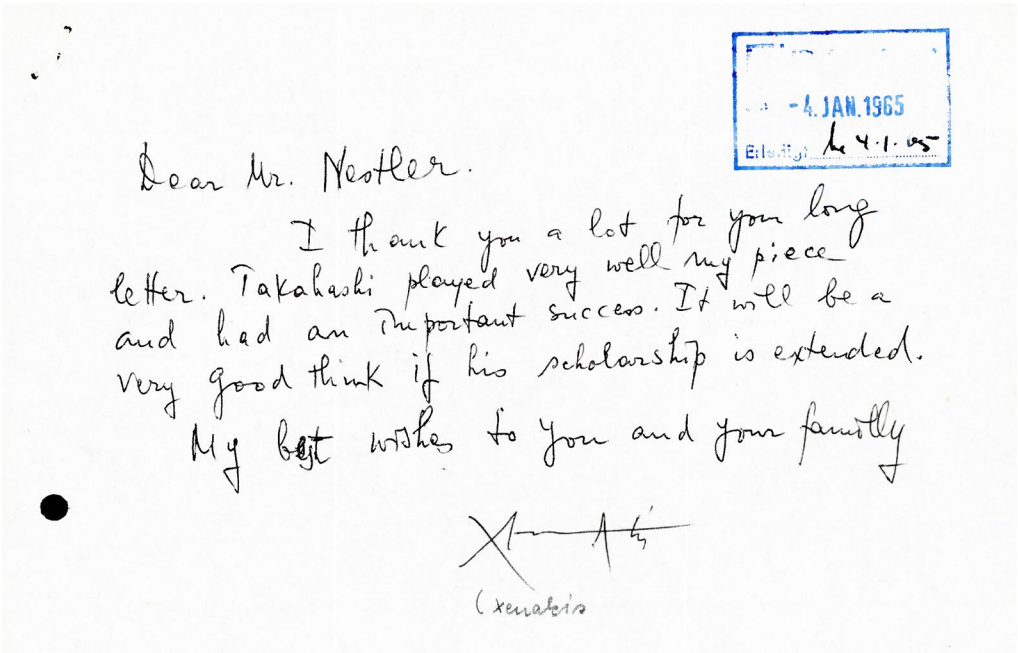


Fig. 3.4 A letter from Xenakis to Peter Nestler, dated 4 January 1965. © By kind permission of Archiv Berliner Künstlerprogramm des DAAD.

Ford Foundation agreed to Takahashi's prolongation to the end of June 1966.[49] Xenakis also recommended a young French composer, Francis Miroglio (1924–2005), the director of the summer festival in Saint-Paul de Vence.[50] Norddeutscher Rundfunk

47 A letter from Xenakis to Nestler, dated 4 January 1965 (Fig. 3.4) (DAAD archives, Xenakis folder, p. 12).
48 A letter from Xenakis to Nestler, dated 18 November 1965 (DAAD archives, Xenakis folder, p. 4).
49 A letter from Nestler to Xenakis, dated 29 November 1965 (DAAD archives, Xenakis folder, p. 2f).
50 A letter from Xenakis to Nestler, dated 18 November 1965 (DAAD archives, Xenakis folder, p. 4).

(Northern German Broadcasting, or NDR) released a four-minute report on Xenakis, titled *Stipendiaten der Ford Foundation: Iannis Xenakis* (Scholarship Holders of the Ford Foundation: Iannis Xenakis), dated 30 April 1964. In the footage, the young Xenakis is seen crossing the road at Ernst-Reuter-Platz in the Charlottenburg district, entering the IBM building, and using the computers. He also gave a brief statement in German about his music.[51]

In the summer of 1965, Xenakis complained to Nestler and Stresemann that the German-American conductor Lukas Foss (1922–2009) had withdrawn his *Pithoprakta* from the concert scheduled to be performed in Berlin by the Berlin Philharmonic on 21 June 1965. At the time, Xenakis was not able to attend the performance, as he was visiting the rehearsals of the National Orchestra of France for the recording of the same piece. He found out about the withdrawal three days before the performance and objected to Foss's arguments of the composition being unplayable by listing twelve successful performances since the premiere in Munich on 7 March 1957.[52]

Theoretical Work in Berlin

By the time Xenakis moved to Germany, his first book was ready to be published. In October 1963, under the title *Musiques formelles: nouveaux principes formels de composition musicale* (Formalized Music: Thought and Mathematics in Composition), it was released as a double special issue of the French music periodical *La Revue Musicale*.[53] The first edition contained six chapters on various aspects of stochastic music. The future editions included extensions and additional chapters, some of which covered the techniques first developed during the Berlin residency.

The most notable Berlin discovery is the application of mathematical sieve theory in music. Xenakis primarily used the theory to construct musical scales, although the rhythmical sieves soon proved to be just as useful.[54] The prototypical example of sieves in mathematics is known as the Sieve of Eratosthenes (?–194 BCE), named after an ancient Greek polymath from Cyrene. It was used for finding all prime numbers up to a given limit. This technique happened to be crucial for Xenakis, as it provided him with a method of "filtering" elements in order to create and manipulate structure.[55] On one of his calculations made in pencil, Xenakis specifically notated in his native Greek in red ink: "Hurray! Eureka!" and "Berlin 28/6/64, 5 pm." He would later

51 See Ford Foundation Fellows: Composer Iannis Xenakis" (30 April 1964), *ARD*, https://www.ardmediathek.de/video/kultur-im-norden/stipendiaten-der-ford-foundation-komponist-iannis-xenakis/ndr/Y3JpZDovL25kci5kZS9lOTEyNDFhYy03MGI3LTQ3OWMtODNiYi0zMzNhZDg1YTg5NDM

52 A letter from Xenakis to Stresemann, dated 3 July 1965 (DAAD archives, Xenakis folder, p. 7–9), and from Nestler to Xenakis, dated 9 July 1965 (DAAD archives, Xenakis folder, p. 5).

53 Xenakis, [1963] 1992, p. viii.

54 The examples are evident in percussion works *Persephassa* (1969) and *Psappha* (1975).

55 Exarchos, 2008, p. 54.

formulate and present the theory in essays such as "Towards a Metamusic" of 1967, which he included in *Musique. Architecture* and the 1992 edition of *Formalized Music*.[56] The manuscript of 'Towards a Metamusic' dates from 1965 and was originally titled 'Harmoniques (Structures hors-temps)'.[57] The text examines Pythagoras (*ca*. 570–*ca*. 500/490 BCE) and Aristoxenus (*ca*. 375–*ca*. 360 BCE), another of Xenakis's Greek precedents he seemed to have occupied himself with during the residency. With this study, he was able to formulate and clarify his tripartite notion of musical structure: outside time, temporal, and inside time. This was also the first time Xenakis summoned the history of music by showing deep interest in the tonal structures of Antiquity and Byzantine music.[58]

Three other essays are the result of Xenakis's Berlin residency, too. These are "Intuition or Rationalism in the Techniques of Contemporary Musical Composition,"[59] "La voie de la recherche et de la question" (The Way of Research and Questioning),[60] and the first version of "Towards a Philosophy of Music." The last one was published in *Gravesaner Blätter* in 1966 (which happened to be Xenakis's final contribution to the magazine) and was later republished in *Musique. Architecture* and *Formalized Music*. All three essays cover the contemporary importance of the pre-Socratic philosophers Pythagoras and Parmenides (*ca*. late sixth to fifth century BCE), the group structure of sound characteristics (such as pitch, intensity, and duration), and the axiomatic development of those characteristics.[61] Together with "Towards a Metamusic," "Towards a Philosophy of Music" would also be included in *Musique. Architecture* and *Formalized Music*.

The Berlin residency gave birth to another notable Xenakis essay, this time architecture-related: '*La ville cosmique*' (The Cosmic City). It was originally published by Françoise Choay (b. 1925) in her 1965 anthology *L'Urbanisme, Utopies et Réalités*, and later reprinted in *Musique. Architecture*.[62] In the text, Xenakis is preoccupied with the utopian proposal of an ideal city. This was his take on the concept that can be traced to the urban planning of the Renaissance and to the theoretical writings of Plato (428/427–348/347 BCE).[63] Many architects before his time were driven to design a city from scratch using their own formal, functional, and philosophical objective. Notable examples include a fifteenth-century polymath Leon Battista Alberti (1404–72) and Xenakis's former employer, Le Corbusier.[64] Xenakis's proposal stands apart by shifting the focus from planar urban design to the vertical, permeated by a strong

56 Xenakis, 1971, p. 38–70 and [1963] 1992, p. 180–200.
57 Exarchos, 2019, p. 34.
58 Solomos, 1996, p. 31 and Harley, 2004, p. 36.
59 Presse- und Informationsamt des Landes Berlin, 1965, p. 14–18.
60 In the Cultural Council Foundation's journal *Preuves*, no. 177 (1965), p. 33–6.
61 Turner, 2014, p. 42.
62 Xenakis, 1971, p. 151–60; Solomos, 1996, p. 31; Varga, 1996, p. 45; Sterken, 2004, p. 159–66.
63 Namely, in *Republic*.
64 *Ville contemporaine* (Contemporary City) and *Ville radieuse* (Radiant City) (the latter not to be confused with *Cité radieuse*).

belief in technology.[65] He pushed the verticality to extremes and imagined parabolic skyscrapers up to several kilometers in height. Led by his engineering experience, Xenakis understood the quality of geometrically and topologically complex algebraic surfaces with which one could produce such large resilient structures.[66] In only one of the skyscrapers, it would be possible to fit the entire population of Paris, leaving the surrounding areas free. The aim of Xenakis's proposal was not only the freeing of the space of the Earth but also decentralization and the avoidance of the city's orthogonality. In *Musique. Architecture*, he published a drawing of the Cosmic City to illustrate its scale.[67]

Xenakis would repeat his 1963 Berlin lecture in 1964 and publish it in his 1971 book *Musique. Architecture*.[68] The lecture titled "Mathematical Formulation of Musical Composition," dated 3 June 1964, took place in the Amerika Haus Berlin at Hardenbergstraße 22–4. The flyer included the following description:

> An attempt to use the universal language of modern thought in musical composition, such as the mathematical theory of probability, or theoretical logic, and of operational research. With the assistance of Yuji Takahashi, pianist, and musical illustrations on tape.[69]

From the same flyer, we find that the first Berlin performance of Xenakis's string quartet *ST/4-1,080262* (1956–62) took place shortly before the lecture, and was performed by the Parrenin Quartet.[70]

Musical Work in Berlin

Although the Berlin period was primarily significant for Xenakis because of his theoretical research and was not the most productive one in terms of completed scores, he did manage to occupy himself with a few compositions at the time. The pieces that were composed during the residency, at least partially if not in their entirety, include *Eonta* (1963), *Akrata* (1964), and *Hiketides: Les Suppliantes d'Eschyle* (1964).[71] *Eonta* is scored for piano, two trumpets, and three tenor trombones. *Akrata* is scored for an ensemble of sixteen wind instruments, consisting of eight woodwinds (piccolo flute, oboe, *E*-flat piccolo clarinet, *B*-flat bass clarinet, *B*-flat contrabass clarinet, bassoon, two

65 Xenakis, 2008, p. 127f.
66 Barczik, Labs, and Lordick, 2009, p. 456.
67 Xenakis, 1971, p. 159. Xenakis also discusses the Cosmic City in an interview with Renée Larochelle, dated 11 May 1967 (archivesRC, "Yannis Xenakis et son Polytope à Expo 67" (24 March 2021), *YouTube*, www.youtube.com/watch?v=eh30vxCDYpg, as well as in his thesis defense (Xenakis, 1985, p. 50–7). The text is published in English in Xenakis, 2008, p. 136–41.
68 Xenakis, 1971, p. 20–5; Di Scipio, 2001, p. 83; Scheubel, 2012, p. 76–82. There are slight but no significant differences between the 1962 and 1964 texts. For further details, compare the German transcript in Scheubel 2012 to the French one in Xenakis 1971.
69 DAAD archives, Xenakis folder, p. 19.
70 The world premiere took place in Paris in 1962, performed by Quatuor Bernède.
71 See *Les Amis de Xenakis*, www.iannis-xenakis.org/en/category/works/music/

double bassoons) and eight brass instruments (two horns, three trumpets, two tenor trombones, and tuba). *Hiketides* is scored for two trumpets, two trombones, and strings (6.6.0.8.4 or multiples).[72] A common denominator of all three pieces is the prominent use of brass instruments, be it in combination with piano, woodwinds, or strings.

The first written notes for *Eonta* date to summer 1963, when Xenakis was still in Tanglewood, but the piece was finalized in Berlin. It was commissioned by the Ensemble du Domaine Musical and the premiere was conducted by the composer Pierre Boulez (1925–2016). The title is a tribute to the philosopher Parmenides and can be translated as "being(s)," which is a present participle verb and a noun in plural form. In *Eonta*, Xenakis uses symbolic logic and stochastic principles to generate musical materials. The piece is characterized by spatial positioning of the instrumentalists: the brass players are directed to perform at different locations on the stage, to walk around the stage, to direct the bells of their instruments in various directions, and to blow directly into the open body of the piano. The spatial gestures were meant to exploit the acoustics of the performance space; however, Boulez objected to these gestures, deeming the piece impossible to play as written. His criticism turned out to be unnecessary, as *Eonta* is regularly performed as intended and remains one of the most successful of Xenakis's works.[73] The premiere took place in December 1964 in Paris. Some of the instrumental parts were calculated on an IBM 7090 computer at the Place Vendôme in Paris.[74]

Unlike *Eonta*, which exploits techniques Xenakis had developed until this point in his career, *Akrata* is the true result of his Berlin residency. Commissioned by the Koussevitzky Foundation, it was completed in 1965 and premiered in June 1966 at the English Bach Festival in Oxford. It is also stylistically different from the virtuosic *Eonta*, as it restricts the material to held or repeated tones. The music proceeds as a series of sounds separated by silences. According to Xenakis, *Akrata* is based on the theory of groups of transformations and the theory of sieves. These theories Xenakis discussed in detail in the essay "Towards a Philosophy of Music"—included in *Musique. Architecture* and *Formalized Music*—but in reference to his 1966 piece *Nomos Alpha* for violoncello, rather than *Akrata*.[75]

After Xenakis's piano quartet *Morsima-Amorsima* premiered in Athens in December 1962, it received the Manos Hadjidakis Prize.[76] The prize resulted in a commission to compose incidental music for a 1964 production of Aeschylus's tragedy *Hiketides* (The Suppliants) at the ancient theater in Epidaurus. It was Xenakis's first work intended for the dramatic stage. The original musical setting was intended for chorus and ensemble,

72 Ibid.

73 Varga, 1996, p. 45, 68, and 100–2; Harley, 2004, p. 31; Kermit-Canfield, 2013, p. 29f. The first performance, conducted by Boulez, included a second set of brass players. The performance with the proper number of players was conducted by Konstantin Simonovitch (1923–2000) in 1965.

74 See Iannis Xenakis, "Eonta (1963–64)," *Boosey & Hawkes*, https://www.boosey.com/cr/music/Iannis-Xenakis-Eonta/446

75 Exarchos, 2019, p. 34.

76 Xenakis shared the first prize *ex aequo* with Anestis Logothetis (1921–94).

but a more popular instrumental suite based upon the original material was scored for brass and string instruments, in which the brass material is drawn from the choral part. As Xenakis was inspired by the music of Antiquity, *Hiketides* does not resemble his typical modernist style. Despite not becoming a standard part of his repertoire, it represents the beginning of an exploration of ancient Greek theater in future stage projects like *Oresteia* (1965–6) and *The Bacchae* (1993), as well as multimedia spectacles *Polytope de Persépolis* (1971) and *Polytope de Mycènes* (1978).[77] The premiere took place in July 1964. In a letter from Xenakis to George Balanchine dated 10 October 1964, we find out that Xenakis had left Berlin.[78]

Later Connections to Berlin

More than a decade after the residency, Xenakis received a prestigious commission from the Berlin Philharmonic. The unusual instrumentation for twelve violoncellos was to be performed by the orchestral players without a conductor. The result was the piece titled *Retours-Windungen* (1976) with circularly positioned instrumentalists located in front of the audience. The piece premiered on February 20, 1976, in Bonn. Two years before that, the city of Bonn would host a Xenakis festival, and the next year, 1977, they would award Xenakis a Beethoven Prize for his orchestral piece, *Erikhton* (1974).[79]

Between 30 March and 2 April 1982, a four-day event titled Inventionen'82 took place in Berlin.[80] It was organized by Ingrid Beirer and Helga Retzer of DAAD, professor Folkmar Hein (b. 1944) of the Technical University of Berlin, and composer Sukhi Kang (1934–2020). The series of four concerts was the result of the collaboration between DAAD, the Technical University, and the Academy of Arts. On 31 March, three electronic pieces by Xenakis were performed at the exhibition hall of the Academy of Arts: *Bohor* (1962), *Légende d'Eer* (1977), and *Mycènes Alpha* (1978).[81] On the same evening, Xenakis was invited to give a talk on the research institute he had established in 1972, CEMAMu (Centre d'Etudes de Mathématique et Automatique Musicales), as well as on his own computer music. The audio of the talk is archived at the Electronic Studio of the Technical University under the title *Xenakis_speech mit telcom*.[82] In the ten-minute recording, Xenakis discusses the UPIC system, which was created at the CEMAMu as a drawing compositional tool. It was first used in *Mycénes Alpha* (1978) and premiered at the ancient site of Mycenae in Greece. The piece was also performed in Berlin on 8 September 1988, the year when the city was designated the cultural

77 Harley, 2004, p. 36.
78 Turner, 2014, p. 89.
79 Harley, 2004, p. 89; Barthel-Calvet, 2009, p. 31.
80 See "Inventionen'82," *Inventionen*, www.inventionen.de/1982/index_1982.html
81 Apart from the first concert at the Technical University, all performances took place at Berlin Academy of Arts.
82 In conversation with Folkmar Hein (15 November 2019).

capital of Europe. For this occasion, Folkmar Hein invited Xenakis's UPIC system to be presented at the Technical University.[83] Apart from the concert with an exhibited graphic score, the event included workshops.[84]

The last musical work Xenakis created for the performance in Berlin was *Roáï* (1991), scored for an orchestra of ninety musicians. The title means "fluxes" in ancient Greek dialect, but it can be taken as indicative of various ideas, such as flow, current, transfer, or fusion. In this piece, Xenakis uses the sieve technique he designed almost three decades previously in Berlin. Under the baton of Olaf Henzold (b. 1960), *Roáï* was premiered on 24 March 1992, by Berlin Radio Symphony Orchestra. The concert marked the fortieth anniversary of the European Festivals Association.[85] Although Xenakis was approaching seventy years of age and was suffering from ill health, with five large orchestral scores produced within a single year, this period turned out to be the last great burst of his compositional activity.[86]

Xenakis's last documented visit to Berlin was in autumn 1994. Initiated by the conductor Guillermo Tuchsznaider, the society Berliner Dirigentenwerkstatt e.V. organized their second Berlin Conductor's Workshop. Between 30 September and 8 October, the event focused on the composer-conductor relationship using works by Xenakis. The workshop, which took place at *Centre Culturel Français* (French Cultural Centre) and Academy of Arts, consisted of rehearsals and a final concert with introductory talks. Alongside Tuchsznaider's direction, the workshop featured Silvia Malbrán teaching rhythmic comprehension and rhythmic-physical perception, Rudolf Frisius (b. 1941) analyzing Xenakis's work, and Heinz Klaus Metzger (1932–2009) discussing Xenakis's aesthetics. The computer team from the Institute for Musicology of the Technical University consisted of Prof. Dr. Helga de la Motte (b. 1938), Dr. Reinhard Kopiez (b. 1959), and Dr. Christian Dahme as a guest. The video team in charge of filming a documentary on the workshop was coordinated by Franz A. Pindorfer. At Tuchsznaider's suggestion, the Canadian media artist David Rokeby (b. 1960) presented his award-winning "Very Nervous System" as an interactive sound installation at the workshop. The list of performers included the chamber choir of the Berliner Dirigentenwerkstatt (coordinated by Sabine Wüsthoff), the Clara Schumann children's choir, the Brandenburg Philharmonic, and vocal soloists. The works by Xenakis that they performed were *Krinoïdi* (1991), *Polla ta dhina* (1962), *Hiketides: Les Suppliantes* (1964), *Les Bacchantes d'Euripide* (1993), *Serment-Orkos* (1981), *Nuits* (1967), *Pour la Paix* (1981), and *À Hélène* (1977). The workshop received over two hundred applications from various countries. The event was covered by *Berliner Morgenpost*.[87]

In 1983, Xenakis became a member of the music section of the Academy of Arts in

83 Ibid.

84 Weibel et al., 2020, p. 156; see also "Werkstatt Elektroakustische Musik" (20 January 1989), *Technical University of Berlin*, https://fhein.users.ak.tu-berlin.de/Alias/Geschichte/chrono/Werkstatt_E88.html

85 *Les Amis de Xenakis*, www.iannis-xenakis.org/en/category/works/music/

86 Harley, 2004, p. 202.

87 Archival materials of DAAD.

West Berlin, together with Aaron Copland and George Crumb (1929–2022). From 1990 to 1993, he was a corresponding member of the same institution in East Berlin, elected in 1989 with György Kurtág (b. 1926) and Edison Denisov (1929–96). From 1993 until his death in 2001, he remained a member of the institution in the reunified city.[88]

Xenakis in Berlin: Aftermath

The fascination with Xenakis's music and his theoretical work did not fade following his death, as several doctoral theses and publications in Berlin prove.[89] In 2007, DAAD and the Technical University collaborated again on a series of concerts, under the name '*fünf+1 – Raumklangkonzerte*'. On 21 September, Daniel Teige performed Xenakis's 1971 electronic piece *Persépolis* within the event. Between 6 September and 27 November 2011, an exhibition titled "*Kontrolle und Zufall—Iannis Xenakis: Komponist, Architekt, Visionär*" (Control and Chance—Iannis Xenakis: Composer, Architect, Visionary) took place at the Berlin Academy of Arts organized by the Schering Foundation, DAAD, Zitty Berlin, and Deutschlandradio Kultur.[90] The event hosted a performance of Xenakis's *Légende d'Eer*[91] as well as the screening of Scherchen's experimental film *Achorripsis*.[92] In July the same year, inspired by Xenakis's multimedia spectacles, a soloist ensemble Kaleidoskop performed the so-called "*ein Polytop für Iannis Xenakis*" on the streets of Berlin.[93] In 2021, Berlin-based composer Christian Dimpker (1982) included his piece *N. 25/2 Klavierstück V* in a Berlin soundwalk as an artistic homage to Xenakis within the Month of Contemporary Music. To commemorate the one hundredth anniversary of Xenakis's birth, a festival was held in 2022 in Berlin with the title "X100: A Festival in the Spirit of Iannis Xenakis."[94] These and other constantly emerging new events continue the legacy of the city's former avant-garde resident long after his death.

88 "Iannis Xenakis," *Akademie der Künste*, https://www.adk.de/de/akademie/mitglieder/index.htm?we_objectID=52587. The membership certificate and election results can be found in the Academy archives under the shelf-marks AdK-O KM, AdK-O 2330, and AdK-W 134–32.

89 To name few scholars: Eugenia Alexaki, Alexandros Droseltis, Marie Louise Herzfeld-Schild, Peter Hoffmann, and Boris Hofmann.

90 "Kontrolle und Zufall – Iannis Xenakis: Komponist, Architekt, Visionär," *Akademie der Künste*, www.adk.de/de/programm/index.htm?we_objectID=30347

91 Archival materials of DAAD.

92 "Kontakte 2015: Freitag, 25.09," *Akademie der Künste*, www.adk.de/de/projekte/2015/Kontakte/teaser_6.htm

93 "XI – ein Polytop für Iannis Xenakis," *Kaleidoskopmusik*, https://kaleidoskopmusik.de/en/projects/xi-ein-polytop-fuer-iannis-xenakis/

94 "X100: 100 Years of Iannix Xenakis," *Kulturstiftung des Bundes*, https://www.kulturstiftung-des-bundes.de/en/programmes_projects/music_and_sound/detail/x100.html

Berlin-related Chronology

1958:	Participation in the competition for the reconstruction of the center of Berlin.
1958:	Publication of *Achorripsis* for twenty-one musicians by Bote & Bock in Berlin.
18 February 1962:	Lecture "Formalization and Axiomatization of Musical Compositions" at the Berlin Congress Hall.
3 March 1963:	Invitation to the Ford Foundation's "Artist in Residence" program in Berlin.
April–May 1963:	Filming of *Achorripsis*, a film by Scherchen and Schmückle.
Late September 1963:	Xenakis moves to Berlin.
3 June 1964:	Lecture "Mathematical Formulation of Musical Composition" in Amerika Haus, Berlin.
Summer 1964:	Xenakis leaves Berlin.
20 February 1976:	First performance of *Retours-Windungen* for twelve violoncellists of the Berlin Philharmonic.
30 March–2 April 1982:	Inventionen'82 with a talk by Xenakis.
1983:	Berlin Academy of Arts membership.
8 September 1988:	UPIC system presented at the Technical University of Berlin.
24 March 1992:	First performance of *Roáï* for orchestra by the Berlin Radio Symphony Orchestra.
30 September–8 October 1994:	Xenakis at the Berlin Conductor's Workshop.
2017:	Berlin Academy of Arts digitizes all volumes of *Gravesaner Blätter* with twelve Xenakis texts included.
2020:	DAAD digitizes archive materials from the period 1963–78 with Xenakis folder included.

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4. Debating the Noise: The Reception of Iannis Xenakis's Music in Serbia as a Part of the SFRY (1960–90)

Jelena Janković-Beguš

Over several decades, the city of Belgrade (the current capital of the Republic of Serbia), enjoyed the privilege of being the capital city and the largest cultural center of the former Socialist Federal Republic of Yugoslavia (SFRY).[1] Despite several attempts to bring the relatively young Serbian musical culture closer to the current music trends in Western Europe, the Serbian musical establishment never developed a particular liking for avant-garde music, even during its greatest flourishing in European countries after the World War II (WWII), from 1950 onwards.[2] Serialism specifically was never really accepted by the vast majority of Serbian composers, while the compositional techniques of the so-called "Polish School" were assimilated to a certain extent, but they were usually combined with other, more traditional approaches to music composition.[3] The situation was somewhat different in other republics of the former Yugoslavia, notably in Croatia and Slovenia, where many more composers ventured into avant-garde and experimental music, and where important contemporary music festivals were founded in the 1960s.[4] The majority of Serbian composers, with the notable exception of Vladan Radovanović (1932–2023), were more interested in various neo-classical syntheses, inspired by the work of Igor Stravinsky (1882–1971) and Paul Hindemith (1895–1963).[5] It is safe to assume that the Serbian composers'

1 As the successor of the Kingdom of Serbs, Croats, and Slovenes (1918–29) and the Kingdom of Yugoslavia (1929–45), the new communist-led country was created in 1945, under the name of the Democratic Federal Yugoslavia. The name was changed in 1946 to the Federal People's Republic of Yugoslavia, and in 1963 it was renamed the Socialist Federal Republic of Yugoslavia. During all these transformations, Belgrade, as the country's largest city, remained the administrative capital of the country.

2 See more in Milin, 2006, p. 93–116.

3 This framework is analysed in great detail in Milin, 1999.

4 The Music Biennale Zagreb was established in 1961, and the Yugoslav Music Review was established in Opatija in 1964. The first festival was international, while the other one was of a Yugoslavian focus.

5 About Vladan Radovanović's unique position among Serbian composers of his generation, see Medić,

 https://doi.org/10.11647/OBP.0390.06

mistrust of the avant-garde was not a consequence of the short-lived "socialist realism" in the period immediately after WWII, but rather was a reflection of the overall artistic climate in Belgrade which was much more inclined towards syntheses of the past and the future than the radical denial of the past in favor of the future.[6]

These overall standpoints of the Serbian musical establishment in the second half of the twentieth century can be observed in the critical thought of the time, and they are clearly visible in the attitudes towards the music of Iannis Xenakis. While Xenakis himself did not actually belong to any of the predominant currents of the European avant-garde (serial, aleatoric), nor was he close to the American experimental current (represented by John Cage (1912–92) and his followers), he was nevertheless perceived in Belgrade as the exemplary European avant-garde composer. Hence, the reception of his music in Serbia was, for a long time, largely negative, with more favorable opinions about his music only beginning to be expressed in the 1980s.

The written critical texts which will be examined here encompass a period of nearly three decades, from the early 1960s until the end of the 1980s. This timeframe was chosen because the beginning of the 1990s marked the onset of the dissolution of the SFR Yugoslavia and a profound change in the cultural landscape in Serbia.

Throughout the observed period, Radio Belgrade Third Programme (founded in 1965) was the tireless promoter of the most contemporary music currents, with a special emphasis placed on European avant-garde music. I am deeply grateful to the musicologist Hristina Medić (b. 1943), who held the position of music editor of the Radio Belgrade Third Programme (1969–2005), and who during that time compiled a vast number of music reviews—a veritable history of the reception of musical life in Belgrade in the 1970s, 1980s, and 1990s—written by her and by many other music critics. This abundant material chronicles musical life in Serbia and particularly in Belgrade, including the performances of Xenakis's pieces in the country. Regardless of their relatively small number, these performances always managed to "stir the pot" and they were usually reviewed by more than one music critic.[7] H. Medić has recently published this collection of texts, where certain reviews are published for the first time, as they were presented orally on the Radio Belgrade Third Programme.[8] The other texts were printed in various daily newspapers (most notably the *Politika* daily), at the time when printed press was still a powerful mass medium. Another valuable source material that H. Medić placed at my disposal were the program books of the Radio Belgrade Third Programme (1967–9): in these volumes one finds diverse sources such as speakers' texts for live broadcasts of concerts, transcripts of discussions which took place after the concerts (which were also broadcast live), and a small number of

2019, p. 157–76.

6 See Milin, 2006, p. 103–15, and Medić, 2007, p. 279–94.

7 The translations of all texts from Serbian into English language are the author's.

8 Medić, 2023a, 2023b.

concert reviews from various newspapers.[9] Regardless of the abundance of material that I have examined, the present research does not pretend to be exhaustive—rather, it should be understood as an initial stage in studying the impact of Xenakis's opus on musical life in Serbia, which is yet to be fully grasped.

Xenakis in Serbia

The two earliest mentions of Xenakis and his music in Serbia date from the early 1960s, several years before his music was actually presented in concert in Belgrade. Both articles were written by one of the most prominent Serbian music writers (and, early in his career, also a composer) Dragutin Gostuški (1923–98), who spent his entire professional career at the Institute of Musicology of the Serbian Academy of Sciences and Arts. His position among Serbian composers and music writers of his generation is unique due to his keen interest in classical Greek culture, which is interesting in the context of his attitude towards Xenakis's opus.[10] Gostuški composed a small number of moderately modern works, but already at the beginning of the 1960s—coinciding with the emergence of interest in the music avant-garde in Yugoslavia—he stopped writing music and devoted himself to musicology.[11] The first article is highly illustrative of the Serbian music establishment's attitudes towards the music avant-garde of which Xenakis's opus was considered symptomatic. The article entitled "Uz račun verovatnoće" (Alongside the Calculation of Probability) addresses the topic of the "crisis of music."[12] This art form, in Gostuški's opinion, became alienated from the audiences due to the extreme nature of many avant-garde and experimental compositions. Gostuški begins his text with the following observation (see Figure 4.1):

> One, hitherto unknown composer with a Greek last name, has appeared in Paris with a new system of composing music: he took the tables of probability calculation, he substituted the numbers with notes, he made additions and subtractions, he multiplied and divided, and so on and so forth. The end result was a miniature score which was performed by a well-known orchestra *Lamoureux*. […] [N]one other but Igor Markevitch introduced this haughty young author to the audience.[13]

9 A thorough analysis of the key role that Radio Belgrade Third Programme had in promotion of the contemporary—i.e., avant-garde and experimental—music can be found in Medić, 2015, p. 141–74 and Medić, 2022 (the latter article is published in English).

10 Gostuški's magnum opus, his book *Vreme umetnosti. Prilog zasnivanju jedne opšte nauke o oblicima* (Time of Art: Contribution to the Foundation of a General Science of Form) clearly demonstrates his admiration of Greek Antiquity (Gostuški, 1968).

11 More on the subject of "moderate modernism" in Serbian art music: Medić, 2007, p. 279–94.

12 Gostuški, 1960, p. 258–62.

13 Gostuški, 1960, p. 258 (see Figure 4.1).Igor Markevitch (1912–83) was the principal conductor of the Orchestre Lamoureux from 1957–61.

UZ RAČUN VEROVATNOĆE

DRAGUTIN GOSTUŠKI

Jedan, dosada nepoznat kompozitor grčkog prezimena, pojavio se u Parizu sa novim sistemom komponovanja: uzeo je tablice računa verovatnoće, brojeve zamenio notama, sabirao, oduzimao, dizao na kvadrat, spuštao i tako dalje. Konac je njegovo delo ukrasio minijaturnom partiturom koju je otsvirao poznati orkestar *Lamoureux*. Francuska kritika odgovorila je antifono u smislu koji bismo nazvali teranjem šege sa izumiteljem, ali i s prizvukom uznemirenosti. Jer, nadobudnog mladog autora pretstavio je publici jedan Igor Markevič.

Čemu nas uči ova priča?

Priča je bogata poukama koje svakako nisu za šalu. Ona nas opominje da takozvana kriza umetnosti nije ni prazna reč ni strašilo koje su izmislili starci, već suva realnost u vidu neumoljivog izvršitelja koji kuca na naša vrata. Više nije nužno prepirati se oko nedokazivih privatnih osećanja, da bi se proverilo je li u pitanju progres ili zastoj, stvaralački znoj ili grč nemoći. Ne treba nam više ničija proročanska intuicija koja bi nam pružila orijentaciju da znamo koji čas istorije zvoni. Sve već piše u partiturama, pod punim potpisima, uzimajući oblik materijalnog dokaza kao što je ovaj o kome govorimo.

Pojava računa verovatnoće u muzici — makoliko sama po sebi beznačajna za sudbinu ove umetnosti — ima vanrednu vrednost jednog simptoma. Na prvom mestu, izvlačimo zaključak da nijedan od tzv. revolucionarnih sistema komponovanja koji nam se predlažu u toku poslednjih pola veka, nije mogao da ispuni očekivanja. Stalno traženje novih metoda vrlo prosto i jasno pokazuje da oni prethodni nisu zadovoljili, makolika da je bila buka koja se oko njih u početku dizala. Nijedan od takvih sistema nije doživeo evoluciju, neophodan uslov da mu priznamo vitalnost. Ili se izgubio u infantilnom obliku, kao četvrttonska i konkretna muzika, ili se prethodno degenerisao, kao dodekafonija. Nismo videli ni razvoj ni napredak. Samo skokove ustranu. Zbogom »juče«, zdravo »danas«, dobrodošlo »sutra«. Mi moramo izvući zaključak da kriza postoji već iz jednostavnog razloga što se nigde ne vidi prosperitet ma čega bilo, tojest ni stila, ni dela, ni samog kompozitora, ukoliko njegova lična snalažljivost ne prevazilazi njegovu umetnost.

Ubedljuju nas u večitu važnost pravila da su novine uvek nailazile na otpor i da će se strpljivim ponavljanjem svi priviknuti na nove zvučne formule. Ponavljanjem čega? Stalno izmišljamo nekakva nova rešenja, jer nijedno od njih ne dajemo čak ni stabilnost ubeđenja ako već ne ostvarujemo neosporne vrednosti. Kako bi i zašto drugi pratili profesionalce ako oni stalno počinju ispočetka? Pred evoluciju stavljaju se barikade u ime napretka, baš onda kada je ozbiljna evolucija potrebnija od jeftine senzacije. Nema nikakve sumnje da guramo kola unatrag, protivno

Fig. 4.1 Dragutin Gostuški, "Uz račun verovatnoće" (1960). First page of the printed article. © *SOKOJ*, reprinted with permission, CC BY-NC-ND.

While Gostuški does not actually mention the composer's name, it is clear from the context that he is speaking precisely about Xenakis, since the author mentions the "calculation of probability," as undoubtedly one of the most distinctive and recognizable characteristics of Xenakis's compositions of the time.[14] Even though it is a false assumption that Xenakis was "hitherto unknown" in Europe, he certainly was a new name in the Serbian context. For Gostuški, the "moral of the story" about the calculation of probability is that "the so-called crisis of the arts is not an empty word [...] but a living reality [...] The appearance of the calculation of probability in music–insignificant as it may be for the future of this art–still possesses significant value as a symptom."[15] Gostuški claims that none of the so-called revolutionary systems of composition that emerged from the second decade of the twentieth century have proven satisfactory, resulting in the near constant search for new methods of composition. These methods are often discarded after a short period of experimentation:

> None of these systems has experienced any evolution, which is a necessary condition to recognize its vitality. [...] We must draw a conclusion that the crisis is self-evident from the simple fact that it is not possible to observe any kind of prosperity—of a style, of works or of composers themselves, unless their personal resourcefulness surpasses their art.[16]

From Gostuški's point of view, the experimentation in itself would not be so detrimental for the art of music had it not become obvious that the music was becoming increasingly isolated, detached from the audiences who did not possess the ability to adjust to the near-constant novelties. For him, the word "progress" (in art) represents an "exceptionally cunning trap which unmistakably catches all the cowards who run towards it out of fear that they would be labelled stupid and retrograde."[17] Gostuški claims that it has been decades since any avant-garde work has built its reputation "based on the interested [audiences'] desire to hear it over and over again," criticizing the current lack of "valuable pieces" that could be compared to Richard Wagner's (1813–83) overtures, Claude Debussy's (1862–1918) *Prélude à l'après-midi d'un faune* (1894), Richard Strauss's (1864–1949) *Don Juan* (1888), Maurice Ravel's (1875–1937) *Daphnis et Chloé* (1912), or Igor Stravinsky's (1882–1971) *Petroushka* (1911).[18] One can say that time has proven Gostuški wrong, and that a number of avant-garde or experimental pieces have remained in the repertoires of various ensembles across Europe and in the

14 This reference to Xenakis in Gostuški's text was first observed by the musicologist Dragana Stojanović-Novičić in Stojanović-Novičić, 2007, p. 61–2.

15 Gostuški, 1960, p. 258 (see Figure 4.1).

16 Ibid. (see Figure 4.1).

17 Ibid., p. 259 [...[*O*]*vde je reč 'napredak' izvanredno lukava klopka u koju bez pogreške uleću sve moguće kukavice iz straha da ne budu oglašene za glupe i nazadne*].

18 Ibid., p. 260 [...[*V*]*eć decenijama nema avangardističkog dela koje je steklo renome na osnovu želje zainteresovanih da bude ponovo, tj. stalno slušano.' 'Moderna svetska muzika nema standardnih dela koja bi se mogla uporediti sa Wagnerovim uvertirama, Debussy-evim Faunom, Straussovim Don Juanom, Ravelovim Daphnis i Chloe ili Petruškom Stravinskoga*].

world (including works by Xenakis). However, from Gostuški's immediate perspective, the art of music composition was endangered by what he observed as the loss of compositional technique in a classical sense—which was being replaced with various pre-compositional procedures. "The application of the calculation of probability to notes can only mean one thing: That music is no longer capable of imposing its own laws but is submitted to a different category of thinking."[19] Gostuški was not happy about the "rise of mathematics" in the works of many avant-garde composers (such as Pierre Boulez (1925–2016), Karlheinz Stockhausen (1928–2007), or Xenakis) because music, in his opinion, should adhere to its own set of innate rules.[20] Gostuški was apparently unaware that for many avant-garde composers—and this is particularly true of Xenakis—mathematics and natural sciences often represented nothing more than a source of inspiration, and not a prescribed route. In Gostuški's opinion, the calculations could not guarantee the establishment of any logical relations between sounds and human consciousness, which is why the result of such procedures "does not belong to music."[21] Thus he concludes his text with a sardonic remark:

> Today we have the score which has originated from the calculation of probability; tomorrow we might have the one which has resulted from a cheese pie recipe. In any case, listening becomes redundant.[22]

The next year (1961), Gostuški had a chance to meet Xenakis in person in Tokyo, Japan, where the Serbian author was a delegate at the congress entitled "Tokyo East-West Music Encounter", and he published an article about it (see Figure 4.2).[23] The congress incorporated a rich festival concert program, with ensembles and artists such as the New York Philharmonic, Gewandhaus Orchestra, Isaac Stern (1920–2001), and so on. Although Gostuški does not provide sufficient detail, it can be concluded that Xenakis was one of the featured composers at the congress since he had an opportunity to present himself and his work to the attendees. In contrast to the dislike of Xenakis's music, Gostuški had nothing but sympathy "for the Greek-turned-French composer of a nonchalant 'Saint-Germain' demeanor, and we parted ways as friends."[24] However, Gostuški was quick to admit that, regardless of this amicable encounter, he still could not grasp the music of his Greek-French peer:

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19 Ibid., p. 261 [*Račun verovatnoće među notama ima znači jedan glavni smisao: muzika nije više u stanju da sama sebi postavlja zakone, već se podređuje jednoj drugoj kategoriji mišljenja*].

20 While expressing his dislike for this new "trend" in contemporary music, Gostuški also implicitly announced his impending withdrawal from composing music (ibid.): "I do not see a reason why I should contribute to such state of the matter. [...] If that is what you call progress of music, then I refuse to take part in such a progress" [*I opet ne vidim razlog da se pridružim takvom stanju stvari.* [...] *Ako se to zove napretkom muzike, onda u tom napretku ne želim da učestvujem*].

21 Ibid. [*I zato rezultat ne spada u muziku*].

22 Ibid. [*Danas je već pred nama partitura proizašla iz recepta računa verovatnoće; sutra može iz recepta pite sa sirom*].

23 According to Gostuški, the congress was organised by the UNESCO and the Tokyo Metropolitan Government in April 1961. Cf. Gostuški. 1961, p. 527. See also Stojanović-Novičić, 2007, p. 62.

24 Gostuški, 1960, p. 528 [*Za pofrancuženog Grka nonšalantnog senžermenskog ponašanja imao sam lične simpatije i rastali smo se kao prijatelji*].

> [M]y general impression about his music is precisely that all of it lacks some sort of calculation, no matter of which sort. The last time I had heard something similar was when kitchen plates were broken in a dining room of a ship, due to rough weather. The main difference lies in the fact that the second case carried more logic–that is, a better connection between the cause and effect.[25]

Obviously, to an ear unfamiliar with "sound masses" and "clouds," these music structures could have appeared as being completely arbitrary. Nevertheless, in one of my earlier analyses, I identified numerous points of convergence between the music-theoretical writings of Xenakis and Gostuški from the mid- and late 1960s—these proximities are especially observable in their relation to Greek Antiquity and its influence on European music and art at large.[26] Had Gostuški had more time to spend in the company of Xenakis, discussing philosophical and artistic matters which were dear to both of them, he might have changed his negative attitude towards Xenakis's music—the attitude which was, in fact, illustrative of Gostuški's rejection of the post-WWII avant-garde as a whole, and of his own failure at finding any musical meaning in these radically untraditional compositional endeavors.

The greatest merit for promoting Xenakis's music in Belgrade goes to the Radio Belgrade Third Programme, which in 1967 launched a concert cycle entitled *Muzika danas* (Music Today); the cycle was renamed *Muzička moderna* (Musical Modernism) the following year. This cycle of concerts and live broadcasts, initiated by Mira Daleore, the music editor-in-chief of the Radio Belgrade Third Programme at the time, lasted until 1985 and it introduced many important pieces of European and American avant-garde and experimental music to audiences in Belgrade and in Serbia (thanks to live broadcasts). Interestingly, Xenakis was among the most performed contemporary composers in the cycle, as his pieces were heard in eleven concerts (ten different pieces in total), which was undoubtedly due to his remarkable reputation in Europe and elsewhere.[27] In addition, during the first two years (until April 1969) each concert was followed by a conversation between invited intellectuals—music critics, composers, etc.—which was also broadcast live, and which provided the first critical commentary of the performed pieces.[28]

25 Ibid. [[*O*]*snovan utisak koji sam o njegovoj muzici dobio* [*je*] *baš taj da u svemu tome nedostaje nekakav račun, kakav bio da bio. Nešto slično čuo sam poslednji put kad su se usled bure polomili tanjiri u brodskoj trpezariji. Glavna je razlika što je u ovom drugom slučaju bilo više logike, tojest bolje povezanosti između uzroka i posledice*].

26 I have examined the relationship of Xenakis's and Gostuški's poetics in my doctoral dissertation: Janković-Beguš, 2021.

27 Cf. Medić, 2015, p. 142.

28 Ibid, p. 144.

MUZIČKI SASTANAK ISTOKA I ZAPADA

DRAGUTIN GOSTUŠKI

U organizaciji UNESCO-a i gradske uprave Tokija, u prestonici Japana održan je sredinom aprila kongres pod nazivom »Muzički sastanak Istoka i Zapada«. Jugoslaviju su predstavljali Dr Dragotin Cvetko, Milko Kelemen i Dragutin Gostuški. U okviru kongresnih koncerata nastupali su Zinka i Božidar Kunc.

Ne bih mogao tačno reći kakav je utisak na Japance činila šarena grupa od pedesetak stranih delegata; ali mogu da tvrdim da su za te strance domaćini bili zanimljiviji od svega ostalog, uključujući bogati festivalski koncertni program koji je pratio sastanak. Naravno: Njujorška filharmonija, Gewandhaus orkestar, Coro Polifonico, Isaac Stern i tako dalje bili bi za svakoga od nas specijalna poslastica na nekom drugom mestu. Ali ovde, u zemlji gde se hipermoderne palate ukrašavaju stoletnim drvećem u saksiji, gde vas u liftu sa fotoćelijom dočekuju uz srednjevekovni ceremonijal — ovde, dakle, na Bernsteina gledate kao na dobro poznatog starog drugara koji ne zaslužuje naročitu pažnju. Uostalom, ti

Fig. 4.2 Dragutin Gostuški, "Muzički sastanak Istoka i Zapada" (1961). First page of the printed article (excerpt). © *SOKOJ*, reprinted with permission, CC BY-NC-ND.

According to the compendium of music critical texts I have examined, the first performance of Xenakis's music in Belgrade and Serbia took place on 28 December 1967, at the Youth Cultural Center (Dom omladine Beograda—DOB), in the final concert and live broadcast of the *Muzika danas* cycle that year. The program was performed by an ensemble of musicians from Belgrade led by the conductor Konstantin Simonovitch (1923–2000) with the soloist Arlette Sibon-Simonovitch on ondes Martenot.[29] K. Simonovitch chose to present Xenakis's *Analogique A + B* for nine strings and tape (1958/9), paired with works by Niccolò Castiglioni (1932–96), André Jolivet (1905–74), Edgard Varèse (1883–1965), and Serbian contemporary composer Vladan Radovanović (1932–2023). The ensuing conversation was led, as usual, by the

29 Belgrade-born conductor Konstatin Simonovitch (b. Simonović, sometimes also credited as Simonovich or Simonovic) was the founder and conductor of the Ensemble instrumental de musique contemporaine de Paris (Paris Instrumental Ensemble of Contemporary Music). In 1966, he was the recipient of the Grand Prix du Disque for his interpretation of Xenakis's *Eonta* with that ensemble (the same vinyl LP record also included the recordings of *Metastasis* and *Pithoprakta* by the Orchestre National De L'O.R.T.F. with the conductor Maurice Le Roux).

Serbian music critic Pavle Stefanović (1901–85), himself a keen advocate of the most contemporary music currents, while other participants were K. Simonovitch, Serbian composer Berislav Popović (1931–2002) and Croatian critic Petar Selem (1936–2015).[30]

After the concert, Simonovitch elaborated on the relationship between the instrumental and electronic sounds of *Analogique A + B*, and he described the piece as Xenakis's "etude rather than a proper composition. At the same time, it is his first serious piece which is devoid of any [external] effect."[31] Popović remarked that he was impressed by "all this mathematical approach, a very rational relationship towards the material," and especially by Xenakis's effort to "establish a constructive engine which would push the whole thing forward." In his opinion, this "constructive engine" can be found in the diversity of sound sources (traditional instruments versus electronic sounds) and their confrontation; however he was under the impression that "in this case, these two sources were incongruent, that they did not merge and that they often appeared as an artificial echo... and that we did not get a crown achievement as a result of Xenakis's efforts."[32] Thus, the first opinions after listening to Xenakis's music in Belgrade were not very favorable, however it is possible that the performance itself, carried out by local musicians who probably had little or no experience in performing such complex sound structures or insufficient time to rehearse with the guest conductor diminished the overall impression of *Analogique A + B*.

The following year, 1968, saw two performances of Xenakis's works in Belgrade. The first concert, entitled "Konkretna muzika—Elektronska muzika" (Musique Concrète—Electronic Music) took place on 22 April at the Belgrade Philharmonic Hall, and it was performed by the members of the Groupe de Recherches Musicales of Radio France under the technical and artistic leadership of Ivo Malec (1925–2019) and François Bayle (b. 1932) (Malec also joined the conversation after the concert).[33] On this occasion, the Serbian audience had an opportunity to hear Xenakis's first venture into electroacoustic music, his famed composition *Diamorphoses* (1957–8). However,

30 The creative opus of Stefanović as a music writer and promoter of contemporary music was elaborated in detail in the collection of papers: Marinković and Janković-Beguš, 2017. The transcript of the conversation is taken from the program book of the Radio Belgrade Third Programme, cycle *Muzika danas*, year 1967. The page numbers refer to the retyped transcript of the discussion.

31 Program book *Muzika danas*, 1967, p. 14 [... [*T*]*o bi se više moglo nazvati etidom nego li zaista delom. To je u isto vreme prvo njegovo ozbiljno delo lišeno svakog efekta*].

32 Ibid., p. 16 [... [*k*]*od Ksenakisa vrlo imponuje sav taj matematički naučni prilaz, mislim jedan vrlo racionalan odnos prema tom materijalu... Međutim, mene najviše impresionira u ovoj Ksenakisovoj kompoziciji napor kompozitora da... pokušava da uspostavi taj jedan konstruktivni motor koji bi gurao celu tu stvar... Čini mi se taj konstruktivni motor, a to je mislim opet jedan fenomen samo raznovrsnost izvora, jedna tradicionalna grupa instrumenata, jedan zvučnik sa elektronskim zvucima, u tom jednom suprotstavljanju jedna suprotnost mislim je jedna poluga za eventualno pokretanje. Međutim, čini mi se da su ta dva izvora u ovom slučaju odudarala, da se nisu spajala, da su delovala kao neki vrlo često veštački eho... i da nismo dobili krunu rezultat Ksenakisovog napora*].

33 Other interlocutors were Stefanović, Serbian composer Enriko Josif (1924–2003), and Selem. The program of the concert featured works by Pierre Schaeffer (1910–95), Ferrari, Luciano Berio (1925–2003), Xenakis, Bernard Parmegiani (1927–2013), Bayle, and Malec. Cf. Program book *Muzika danas*, 1967, p. 21.

the conversation after the concert took an unexpected turn, since the traditionally oriented composer Enriko Josif (1924–2003) disputed the right of the pieces on the program to be called "music." His interlocutors—Malec, Stefanović, and Selem, all responded with their "defense" of electroacoustic music, which Stefanović considered a "creation of the human consciousness," while Selem discussed the establishment of a new music hierarchy which was replacing the traditional one—"only it is no longer absolute but relative, and it is valid for each individual case in which it is created."[34] Selem also published a review of this concert in which he assessed *Diamorphoses* rather unfavorably: while he commended Xenakis's attempt to create autonomous sound structures, intentionally obscuring the origin of sounds, Selem thought that the piece was "still rudimentary" (especially compared to more recent compositions by Malec, Parmegiani, and Bayle) and unsuccessful in avoiding "naturalistic representation."[35]

The second concert in 1968 which featured Xenakis's music took place on 17 October at the Belgrade Philharmonic Hall. Once again, Konstantin Simonovitch led a group of musicians from Belgrade; however, Xenakis's famous piece *Nomos Alpha* for solo cello (1966) was performed by a guest from France, cellist Jacques Wiederker. A brief review written by the critic Branko Dragutinović (1903–71) and published in the daily *Politika* on 22 October does not provide any qualitative assessment of the pieces performed at the concert,[36] so the only trace of reception is found in the transcript of the discussion which ensued after the concert.[37] Together with Stefanović and Simonovitch, the interlocutors were Gostuški and Rajko Maksimović (1935–2024), at the time one of the young Serbian composers interested in certain techniques of the "Polish School." Once again, the discussion about *Nomos Alpha* showed a lack of understanding for the constructive procedures which governed the compositional process in this piece. While Maksimović was impressed by the virtuosity of the cellist, he scrutinized the piece which he thought represented nothing more but a "demonstration of what the instrument can play. […] We had 20–25 or 30, I don't know exactly how many, technical procedures, let's call them tricks, which […] are completely unconnected to one another.' Simonovitch, who had personally collaborated with Xenakis in the

34 Ibid., p. 22 [*Dakle, bez obzira na jezički sistem, čim nešto, koji bilo predmet zvuči a ne zato što spontano prirodno zvuči, nego je odabrano čovekovom svešću da zvuči i da se kombinuje sa nekim drugim momentom zvučanja, tu počinje muzičko mišljenje*]; ibid., p. 23 [*Jer, koliko sam ja shvatio, jedina konkretna stvar koja nam je ovde trebala biti razmeđa, razgraničenje dokle muzika ide, odakle ne ide, u prvom času nije bilo samo pitanje nestanka stanovite hijerarhije, vrijednosti, jer se ona opet stvara samo što ona sad više nije apsolutna, nego relativna i vredi za svaki pojedini slučaj u kojem se stvara*].

35 Selem, 1968, p. 6 [*Xenakis čak izričito, u komentaru svoje skladbe, postavlja zahtjev za oslobađanjem od porijekla, ili, kako on kaže, treba "zaboraviti definiciju porijekla zvukova". Ipak, i pored očitih ambicija da se u prostorima što ih otvara mogućnost tehničke obrade pa i proizvodnje zvuka ostvare autonomnosti glazbene strukture, ove skladbe ostaju još rudimentarne, a njihova se sonorna događanja, kao po nekoj fatalnosti, počinju vezivati uz stanovitu naturalističnu predodžbenost, uz stanovite asocijativne smjerove*].

36 Program book of the Radio Belgrade Third Programme, cycle *Muzička moderna*, years 1968–9, p. 10–11 [*Inače što se tiče ove Ksenakisove kompozicije, to je po koji put već imamo kompoziciju za solo instrument koja je samo demonstracija onoga što može instrument da odsvira. Imali smo jednog izvrsnog instrumentalistu virtuoza večeras, svakako virtuoz. Međutim, imali smo jednog 20–25 ili 30, ne znam koliko postupaka tako nekih tehničkih, da ih nazovemo, trikova koje je on izveo ili koji su totalno nepovezani među sobom*].

37 Dragutinović, 1968.

past, rightfully observed that music professionals' experience of listening to music is marred by a burden of habit, of certain expectation, which can prove limiting "if one considers certain music which has nothing to do with earlier music, which is the case with Xenakis, with entire Xenakis. In such a case, a wider audience is far more open [to novel sound] than the audience of composers, musicians, etc."[38] Stefanović, who was always open minded and curious when it came to novelty, still expressed his disappointment in himself that he was not able to understand any of the mathematical "precompositional" procedures and he regretted that the audience of the broadcast did not have a more competent interlocutor for this particular segment of the discussion.[39] It is obvious that these early attempts at presenting Xenakis's music in Serbia (in the seventh decade of the twentieth century) were hampered by the inability of local music critics to adequately mediate the full scope of the composer's creative endeavor, even to the interested audiences.

The following performance in Belgrade of a piece composed by Xenakis took place four years later, on 10 February 1972: his choral work *Nuits* (1967–8) was performed by the vocal soloists of the French Radio and Television choir at the Belgrade Philharmonic Hall, and the ensemble was led by the French conductor Marcel Couraud (1912–86). Two critical reviews of this performance are preserved, one written by the composer (Leon) Miodrag Lazarov (= Lazarov Pashu, b. 1949) for the Radio Belgrade Third Programme (broadcast on 11 February), and the other one published in the daily newspaper *Politika* by the composer Aleksandar Obradović (1927–2001). The younger of them, Lazarov, who at the time of this performance was still a student of composition, would later establish himself as one of a few radical minimalists in Serbian art music.[40] Obradović, on the other hand, belonged to the generation of composers who assimilated certain compositional techniques of the "Polish School" (notably controlled aleatorics) and elements of György Ligeti's (1923–2006) micropolyphony, and mixed them with traditional motivic work and sonata forms. Concerning the performance of *Nuits*, both critics point out the exemplary musicianship of the French artists. Lazarov qualifies them as "an ideal instrument" for the most contemporary music.[41] Obradović was even more pleased with the French artists:

38 Ibid, p. 12 [*Na kraju krajeva, radi se o tome da mi slušamo muziku ipak sa jednom izvesnom navikom, odnosno navikom izvesnih struktura koje poznajemo, analize koje smo radili i koje nas možda čak i sputavaju. Ako se radi o jednoj demonstraciji, o jednoj muzici koja nema uopšte nikakve veze sa prethodnom muzikom što je slučaj sa Ksenakisom, sa celokupnim Ksenakisom. U tom slučaju je široka publika daleko otvorenija nego li publika kompozitora, muzičara, itd*].

39 Ibid, p. 16–17 [*Ali, onako kako sam samo slušajući, dakle, primećujući samo auditivni utisak, opet sam imao onu asocijaciju, nažalost, kao što sam već rekao, 'iz struke' o kojoj ništa ne znam.* [...] *Da li za ovu priliku, s obzirom na tako veliki oslonac* [...] *onaj predmuzički i van muzički u čistoj matematici, da je koja sreća, čini mi se, da nije kad bismo ovde mi za slušaoce imali jednog poznavaoca...*].

40 For more on minimalism in Serbian art music, see Masnikosa, 2012, p. 181–90; Stojanović-Novičić, 2013, p. 357–67.

41 In addition to *Nuits*, they also performed the pieces *Exhortatio* (1970) by Luigi Dallapiccola, *Recitatif, air et variation* by Gilbert Amy (1970), and *Dodecameron* by Ivo Malec (1970). Cf. Lazarov, 1972. [*Ovog puta kao idealan "instrumentarij", oni su, izrazitom elastičnošću i tehničkom briljantnošću, izveli dela*: Opomena *Dalapikole*, Rečitativ, ariju i varijacije *Amija*, Dodekameron *Maleca i* Noći *Ksenakisa*].

> Twelve soloists of this chamber choir (6 female and 6 male) dispose of wonderful voice materials, homogenous, and exquisitely uniform, with astonishing perfection of pitch control [...]. I was under the impression that I was listening to a living organ, and that the excellent and intelligent artist—the conductor Marcel Couraud—was pulling out sound colors from this instrument as if he were changing organ stops and manuals. His refined affinity for extremely different styles [...] reveals high professionalism and extensive knowledge.[42]

While neither critic reviewed the individual pieces performed on the program, being more focused on the musicianship of the French choir and their conductor, it is interesting to mention that Obradović stressed out the dedication of the piece *Nuits* "to all political prisoners in the world!"[43] As a lifelong communist who as a teenager actively participated in WWII as a member of the liberation army, Obradović was clearly intrigued by this dedication from a composer who had also survived the horrors of war.[44]

The next performance of Xenakis's music in Belgrade took place on 10 January 1974, when his piece *Aroura* for twelve strings (1971) was performed by the Belgrade Chamber Ensemble, conducted by Boris de Vinogradov (1929–2008), at the Students' Cultural Center in Belgrade. Subsequently, two largely negative reviews of the concert appeared, this time focusing on the works themselves. The first one, written by the musicologist Mirjana Veselinović (= Veselinović-Hofman, b. 1948), revealed the author's impression that the extra-musical organization of the sound material in all the performed pieces did not produce truly impactful music.[45] Concerning Xenakis's piece *Aroura*, Veselinović briefly remarks that this work "lacks the musical expression of its professed goal: to discover and to investigate layers of sound."[46] Petar Ozgijan (or Osghian, 1932–79), Belgrade-based composer and occasional critic, who (similarly to Obradović) was keen to combine certain avant-garde compositional techniques with essentially neo-classical musical language, had an even harsher account of the pieces performed at the concert:

> One of the common characteristics of nearly all performed compositions [...] is the lack of good measure in terms of duration, where the authors simply did not pay attention to the perceptive abilities of a listener. This negative quality could be observed [...] notably in Xenakis's *Aroura* (1971), whose length doesn't only cause fatigue, but appears to be even more stretched out and boring due to the persistent repetition of the same compositional procedures.[47]

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42 Obradović, 1972 [*Dvanaest solista ovog kamernog hora* (*6 ženskih i 6 muških*) *raspolažu divnim glasovnim materijalima, homogenim i izvanredno ujednačenim, sa intonativnom perfekcijom koja zadivljuje* [...]. *Imao sam utisak da slušam žive orgulje na kojima je vrsni i inteligentni umetnik, dirigent Marsel Kuro, izvlačio tonske boje kao da je menjao orguljske registre i manuale. Profinjeni smisao za krajnje različite stilske pravce* (*od renesanse do avangarde*) *odaje visoki profesionalizam i široko znanje*].

43 Ibid. [[*P*]*osvećena svim političkim zatvorenicima sveta*!'].

44 For additional information about Aleksandar Obradović, see Janković-Beguš, 2017, p. 141–63.

45 Veselinović, 1974 [*Logičnost sistema kao takvog, ne obezbeđuje uvek umetničku komunikativnost zvučnog rezultata, smisao i epitet umetničkog dela. Tada taj sistem ima samo vrednost po sebi. Ovaj problem bio je evidentan na ovogodišnjem prvom koncertu iz ciklusa Muzička moderna. Izvedene kompozicije* [...] *postavljaju pitanje umetničkog dejstvovanja*].

46 Ibid. [*Delu Aroura za 12 gudača Janisa Ksenakisa, međutim, nedostaje i muzički izraz njenog–rečima samouvereno iskazanog—cilja: otkrivanje i ispitivanje zvučnih slojeva*]

47 Ozgijan, 1974 [*Jedna od zajedničkih osobina svih izvedenih kompozicija* [...] *jeste pomanjkanje osećanja mere*

Ozgijan also noted that the conductor Boris de Vinogradov "limited himself to the role of a reliable pointsman, allowing his exquisite musicians to navigate their own path through this 'traffic jam.'"[48] Clearly, *Aroura*, with its profuse use of *glissandi* over the duration of approximately twelve minutes, combined with an underwhelming performance, proved to be too much for Serbian music critics.

Equally unfavorable was the reception of Xenakis's *Medea* for male choir, four instruments and percussion (1967), on its performance at the Student's Cultural Center in Belgrade on 21 November 1974. The French conductor Couraud, who had received praise for his performance with the French vocal ensemble two years earlier, performed this time with the Belgrade Radio and Television Choir. Aleksandar Obradović commended the efforts of the Radio Belgrade Third Programme to keep the Belgrade audiences in touch with the contemporary music world within their series of concerts aptly titled *Musical Modernism*. However, he thought that the program was "pretty one-sided" and he also noted that the "pieces by the well-known bearers of contemporary modernism, Ligeti (*Lux aeterna*–for mixed choir (1966)) and Xenakis [...] left more of an impression of cerebral creations then music that one would happily listen to more than once."[49] In his opinion, a part of that lackluster effect resulted from Couraud's routine approach, which lacked creativity that could have stimulated the performance potential of the choir, consequently unravelling more of the musical substance of the abovementioned pieces.[50] Lazarov was equally unimpressed with the performance (which is reflected in the title of his review, "Nedorađenost u studiranju detalja" (The Incomplete Study of Details)):

> A great apprehension in approaching a contemporary music score is caused by its complexity. If it is not presented in its full scope, and especially if certain imprecision is allowed in the interpretation of details, the modern score loses its flexibility. [...] [At this concert] we must ascertain the lack of minute study of the scores, which inevitably reflected on our impression about the presented pieces.[51]

However, his criticism is directed not only towards the performance, but also towards the pieces themselves, and especially towards Xenakis's *Medea* which he labels the

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o dužini kompozicije, pri čemu autori jednostavno ne vode računa o mogućnostima percepcije slušaoca. To se i ovaj put moglo uočiti [...] *posebno u Ksenakisovoj* Aroura (*1971.*), *koja ne samo da zamara svojom dužinom već deluje još razvučenije i dosadnije usled stalnog ponavljanja istih kompozicionih postupaka*].

48 Ibid. [*Dirigent Boris de Vinogradov je u mnogim izvedenim kompozicijama sveo svoju ulogu na dobrog saobraćajca, prepustivši izvrsnim muzičarima da se sami snalaze u toj "saobraćajnoj" gužvi*].

49 Obradović, 1974 [*Kompozicije poznatih nosilaca savremene moderne, Ligetija* (Luks eterna – *za mešoviti hor*) *i Ksenakisa* (Medeja—*za muški hor, četiri instrumenta i udaraljke*), *izazvale su utisak više kao cerebralne tvorevine, nago kao muzika koja bi se rado još jednom čula*].

50 Ibid.

51 Lazarov, 1974 [*Velika opreznost pri pristupu tumačenja moderne partiture proizilazi iz njene kompleksnosti. Ako se ne tumači u punom njenom obimu, naročito ako se dozvoli nepreciznost u tumačenju detalja, moderna partitura gubi u svojoj fleksibilnosti.* [...] [*Na ovom koncertu*] *moramo konstatovati pomanjkanje detaljnog studiranja partitura, što se neminovno reflektovalo i na naš utisak o prezentiranim delima*].

"biggest surprise in a negative sense."[52] Following the ancient Greek instrumental and vocal tradition while enriching it with certain procedures of the avant-garde principles of composition, Xenakis created, in Lazarov's opinion, a "ridiculous, completely incoherent work which will either represent a passing, temporary weakness and delusion in his opus, or a turnaround in his creative output."[53] While *Medea* may not represent the pinnacle of Xenakis's incidental music, it certainly does not deserve the disdainful reviews that it has received from Lazarov or from another sharp-tongued Serbian composer-turned-music critic, Konstantin Babić (1927–2009), whose text is entitled "Neveseo zvuk avangarde" (Unjoyful Sound of the Avant-garde).[54] Babić was one of the more traditional composers of his generation who remained faithful to neoclassicism throughout his creative life, and his short text, published in the daily *Večernje novosti*, clearly illustrates the attitudes of the conservative music circles in Serbia towards the avant-garde music as a whole:

> In this concert, [...] the same unjoyful picture from the earlier "happenings" of the musical avant-garde was repeated once again. The sparse audience [...] greeted with anemic applause the pieces entitled *Tužbalica* [*Threnody*], *Radosno opelo* [*Joyous requiem*], *Medea*, *Sferoon* and *Lux aeterna*. [...] [A]ll these works are oddly similar, and they only present whining and certain stiff horror. [...] [A]ll these compositions are based on the repetition of a small number of technical procedures, which lethally impoverishes the already unconvincing content. All this music seems static, immobile, cramped or, at times, manic and hysterical.[55]

On the other hand, Lazarov displays an increasingly hostile attitude towards any music that is not serial or radically minimalist–since, in his opinion, only these two main principles ("the maximization of serialization and minimization of constitutive elements") characterize Modernist thinking from the 1960s onwards.[56] All other approaches to contemporary music, which fall somewhere "in-between" these two, produce "vulgarisms of a smaller or larger scope."[57] He expresses these attitudes in

52 Ibid. [*Najveće negativno iznenađenje, ako tako može da se kaže, predstavljalo je izvođenje dela* Medeja *za muški hor i pet instrumentalista Janisa Ksenakisa*].

53 Ibid. [*Pridržavajući se stare grčke instrumentalne i vokalne tradicije, a obogaćujući je pojedinim postupcima avangardnih principa komponovanja Ksenakis je napravio smešno, poptuno nekoherentno delo, koje će u njegovom opusu predstaljati ili prolaznu, trenutnu slabost i zabludu, ili zaokret u stvaralaštvu*].

54 Babić, 1974, p. 27.

55 Ibid. [*I na ovom koncertu* [...] *ponovila se ona nevesela slika sa ranijih „priredaba" muzičke avangarde. Malobrojna publika* [...] *pozdravila je malokrvnim aplauzima kompozicije sa nazivima* Tužbalica, Radosno opelo, Medeja, Sferoon *i* Luks eterna. [...] [*S*]*va ova dela* [*su*] *neobično slična i što se u njima zapaža samo lelek i kuknjava i neka ukočena strava.* [...] [*U*] *svim ovim kompozicijama ponavljaju svega nekoliko tehničkih postupaka, koji ubistveno osiromašuju ionako neubedljiv sadržaj. Sva ova muzika deluje statično, ukočeno, zgrčeno, ili, katkad, panično i histerično*].

56 Lazarov, 1978 [*Ako je za Modernu, maksimalizacija serijalizacije i minimalizacija konstitucije karakteristika posle šezdesetih godina, tada su svi oni drugi pristupi emanacija nečega što se nalazi između toga, te se, u komparaciji sa prethodnim kategorijama, odnose ili sa pozicija neshvatanja prave suštine stvari* (*često i sa pozicija odsustva želje za shvatanjem*)*—stoga su u stanju da proizvode vulgarizacije manjeg ili većeg obima—stvarajući izomorfne oblike*].

57 Ibid.

his review of the concert performance given by the renowned harpsichordist Elisabeth Chojnacka (1939–2017), herself a champion of Xenakis's music, on 23 February 1978, again at the Students' Cultural Center (she performed *Khoaï* for solo harpsichord (1976), among other pieces). While Lazarov calls Chojnacka "the harpsichordist with an extraordinary affinity for performing pieces of avant-garde music (probably one of the most convincing that we have ever heard in Belgrade)," he feels that the majority of pieces performed were exemplary of the abovementioned "third approach," i.e., neither serial nor minimalist—and in his opinion this is particularly true of the compositions by Xenakis, Luc Ferrari (1929–2005) and partly by François-Bernard Mâche (b. 1935):[58]

> Iannis Xenakis generally finds himself in the rift between the total serialization […] and the amalgamation of Greek folk idioms. However, his harpsichord piece *Khoaï* apparently insists on these shortcomings of Xenakis's creativity, the shortcomings caused by the insufficient correlation between the elements necessary for shaping the musical form. Thus, *Khoaï* is formally divided in two parts: the first is dominated by the elements of quasi-minimalist approach […] and especially by the elements of Greek folklore; in the second part (in stark contrast to the first) we observe neo-punctualist elements (but not in the Webernian sense), closer to atonality in any case. From a structural point of view, this approach does not provide the possibility to ensure the coherence of the piece; these are the shortcomings of earlier Xenakis's works and they are factually explicit in this piece as well.[59]

The same harpsichord piece, together with several other important works by Xenakis, was performed once more in Belgrade several years later, on 24 April 1985 at the National Museum in Belgrade. This was a particularly festive occasion as it marked the only time that Xenakis himself visited Belgrade. The concert was co-organized by the Radio Belgrade Third Programme, French Cultural Center (today the French Institute) in Belgrade and the Serbian concert agency Jugokoncert.[60] The concert featured Xenakis's

58 Ibid. [*O upravo ovom, trećem pristupu* (*koji je na 'pola puta,' koji je negde između glavnih principa karakterističnih za način mišljenja Moderne*) *može biti reči kada se želi izvršiti nekakva klasifikacija dela izvedenih od strane Elizabete Hojnacke, inače klavsenistkinje sa izvanrednim smislom za tumačenje dela avangardne muzike* (*verovatno jedne od najuverljivijih koje smo uopšte čuli u Beogradu*). *To se pre svega odnosi na kompozicije Janisa Ksenakisa, Lika Ferarija i delimično na Fransoa-Bernara Maša*]

59 Ibid. [*Janis Ksenakis se i inače nalazi u procepu između totalne serijalizacije* […] *i amalgamizacije grčkih folklornih idioma.* Khoai, *delo za klavsen, međutim, kao da u ovom smislu potencira upravo te nedostatke Ksenakisovog stvaralaštva, nedostatke dovoljnosti korelacije između elemenata potrebnih za oformljenje. Tako se* Khoai *formalno razgraničava u dva dela: u prvom dominiraju elementi kvaziminimalističkog pristupa* […] *i izrazito— elementi grčkog folklora; u drugom* (*suprotno*) *evidentiramo neopunktualne elemente* (*no ne u Vebernovom smislu*), *svakako bliže atonalnosti. Ovakav pristup, u strukturalnom smislu ne pruža mogućnost obezbeđenja koherencije dela; ovo su mane i ranijih Ksenakisovih ostvarenja, one su se kao činjenica eksplicirale i u ovom*].

60 This visit was made possible by the fact that in April 1985 Xenakis was the guest of the Muzički Biennale Zagreb (Music Biennale Zagreb), the oldest festival of contemporary music in ex-Yugoslavia (today in Croatia), together with several other world-known contemporary composers such as John Cage, Luciano Berio and Krzysztof Penderecki. Cf. Pešić, 1985. As observed by Ivana Medić, the entire cycle *Muzika danas*/*Muzička moderna* (which was renamed once again in its final year, 1985, as *Musica viva*) relied heavily on the program of the Music Biennale Zagreb, since the Radio Belgrade Third Programme did not dispose of financial resources to invite foreign performers and composers. See

recent compositions dedicated to and written especially for Elisabeth Chojnacka and the percussionist Sylvio Gualda, both of whom performed in this concert: *Khoaï*, *Psappha* for percussion (1975), *Naama* for harpsichord (1984) and *Komboï* for harpsichord and percussion (1981). According to the musicologist and music critic Zorica Premate (b. 1956), the composer attempted to animate to the extreme all of the creative, performing, and technical capabilities of these sensitive musicians, and he did so to a great result: "the pieces with their enormous internal expressiveness, extraordinary technical demands and untamed temper, left the performers and the audience nearly out of breath."[61] Premate rightfully observes that all these pieces were created within the same circle of inspiration and ideas, with similar compositional-technical and formal solutions. Thus, "[t]he concert was envisaged as the development of a single idea and of a certain creative principle: during the performance it was first exposed, then elaborated in several variants, culminating with the performance of the final piece."[62] Unlike previously cited authors, Premate's reception of Xenakis's music is highly favorable:

> Iannis Xenakis convinced us with his music that the work created [...] with the aid of calculations and mathematical logic, does not have to be inartistic, even when measured by the classical aesthetic methods which observe form, clarity, dramaturgy, and even compositional technique. The performed pieces did not reveal their mathematical, non-media origin, not for a single second. Even more, with their clear, usually fragmentary form, where each segment represents a logical continuation and adds to the dramaturgical development of the whole, and especially with their gigantic agglomerates of energy and authentic temper, these stochastic compositions carry within themselves more liveliness and they draw attention much more that many other, classically composed contemporary pieces. Nevertheless, because Xenakis is above all an artist, and only then mathematician and someone infatuated with computer technology, many bits of his scores show [human] interventions compared to the would-be computer dictated shape of the work. It is apparent that Xenakis uses mathematical programs and their digital superstructure as some sort of 'material,' not even as a strict compositional technique; and that after many years of avant-garde experimentation and exploring possibilities with stochastics, music is what is most important to him.[63]

Medić, 2015, p. 142, 144.

61 Premate, 1985 [[*Izvedene*] *kompozicije svojom ogromnom unutarnjom ekspresijom, izuzetnim tehničkim zahtevima, neobuzdanim tempermentom ostavile su gotovo bez daha i izvođače i publiku*].

62 Ibid. [*Koncert je bio i osmišljen u smislu razvoja jedne ideje i određenog stvaralačkog principa koji je, tokom izvođenja, izložen, pa razrađen u nekoliko varijanti, kulminirao poslednjom izvdenom kompozicijom*].

63 Ibid. [*Janis Ksenakis nas je, svojom muzikom, uverio da delo nastalo* [...] *uz pomoć računskih operacija i matematičke logike, ne mora biti i neumetničko čak i ako je mereno klasičnim estetskim merilima koja se bave formom, jasnoćom, dramaturgijom, pa i samom kompozicionom tehnikom. Izvedena dela nisu ni jednog trenutka odala svoje matematičko, nemedijsko, poreklo. Čak, jasnom formom, uglavnom fragmentarnog oblika u kojoj svaki odsek predstavlja logičan nastavak i dramaturški razvoj celine, a pogotovu ogromnim akumulacijama energije i izvornog temperamenta, ove stohastičke kompozicije nose u sebi više živosti i vezuju pažnju u mnogo većoj meri od mnogih drugih, klasično komponovanih savremenih dela. Ipak, kako je Ksenakis pre svega stvaralac, pa tek onda matematičar i zaljubljenik u kompjutersku tehniku, na mnogim mestima u pariturama, vidljive su stvaralačke intervencije u odnosu na kompjuterski diktiran izgled dela. Očigledno je da se Ksenakis služi matematičkim programima i njihovom digitalnom nadgradnjom kao 'materijalom,' čak ne ni kao striktnom kompozicionom tehnikom i da mu je, nakon godina avangardnog eksperimentisanja i ispitivanja mogućnosti u okviru stohastike, najvažnija muzika*].

Premate lauds the exceptional potential of the performers whose temper, as well as their immersion into the performed pieces, contributed a great deal to the success of the concert of Xenakis's music. She stresses the surprising sonic potential of the harpsichord "which sounded like a powerful percussion instrument such as the xylophone, glockenspiel, bells or marimba, or as an electronic generator."[64] In the manner of a music critic who truly understands contemporary music in all its facets, Premate concludes her review with the following remark: "In his rich creative fantasy, Xenakis has succeeded in creating a sound whose timbre is nearly identical to that of electronic music—but in contrast to the majority of generator synthetized pieces, it contains a high level of living, tangible human emotion."[65]

However, the same level of enthusiasm for the same concert was not shown by another Serbian music critic, Milena Pešić (b. 1941). In her account, entitled "Grubost zvuka" (The Roughness of Sound), she focuses on the resemblance of Xenakis's aesthetic postulates to those of his "role-model" Le Corbusier, "submitting [...] to the forms of machinist civilization, castrated lines and cubic shapes."[66] Unlike Premate, Pešić is not impressed with Xenakis's treatment of musical form and micro-structure:

> Using a habitual auditory method of observation, we could not detect the living music cells and their natural morphogenesis in the given timeframe [...]. The pieces *Naama* and *Khoaï* revealed to what extent this fragile instrument [the harpsichord] could be deformed by the aggression of the cluster sounds. Sylvio Gualda's virtuoso performance on various percussion instruments, including ceramic jars, did not reduce the acoustic terror, just as the astonishing skill and complementarity between him and Chojnacka in the performance of *Komboï* was not sufficient on its own.[67]

While Pešić acknowledges the spirit of experimentation which has contributed to Xenakis's reputation as one of the most prominent contemporary composers, she comments on what she observes as a certain lack of evolution in his music writing: "the avant-garde, which lasts too long and which stays the same, inevitably becomes fossilized."[68] It has to be mentioned that by the time of Xenakis's arrival in Serbia, the avant-garde musical thinking had already begun its decline, making way for the rise of postmodernist approaches which were no longer concerned with ideas of progress and novelty, but which (re-)established various forms of dialogue with the musical past.

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64 Ibid. [*Iznenadili su zvučni potencijali čembala koje je zvučalo kao moćna udaraljka, ksilofon, zvončići, zvona ili marimba, ili pak, kao elektronski generator*].

65 Ibid. [*U svojoj bogatoj stvaralačkoj fantaziji, Ksenakis je uspeo da ostvari zvuk, po boji gotovo identičan elektronskoj muzici, a ipak za razliku od većine dela sintetizovanih na generatoru, visokog naboja žive, opipljive ljudske emocije*].

66 Pešić, 1985 [*Usvojivši estetske postulate svoga uzora* [*Korbizjea*], *podređene* [...], *formama mašinske civilizacije, kastriranih linija i kubusnih oblika, Ksenakis je nastojao da slične matematičko-projektantske radnje implantira u tkivo muzike*].

67 Ibid. [*Uobičajenim auditivnim načinom nismo mogli da otkrijemo žive ćelije muzike i njihovu prirodnu morfogenezu u zadatom vremenu* [...]. *Kompozicije* Naama *i* Koai *za čembalo otkrile su do koje mere ovaj krhki instrument može biti deformisan agresivnošću klasterskog zvučanja. Bravurozno izvođenje Silvija Gualde, njegovo virtuozno snalaženje na raznovrsnim udaraljkama među kojima su bili i keramički ćupovi, nije umanjilo akustički teror, kao što ni zadivljujuća veština i komplementarnost njega i Hojnacke u delu* Komboi *nije sama sebi mogla biti dovoljna*].

68 Ibid. [*No, avangarda koja predugo traje, ne menjajući se, doživljava neminovnu fosilizaciju*].

Conclusion

The final performance of Xenakis's music in Belgrade during the composer's lifetime occurred on 26 May 1998, when one of his earliest preserved pieces was included in the concert program of the French contemporary music ensemble Accroche note: *Ziya* for soprano, clarinet, and piano (1952).[69] It was my first live encounter with Xenakis's music, albeit with an uncharacteristic piece, and the beginning of a life-long fascination with his creative opus.

Owing to the enthusiasm and dedication of the Radio Belgrade Third Programme, the presence of Xenakis's music on Belgrade concert podiums was considerable over several decades (in the 1960s, 1970s, and 1980s), especially in comparison to the music of other reputable European modernists of his generation. Even though the concerts of the *Muzika danas/Muzička moderna/Musica viva* cycle usually took place in smaller venues in Belgrade and were not attended by large, live audiences (not including the radio audience), they attracted the interest of various music critics, although their reception of modernist music—including Xenakis's own—was more often unfavorable than not. Xenakis's reputation as one of the contemporary music greats, as well as the opportunities to hear renowned European performers, were the most likely reasons for the critics' interest in these concerts. The pieces themselves were usually received with the habitual skepticism of the Serbian music establishment towards avant-garde music. Only Zorica Premate, and as late as in 1985, fully embraced Xenakis's musical *procédé* and paved the way for future understanding of his music in Serbia. However, since the composer's death, his works have been presented in concerts in Belgrade sporadically, notably within the framework of the International Review of Composers, and rarely in other settings.[70] Serbian concert stages have yet to welcome any of Xenakis's major large-scale works, giving yet another testimony to the persisting traditionalist taste of the majority of Serbian music institutions.[71]

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69 The concert took place within the program of the 7th International Review of Composers in Belgrade, at the Kolarac Foundation Hall. The program also featured works by other French contemporary composers (Mâche, Dutilleux, Prin, Dusapin, and Aperghis) and one piece by Petar Bergamo (1930–2022). Several years earlier, Xenakis's piece *Rebonds* for solo percussion (1987–9) was performed by the Romanian percussionist Liviu Dănceanu at the 4th International Review of Composers in Belgrade, on 13 May 1995 at the Foyer of the Sava Center, within the concert presented by the Ensemble *Archaeus* from Bucharest which featured mainly Romanian contemporary music. More information about the International Review of Composers' history and programming in Janković-Beguš and Medić, 2020, p. 139–68.

70 Apart from the already mentioned, Xenakis's pieces were performed three more times within the International Review of Composers after the composer's death: *Akea* for piano and string quartet (1986) on 12 May 2002 at 7:00 PM, Kolarac Hall (Ensemble Avantgarde, Germany), *Waarg* for thirteen musicians (1987–8) on 15 November 2009 at 8:00 PM, Kolarac Hall (Klangforum Wien, Austria, Conductor Emilio Pomárico), and *Theraps* for solo double bass (1975–6) on 7 October 2016 at 5:30 PM, National Bank of Serbia (Goran Kostić, Serbia). Most recently, Serbian percussionist Darko Karlečik performed *Rebonds B*: the concert took place on 2 September 2022 at 8:30 PM at the District Music Stage in Novi Sad.

71 For instance, the Belgrade Philharmonic Orchestra, as arguably the best orchestral ensemble in Serbia, has never performed any of Xenakis's works.

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5. Iannis Xenakis in Japan: Productive Performances and Reception of Texts

Mikako Mizuno

Introduction

This text was given as an introduction to the lecture-concert presented by Yasuko Miyamoto (b. 1970) on 1 October 2022, in Nagoya, as part of the Japan team's contribution to the Meta-Xenakis Symposium, and offers a short description of Japanese performers who contributed to the reception of the work of Iannis Xenakis in Japan. This overview covers only a few performers, but it demonstrates their important impact on the music scene in Japan to this day.

Over the last two decades several excellent younger players of Xenakis's work have emerged. They were all born in Japan and are establishing a new phase of Xenakis performances in Japan. They succeed the first generation of performers, who had shared with Xenakis the same years of the cultural avant-garde period after World War II.

We can say that the years between 1960 and the early 1970s generated the first phase of Xenakis's reception in Japan, and that the second phase encompasses the period from the 1990s until the present day.

First Generation, First Phase

The first generation of Japanese Xenakis performances were led by Yuji Takahashi (b. 1938) and Aki Takahashi (b. 1944), who presented Xenakis's piano works, as well as, for the former, his texts on philosophical and mathematical theories. In February of 1962, Yuji Takahashi premiered *Herma* (1961) in Tokyo, which the pianist had commissioned directly from the composer. Takahashi wrote about the process of commission and the piece:

https://doi.org/10.11647/OBP.0390.07

> I first met Xenakis when I played Takemitsu's *Piano Distance* at a Sogetsu Art Center concert [in 1961]. Later, at the recommendation of Kuniharu Akiyama [1929–96],[1] I wrote a letter to Xenakis and commissioned a piano piece from him. The piece I received was *Herma*. It took thirty days of practice, dividing it into small sections, because the piece jumps all over the keyboard. The younger generation of pianists later criticized me if I played these rhythms incorrectly. But the score, by using a grid of 1/5 and 1/6 of the probability-calculated time of occurrence of the notes, vaguely reflects music that cannot be written in regular rhythms. My hands and fingers playing those phrases bring out unexpected music. Two layers of sound are simultaneously heard: a slow-moving surface and a fast-scattered line.[2]

Takahashi played as soloist for the world premiere of *Eonta* (1964) in December 1964 in Paris with Pierre Boulez (1925–2016) conducting, and played that same piece in the project Orchestral Space on 4 May 1966, at Nissei Theater (Tokyo) with the brass players of Yomiuri Nippon Symphony Orchestra.[3] The project Orchestral Space was planned and designed by Tōru Takemitsu (1930–96) and Toshi Ichiyanagi (1933–2022). It was one of the big series of contemporary music events which were held in the 1960s to introduce and promote cutting edge Western compositions.[4] Notably, 1966 was the year Karlheinz Stockhausen (1928–2007) came to Japan and created *Telemusik* (1966) and *Solo* (1966) in the NHK electronic music studio. Stockhausen gave a lecture, including an introduction to the concept of stochastic music, but there was no information in Japan about the theory of Xenakis's stochastics until 1975 when Yuji Takahashi translated and published parts of Xenakis's *Music and Architecture*.[5] In the 1970s Yuji Takahashi translated some other texts by Xenakis and published some articles in the magazine *TRANSONIC*, among others.[6]

The first collaborations between Xenakis and Japanese musicians culminated in the Osaka World's Fair (1970) and the preparatory process of *Hibiki-Hana-Ma* (1969–70) in the NHK's electronic music studio. This experience made important footprints not only on musical concepts among Japanese contemporary composers but also on collaborative teamwork between musicians and engineers of electronic music.[7]

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1 Kuniharu Akiyama was the husband of Aki Takahashi, and a well-known music critic as well as a sound artist associated with the Fluxus movement.

2 Yuji Takahashi, "Who – Where –, no.2 Iannis Xenakis," https://www.suigyu.com/yuji/ja-text/dare_doko1-11.html#xenakis (translation by the author).

3 The concert featured: *Sosokusonyu* by Joji Yuasa (b. 1929), *AMBAGES* by Roger Reynolds (b. 1934), *Eclipse* by Tōru Takemitsu (1930–96), *The Wonderful Widow of 18 Springs* (1942) by John Cage (1912–92), and *Eonta* (1963) by Iannis Xenakis.

4 The others are: Sogetsu Art Center Contemporary Series, Contemporary Music Festivals of Nijyusseiki ongaku kenkyujyo (research institute of twentieth-century music) and the Contemporary Music Festival of Autumn of Osaka. Takahashi premiered *Herma* at a concert as part of the Sogetsu Art Center Contemporary Series.

5 Xenakis, [1975] 2017.

6 For example, a translation of the ninth chapter of *Formalized Music*, in the fourth volume of the magazine *TRANSONIC*, or *Chi no senryaku Xenakis no baai* (Strategy of Knowledge in the Case of Xenakis), *Eureka*, April 1974, in which Takahashi explains and summarizes Xenakis's theory of stochastics, combination, and sieves as an intellectual strategy.

7 See Chapter 17 in this volume for more information on this subject by the same author.

Also, *Evryali* (1973) and *Herma* (1961), as well as the Japanese premiere of *Synaphaï* (1969), all played by Yuji Takahashi in the 1970s, were so fascinating that many young and future Japanese musicians became determined to proceed to study and research Xenakis and his theories, and strived to attain the level of virtuosity required to perform his music.

For example, the percussionists Sumire Yoshihara (b. 1949), Yasunori Yamaguchi (b. 1941), and Jun Sugawara (b. 1947) should be mentioned as part of the generation that was inspired by those early exposures to Xenakis's music. All of them have included Xenakis's percussion works in their repertories. In turn, they themselves made recordings which have become the established models for Japanese contemporary percussion performance.

Yoshihara's performance of *Psappha* has also been highly influential because she, like Yamaguchi, has been a professor in music colleges and universities in Japan. In the workshop organized around Xenakis, after having been awarded the Kyoto Prize on 12 November 12 1997, Yoshihara played *Psappha* (1975) in celebration of Xenakis.

In 1988, Jun Sugawara held a concert entitled "Sound of Xenakis and Yuji Takahashi." The program was composed of works by Xenakis (*Persephassa* (1969), *Psappha* (1975), *Dmaathen* (1976)) and by Yuji Takahashi (*Lullaby* for marimba (1985) and *Wolf* for percussion (1988, world premiere)).

Pianists Following Takahashi

In the 1990s, the second generation of pianists took on the challenge to perform recitals featuring the music of Xenakis, Stockhausen, Boulez, and György Ligeti (1923–2006). Leaders of this new generation of pianists included Hiroaki Ooi (b. 1968) and Hideki Nagano (b. 1968).

Hiroaki Ooi started his career as a self-taught pianist and is now a multi-keyboardist. In July of 1996, Hiroaki Ooi received attention when he played and recorded the piano solo for *Synaphaï*, with the Japan Philharmonic, with Michiyoshi Inoue (b. 1946) conducting.[8] At that time, Ooi was the youngest Xenakis performer in Japan. Three concerts conducted by Michiyoshi Inoue were held in Tokyo and Kyoto featuring *Synaphaï* with Ooi. The performance in Kyoto was recorded, and Xenakis received this recording via his publisher Salabert. As Xenakis listened to the recording, he said that Japanese musicians are interesting because they play "so precisely."[9] Xenakis's principal publisher, Salabert, used that recording as an exemplary reference of *Synaphaï* for promotional purposes for many years.

8 This performance can be viewed here: PTNA, "Xenakis 'Synaphai' Ooi/Inoue/NewJapanPhilharmonic" (18 September 2018), *YouTube*, https://www.youtube.com/watch?v=rZYN4kdorVQ

9 Takuo Ikeda, "Japan Premiere of Xenakis' 'Cecrops'!" (10 February 2022), *TPO*, https://www.tpo.or.jp/information/detail-20220210-01.php (translation by author).

In 2001, Ooi received the Idemitsu Music Award[10] and performed the Japanese premiere of *Erikhthon* (1974) with the Tokyo City Philharmonic Orchestra conducted by Tatsunori Numajiri (b. 1964). Ooi played *Synaphaï* for a recording with Arturo Tamayo in 2002, and in 2004 he was featured in Tamayo's recording of *Erikhthon*, both with the Luxembourg Philharmonic Orchestra and released on the Timpani label.[11]

In the booklet Salabert published to commemorate the 10th anniversary of Xenakis's death in 2011, Ooi composed *Oser Xenakis* (Daring Xenakis):

> Before tackling *Synaphaï*, it is necessary to go through his three solo piano pieces carefully. [...] The more training you have, the more you may be frustrated that you cannot play the music at sight, and that it is far removed from the academic conservatory style.[12]

Ooi played all of Xenakis's solo piano pieces in a concert titled "Portraits of Composers #6" on 23 September 2011, in Hakuju Hall in Tokyo. And in 2022, he played the Japanese premiere of *Keqrops* (1986) with the New Japan Philharmonic conducted by Michiyoshi Inoue.

The Summer Festivals and the Prize by Suntory Foundation for the Arts

The millennium successors had experienced several important Xenakis events in Japan in their younger days, such as the world premiere of *Horos* (1986), commissioned by Suntory Hall. The Suntory Hall International Composition Commission Series was a project through which Suntory Hall commissioned new orchestral pieces from leading composers selected by the music director, Tōru Takemitsu (1930–96). The selected composers themselves would be in charge of selecting works, responding to prompts including "works that have influenced me" and "young composers I am paying attention to." In 1986, Xenakis was selected for the second concert of the series, for which he composed *Horos* and where Olivier Messiaen's (1908–92) *Chronochromie* (1960) and François-Bernard Mâche's (b. 1935) *La Peau du silence I* (1962) were also featured. That concert was performed by the Japan Philharmonic Orchestra conducted by Hiroyuki Iwaki (1932–2006).

In 1997, there was a celebration concert for Xenakis who won the Kyoto Prize that year, and the Suntory Summer Festival thematized Xenakis, and featured two nights of Xenakis's work.[13] The first night included: *ST/4* (1956–62), *Jalons* (1986), *Phlegra* (1975), *Tetras* (1983), and *Persephassa* (1969).[14] The second evening was an orchestral

10 Ooi was awarded the "Best young musician of the year" with a strong recommendation by Takahiro Sonoda (1928–2004), who was a member of the jury of the Messiaen International Competition.

11 Luxembourg Philharmonic Orchestra, Ooi, and Tamayo, 2007.

12 Barthel-Calvet, 2011, p. 7.

13 The text of Xenakis's acceptance speech can be read both in Japanese and in English at: https://www.kyotoprize.org/wp-content/uploads/2019/07/1997_C.pdf

14 Norio Sato (conductor), Ensemble Nomade, Alberi String Quartet; percussion: Jun Sugawara,

concert with the Tokyo Philharmonic Orchestra, conducted by Hiroyuki Iwaki, playing *Syrmos* (1959), *Synaphaï, ST/48* (1962), and *Kyania* (1990). This time, the solo pianist in *Synaphaï* was Hideki Nagano (b. 1968), who had been a member of the Ensemble InterContemporain since 1995.

In 2012, the Suntory Summer Festival produced its original production of the complete staging of Xenakis's *Oresteïa*. The *Oresteïa* was first staged in Japan as a suite for mixed choir in 1976 at Nissei Theater (Tokyo), which was conducted by Yuji Takahashi. In the program pamphlet, Takahashi wrote about the universe and music of Xenakis:

> The kernel of Xenakis's music and his thought can be said to liberate man from the wheel of destiny into which he is thrown. Science, history, and culture are all tools for this journey of the human spirit, and the artist, as the freest in the realm of the intellect, assumes the role of pilot to carry out this mission.[15]

Xenakis started to compose his *Oresteïa* in 1965 and completed it in 1966 in Japan, where Xenakis stayed in our country for a short time. In 1986, *Kassandra*, and in 1992, *La Déesse Athéna* were composed, both of which include solo voice. In 2012, *Horos* was selected by Toshio Hosokawa (b. 1955), who was then the music director for the series. It was the second performance of *Horos* in Japan in Suntory Hall, which was realized by Kazuyoshi Akiyama (b. 1941) and the Tokyo Philharmonic Orchestra.

In 1992, the 15th concert of the Suntory Hall International Composition Commission Series, for which José Maceda (1917–2004) was selected, featured Maceda's new piece *Distemperament* (1992), Edgard Varèse's *Intégrales* (1924) and Xenakis's *Kyania* (1990), as well as Yuji Takahashi's *Thread Cogwheels* (1990). *Intégrales* is, as Maceda asserted, responding to the prompts indicated above, the "work that has influenced me" and stated that Xenakis and Takahashi are the "young composers I am paying attention to."[16] All four pieces were performed by the New Japan Philharmonic conducted by Yuji Takahashi.

The baritone, Takashi Matsudaïra (b. 1963), known as a specialist of Stockhausen, applied his marvelous voice in this 2012 production of Xenakis's *Oresteïa*. Takashi Matsudaïra wrote a minute analysis about the *écriture* of Xenakis on his website.[17] The stage sound plan was designed by Sumihisa Arima (b. 1965). Sumihisa Arima is the key person for today's electronic staging in Japan, and he worked as the sound designer and operator also for Xenakis's *Persépolis* (1971) produced in Akiyoshidai in 2020.[18] *Persépolis* in Akiyoshidai was an open-air, electroacoustic performance, and

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Toshiyuki Matsukura, Takafumi Fujimoto, Kyoko Kato, Daiji Yokota, and Yu Ito.

15 Takahashi, 1976. Program pamphlet translated by author.

16 José Maceda quoted in Kakinuma, 1992, p. 84–5. Although Xenakis was seventy years old and Yuji Takahashi was sixty-two years old in 1992, Maceda, at seventy-five years old, was still their elder, and therefore viewed them as "young composers"!

17 Takashi Matsudaira, "Writing for the Baritone Solo in Xenakis's 'Oresteia,'" http://matsudaira-takashi.jp/analysis/oresteia/

18 "Persepolis: Tape Music Played at Akiyoshidai," *Akiyoshidai International Art Village*, https://aiav.jp/13357/

with the contribution of Arima and the lighting designer Tomomi Adachi (b. 1972). This concert was awarded the Saji Keizo Prize from the Suntory Foundation for the Arts.

The Year of Xenakis's Centennial

In 2022, there were several concerts prominently featuring Xenakis as a celebration of the centennial of his birth. For example, musicians and ensembles like Quartiers Musicaux, Trio à Cordes de Pointe, Izumi Sinfonietta, Ichiro Nodaïra (b. 1953) and the Arditti Quartet. Also the Tokyo Philharmonic Orchestra featured a special concert including the Japanese premiere of Xenakis's piano concerto *Keqrops*, featuring pianist Hiroaki Ooi, conducted by Michiyoshi Inoue. The percussionist, Kuniko Kato (b. 1969), produced a concert titled *Xenakis and Dance* in SAïTAMA. The Suntory Summer Festival had a day titled *100% Xenakis*. The musical group Nymphe Art had a concert which focussed on Xenakis. Kunitachi College of Music produced a special event titled *transmitting/transmitted by hearing*.

Yasuko Miyamoto and Sumire Yoshihara

After graduating from the department of music of *Doshisha Women's College of Liberal Arts*, Yasuko Miyamoto went to Germany and graduated from the Freiburg College of Music's soloist course in 1999.

When she encountered Xenakis's score of *Psappha*, she was shocked because she did not know how to interpret its notation. She took two months to rewrite by herself the seemingly graphic notation of *Psappha* into a more traditional type of musical score. Miyamoto has been deeply impressed by Yasunori Yamaguchi and Sumire Yoshihara concerning their performance styles in contemporary music. And it was Sumire Yoshihara who directly showed her how to perform *Psappha*.

Under the influence of Yamaguchi and Yoshihara, Miyamoto studied *Zyklus* (1959) and *Kontakte* (1958–60) by Stockhausen and works by Luc Ferrari (1929–2005). In Freiburg, Miyamoto also challenged a wider variety of repertories[19] under Professor Bernhard Wulff (b. 1948).

In Europe, she played as a member of Ensemble Charis (Zurich), YMMO Ensemble (Freiburg), and performed as a guest player for Ensemble Recherche (Freiburg), Musikfabrik (Köln), Radio Symphony Orchestra Stuttgart, Sinfonieorchester Basel, and Bremen Philharmonie.

In contrast to Stockhausen's pieces, in which performers have the heavy duty of interpreting many indications concerning how to use the mallets, or the necessity

19 "Information: 2001," *Yasuko Miyamoto*, http://www.yasukomiyamoto.com/information/2001.html

of needing to memorize the tape sounds, Xenakis's pieces, Miyamoto says,[20] give performers free choices, which demand a performer's own imagination.

For example, in *Rebonds B* (1987–9), the composer indicates at places to play "wooden instruments." So, Miyamoto tried with wood blocks. But she had to abandon simply playing wood blocks because it is impossible to play *pianissimo tremolo* with normal wood blocks. Her teacher, Sumire Yoshihara, put several rubber bands on the wood blocks which muted them. Miyamoto realized that performing Xenakis should mean finding a way to create timbre. Again, it demands the performer's imagination.

As an example, this video linked in this footnote starts with excerpts from *Rebonds B* performed by Yasuko Miyamoto and the dancers Tamae Ogawa & TM Performance Professional (TMPP).[21] *Okho* (1989) follows with Mitamoto's short explanation about the instruments.

Rebonds B and accompanying dance was recorded in February 2004 in Kyoto Arti Hall, which was a part of the Arti Dance Festival 2004. Their performance was titled "Sozo Kukan, Dance no Miraï vol.2" (Space for Creation, Dance in the Future vol.2).

The dancer/choreographer Tamae Ogawa[22] made a table of rhythms from the score of *Rebonds B* as a choreographic notation. Keeping to the beat of the semiquaver, the dancers responded to the musical accents and made interesting movements.

Concerning this video recording of *Okho*, Miyamoto herself talks about how she and her collaborators approach timbre in Xenakis. For the performance recorded in the video they used three sets of multi-percussions, replacing the three djembes called for in the score, and various sticks: long and heavier sticks, mallets for timpani, beaters for bass drum, rubber tipped mallets, hand-made sticks with rubber to be handled, cooking chopsticks etc. In the twenty years of her activities as a percussionist, Miyamoto has performed all of Xenakis's percussion solo and ensemble pieces in Europe and Japan. Miyamoto indicates in the video that she found a phrase in *Rebonds A* which appears also in the last part of *Okho*. She feels quite excited when that phrase appears.

20 In an online interview with the author (18 April 2022).

21 Mikako Mizuno, "Yasuko Miyamoto, Meta-Xenakis," *Vimeo*, https://vimeo.com/802224852/1e49632017?share=copy. Recorded at Shokeikan Hall of Doshisha Women's College, Kyoto, on 5 September 2002. Recording provided by Masanori Kasai and Kazuko Narita.

22 Tamae Ogawa started a dance project named "Butai Bijyutsukan" (Performance Museum) in 1989. Since then, she has been actively creating dance workshops in collaboration with contemporary artists: musicians, visual artists, stage designers. In 1996, she founded her company TMPP and produced several performances: Kyoto City Art Festival, Kyoto Sozo Kukan projects 2001/2002/2003/2004/2005, the 40th anniversary ceremony of the EXPO'70 world exhibition, the 26th National Cultural Festival, etc.

アルティ・ブヨウ・フェスティバル 2004

1991年から国内外の舞踊団・個人を公募するA公募公演と、その時々の注目されているアーティストや作品を上演するB特別公演の2本立てで、準備リハーサルを含めおよそ1ヶ月間ブヨウフェスティバルを実施してまいりました。

過去11回の公演において日舞・バレエ・モダン・コンテポラリー・舞踏などジャンルを超えて370団体（個人）2200人を超える出演者、総観客数2万5千人の公募公演と勢使河原三郎・山崎広太の出演や望月則彦・石井満・神沢和夫振付作品の上演、スーザン・バージを中心としたプロジェクトを立ち上げ、海外公演まで実施した作品などの特別公演を開催してきました。

かえりみれば、発表・公開の場の提供を目的とした第1期、発念な舞台造りにより舞踊家・舞踊作品の質的向上を求めた第2期、舞踊評論や観客造りを目指した第3期、その時々にフェスティバルの形態を変え、出演団体数を増やす、十分な日程をとる、舞踊評論家や観客を交えた公演後の交流会を持つなど、フェスティバルの目的や成果を、絶えず問いかけていく試みを併せて行ってきました。

この間、関西の舞踊環境もずいぶん変わってきました。伊丹のアイホール・大阪のダンスボックス・京都のアートコンプレックス1928や京都芸術センターさらに滋賀県のびわ湖ホールとダンス公演を考える土壌も豊になり、関西圏のダンサーの交流も増え、JCDNなどのNPOが生まれました。

2000年を契機に事業そのものを見直す時期と考え、10年間でできたアーティスト・観客・制作者と、ホールのネットワークを核とし、身体表現をさらに考える事業を目指しました。

前回は、NPO法人と協同作業を目指し、アルティ・ブヨウ・フェスティバル'02特別公演は、「ダンスの未来」と銘打ち、映像・音楽・舞台美術・舞踊と複数アーティストによって構成されたユニットを募集し、ワークインプログレスを繰り返し、観客も創造の現場に入り込み、公演を行うため何名かのサポーターを募集し実施した結果をふまえ、今回のアルティ・ブヨウ・フェスティバル'04特別公演「ダンスの未来 Vol.2」は、最初に三つの団体を中心に制作サポーターを募り、今回は「音楽とダンスの関係性」をテーマに、音楽家と舞踊家が協同で創作するダンス芸術の新たな可能性を模索する試みとし、舞踊家と音楽家のユニットを公募した結果18のユニットの応募があり、公開プレゼンテーションや制作サポーターを含めた機関で今回上演の2団体の作品制作を決めました。

ダンサーは見えるのだが作品が見えない公演が多い昨今、作者の主張と身体表現のバランスの良い作品を求め、ワークインプログレスの機会をつくり作家と観客と制作者が共にダンス作品を創って本日を迎えることが出来ました。これはまだ完成ではありません、今後発酵・熟成されることに期待します。

平成15年度文化庁芸術拠点形成事業

ダンスの未来 Vol. 2

2004年2月7日（土）19:00開演 ／ 8日（日）15:00開演

創・肉体音楽ユニット（小川珠絵＆TMPP with 宮本妥子）『リズム プリズム』

花嵐×三木俊治（Original Art Project）『カミダラケ ～同時進行による神話創造～』

創・肉体音楽ユニット（小川珠絵＆TMPP with 宮本妥子）

ダンスと音楽の関係について　振付ノート

小川珠絵

昔、人は大地を踏みならし、木や石をたたき歌い、飛んだり廻ったりして喜びや願いを表した。

その時、身体と音楽の関係など意識せず自然なものであったと思う。

伝達の中で発展し複雑になり、独立したジャンルとなったのだろうか。

今回は2つの方法を取った。1つは肉体の音を探る。音楽家側から見て肉体を音にするとどうなるのか？という視点で即興をエネルギーを如何にぶつけられるか？感じられるか？という点だが、宮本氏と出会って、その大切さを再認識した。そしてもう1つの方法は、音楽を如何に理解するか？

振付師は音楽を聴き、センスと感性で肉体の音符なるものを身体で試してダンサーに伝える。

振付師によって音感の違いがあり、伝えられたダンサーの音感にも左右される。

そこで、クセナキス「リボン」の楽譜を立体化する作業で振付をはじめた。

「リボン」は宮本氏のレパートリーの中で彼女がもっともダンスのだと感じる楽曲である。

代表的な現代音楽であるだけに、実に複雑で速すぎてわからない。

私は1小節づつこの楽譜を元に振付譜を起こすことにして、まず表を作ることを考えた。

「リボン」のベースのリズム、16分音符でビート感を出しているのがボンゴ、その上にコンガ・トム・大太鼓のテーマがアクセントのように入ってくる。

この順番も1拍目の次は2拍目と数学的に配置され、木琴がエッセンスのように重なる。

ベースの16分音符で動き続けるだけでは、踊りとしてムーブメントが面白くない。

ダンサーに振付譜と楽譜の理解、16分音符のビート感を保ちつつ、アクセントをどのように踊るのかが要求され、87小節の肉体訓練をした。

花嵐×三木俊治（Original Art Project）

～原作者・舞踏家から見た「カミダラケ」～

三木俊治

この舞台劇では、音楽家もダンサーも一緒になってカミサマになってしまう。それは昔の道祖神だったり、新しいハイテクの神だったりするのだが、どれもこれも、本来のアニミスティックなものに帰ろう、と原作で企図した。

「人間は勝手なもので、カミサマも自分の都合で色々利用してきた経緯があるが、カミサマは本来そういうものではなく、万物に偏在する宇宙原理みたいなものである」というのが表現目的だが、新しいカミガミを出すわけだから当然音楽のほうも新しい音色を設計する必要がある。すべての楽器を新作する、というしんどい目をすることになった。

できたばかりのものだから、舞踊・音楽ともご叱責もさまざまであろうが、これをひとつの出発点としてアジア文化の可能性について探求を深めていきたいと考えている。

今日は、踊りの不可思議さと楽器の音色を楽しんでいただければ幸いである。

花嵐

三木俊治氏とは「お見合い」のような形で紹介を受け、今回が初めての共同作業でした。最終選考の結果が出てから今日まで、十分な時間があったとは言い難いですが、花嵐と三木氏4人でコンセプトづくりから始め、社会や世界、科学について話し合い、三木氏から文化人類学などについて講義を受けました。作品テーマは神話です。なぜ今「神話」か、身体性が希薄な現代で、「神話」を通して人が持つ根源的な創造力に触れたいと感じたためです。混沌としたこの世は混沌とした身体の写し鏡のようでもあります。混沌は「役に立たない」と排除されるのではなく、人類が抱える「闇」として共有できないだろうか。その闇にこそ創造力というカミが宿るのではないかと考えております。

本日はありがとうございました。

ARTIST'S PROFILES

創・肉体音楽ユニット（小川珠絵＆TMPP with 宮本妥子）

小川珠絵　舞踏作家／ダンサー

1989年より肉体と美術の融合をコンセプトにした「舞台美術館」のシリーズを立ち上げる。舞踊のジャンルにとらわれず、奇抜な発想と新鮮な振付けでユニークなダンス作品を創り続ける。50を越えるレパートリーを持つ。2000年舞台芸術「死宮舞」受賞。TMPスタジオ・T-Mパフォーマンス・プロ主宰。

宮本妥子　パーカッション

現在ドイツ・フライブルクで州立音楽学校の指導にあたりながら、スイスのアンサンブル Le Chassis 所属して演奏活動や多数のラジオ放送、CD録音をおこなっている。ソリストとして日本、ヨーロッパを中心に活動し、これまでに世界各国の現代音楽祭に招かれる。

山口陽子　ダンサー

TMPPスタジオ所属。小川珠絵氏に師事。「舞台美術館」シリーズ、京都市立芸術劇場空間'01～'03などに出演。'96 ROAD FISH 結成。'00 ROAD FISH「1」～「Ⅲ」。舞踊家として創作活動中。

西山由加　ダンサー

TMPPスタジオ所属。小川珠絵氏に師事。TMPP主催「舞台美術館」シリーズに出演。関西を拠点にジャズダンスを指導、様々なイベントや公演に参加。振付も手がける。ソロ、デュオ等の作品も創り始める。

野田まどか　ダンサー

TMPPスタジオ所属。小川珠絵氏に師事。TMPP主催「舞台美術館」シリーズに出演。京都精華大学にて片桐ユズルゼミ「アレクサンダーテクニーク」専攻。00よりコンテンポラリーダンスに触れ、ソロやデュオの作品を創り始める。

植村佳奈恵　ダンサー

1995年より小川珠絵氏に師事。TMPPスタジオ所属。TMPP主催「舞台美術館」をはじめ多数の舞台に出演。ステージダンスを習得し、アジスタントも努める。さまざまなダンスに挑戦、自らもソロダンスを発表。

花嵐×三木俊治（Original Art Project）

伴戸チカコ　ダンサー／振付家

演劇、バリダンスを経て、93年から舞踊を学ぶ。98年花嵐結成以降、花嵐の全ての作品に参加。ダンスとは、未知なる身体への冒険と捉え、更に深く掘り光をあてる作業を行う。その過程で引きずりあげた言葉と身体を結びつけた表現を得意とする。個人の主な作品に「石道」「すなた」がある。

吉川　遠　ダンサー／振付家

長い手足を持ち、空間を浮遊する。時に踊り廻らされず。94年、踊りに飛びから、結成時より花嵐の全作品に参加。個人活動ユルル身体「ヨルノコエ」では、恥ずかしい"思い"をさらすことにより身体の解放を試みた。花ばかりでなく、石を見ることにも挑戦しようと思う。

ニイ・ユミコ　ダンサー／振付家

小さい頃から始め好きな子で、18才から歌い始める。その熱っぽいメロディーと変幻好きなダイム感で不思議な世界を完成させた。24ヶ月体について学び、モダンダンス、舞踊を経て、最近は新体道と出会でいる。そこにあるものを丸ごまる受け入れて、瞬間する瞬かれた身体を目指す。

三木俊治　楽器デザイン／作曲家

鍛華・竹等の伝統環境音楽素材とハイテクを組み合わせた楽器開発から、比較文化研究～舞台演で手掛ける総合音楽制作を展開。ベトナムの国立博物館等、国内外で楽器が収蔵・展示され、音楽監督として手兵'Original Art Orchestra'を率いアジア各国の国家芸術家達との交流等、国内外で多様なかたちの公演を行う。

大森ヒデノリ　フィドル奏者

スウェーデン、アイルランド等のフィドル音楽の研究と演奏を中心に活動しており、特にスウェーデン・ダーラナ地方との交流が厚い。オリジナル・アートプロジェクトでは、弓奏弦楽器・擦弦楽器双方を演奏する。

高橋直己　口琴奏者

2002年10月から1年間、カザフスタン共和国に留学。国民的擦弦楽器ドンブラ等を国立クルマンガズイ名称音楽院アクボタ氏他に師事。2003年1月に帰国し、日本人初のドンブラ奏者としてオリジナル・アートプロジェクトより活動開始。

三木理恵　作曲家

大阪音楽大学作曲学科卒。

Fig. 5.1 Flyer for "Dance no Miraï" (Dance in the Future), 2004. © Tamae Ogawa, reproduced with permission.

Conclusion: Beyond the Centennial in Japan

In Xenakis's centennial year, Japanese players had more opportunities to perform his works than ever before. Some of the concerts seemed to provide new encounters with Xenakis's music for younger musicians. For example, the concert realized by the Kunitachi College of Music on 1 October 2022 featured *Achorripsis* (1957), *Anaktoria* (1969), *Echange* (1989), *O-Mega* (1997), and two special concerts for *La Légende d'Eer* (1977), which attracted young audiences who filled up the concert venue and provided a great educational experience. The Tokyo University of Arts held a symposium and concert on 4 December 2022. The concerts included performances of *Kottos* (1977), *Nyuyo* (1985), *Khal Perr* (1983), *Kassandra* (1987),[23] and *Waarg* (1988). Both concerts revealed several excellent performances of Xenakis by very young players. Both the players and the audience were enthusiastic, which is not the case in most contemporary music concerts these days in Japan! For the players, performing Xenakis's work is a great and challenging task. Rewriting scores, physical training to become familiar with the use of the instruments, or preparing for the performance (including memorization) seem to be difficult—but worthwhile—goals for the players to overcome, as a Japanese bassist, Yoji Sato (b. 1979) said in an interview with the author.[24] We will certainly witness many more performers and performances of Xenakis's music in the near future in Japan.

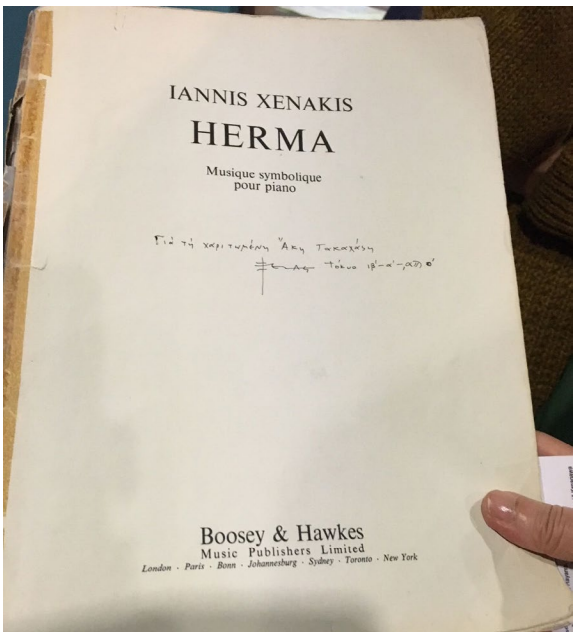

Fig. 5.2 Autographed score of *Herma* by Xenakis to Aki Takahashi: "To dearest Aki Takahashi, Tokyo, January 12, 1970."[25] Reproduced with permission from the dedicatee.

23 The countertenor Toshiharu Nakajima's performance was powerful. Nakajima (b. 1986) received the Bunkacho Prize of 2022 for young artists.

24 25 September 2022, at Aichi Art Center.

25 This date is two days after Xenakis's arrival in Osaka for work on *Hibiki-Hana-Ma*. See Chapter 17 in this volume.

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NEW CONTEXTS FOR UNDERSTANDING XENAKIS

Plate 5 Iannis Xenakis, Glasgow, May 1987. Photos by Henning Lohner, courtesy of CIX Archives, Lohner collection.

6. Iannis Xenakis's Free Stochastic Music Program as an Aid to Analysis

Ronald Squibbs

Introduction

In this chapter, I aim to do the following: firstly, to introduce Iannis Xenakis's Free Stochastic Music program (both its history, and what it does); secondly, to explain how the code for the program became available to the general public; thirdly, to discuss the challenges involved in, and opportunities for, running the program today; fourthly, to present a sample of music composed based on a recent run of the program; fifthly, to examine a movement from Xenakis's *Atrées* (1960), informed by practical experience with the program; and sixthly, to consider possible directions for future research on the program and on the works Xenakis composed with it.

The Free Stochastic Music Program

Xenakis's program, Free Stochastic Music, was a computerized implementation of probability-based compositional procedures he had previously calculated by hand in the composition of works such as *Achorripsis* for chamber orchestra (1956–7) and in portions of *Pithoprakta* for orchestra (1955–6). The computer program allowed for a more thorough implementation of his ideas than had been possible previously. It was used in the creation of five works, generated between the years 1956 and 1962: *ST/48, 1-240162* for orchestra, *ST/10, 1-080262* for chamber ensemble, *ST/4, 1-080262* for string quartet, *Morsima-Amorsima* (*ST/4, 2-030762*) for piano, violin, cello, and bass, and *Atrées* (*ST/10, 3-060962*) for chamber ensemble. The titles of these works indicate that they were composed using data generated by the stochastic program ("ST") and the dates on which the data was generated by the Free Stochastic Music program. For *ST/48*, for example, the sequence of numbers "1-240162" indicates that the work was based on the first set of data generated on 24 January 1962. The sequences of integers in the titles of the works as a group show that the data for them was generated between January and September of 1962, with *Atrées* being the last work in the series.

 https://doi.org/10.11647/OBP.0390.08

The earlier date in the range 1956–62 that applies to all five works indicates the year in which the planning for the project was begun.

The Free Stochastic Music program produces numerically encoded notations for sections of music which, within the program, are termed "sequences." In finished compositions, the sequences may follow one another in order or the composer may choose to select from among them, reorder them, or combine them by presenting their contents simultaneously. The length of the sequence and the number of sounds the sections will contain are calculated first, with the specific properties of the sounds to be filled in afterward. The number of sounds per second, which Xenakis terms "density," provides a quantitative measure of the texture in a sequence.

Next, the instrumentation of the sequence is determined. Within the ensemble defined for a specific composition, the instrumentation varies as a function of the sequence's density. Controls are implemented so that the density (and therefore the instrumentation) varies gradually from sequence to sequence. This regulation of the changes in density represents a difference from the approach taken in the hand-calculated *Achorripsis*, for example, in which the changes in textural density were sometimes quite sharp. Sudden changes in density can add drama to a composition and can also help to delineate a work's form as it unfolds in time. Gradual transitions in density can help the sequences blend into one another—if the order of the calculated sequences is maintained—but they can also have the effect of limiting opportunities for structural drama.

An additional six functions determine the qualities of an individual note: firstly, the time at which it begins; secondly, the instrument on which it is played; thirdly, its pitch if it is performed on a pitched instrument; fourthly, the characteristics of the *glissando* if it is performed on an instrument producing *glissandi*; fifthly, the duration of the sound; and sixthly, the dynamics of the note, which may be steady or changing.

Further notes in the sequence are produced until its time limit is reached. Then the program moves on to the next sequence and repeats the process until the last sequence is complete. The program terminates when fifty sequences have been completed or when it reaches a specified time limit or number of notes.

The Free Stochastic Music program was run at IBM France on an IBM 7090 mainframe. The IBM 7090 was a multi-million-dollar, state-of-the-art computer system that was produced between 1959 and 1969. A description from an IBM technical fact sheet from 1960 reads, in part: "As a scientific computing system, the 7090 will greatly speed the design of missiles, jet engines, nuclear reactors and supersonic aircraft."[1] Xenakis's use of this computer for the purposes of aesthetic creation represents a notable peacetime, non-commercial application of the computer system's potential, providing a momentary respite to its normative military, aeronautic, and aerospace applications.

1 IBM Data Processing Division, 1960.

Documentation

Xenakis published the code for the Free Stochastic Music program, either in part or in full, several times during the 1960s and 1970s. Publication began in the French edition of his major treatise, *Musiques formelles*, in 1963.[2] This was followed by the translation of the chapter on Free Stochastic Music from that book into German and English in the Swiss periodical *Gravesaner Blätter* (Gravesano Review) in 1965.[3] The most complete publication occurred in the first English edition of *Formalized Music* in 1971 and was reprinted in the second edition of 1992.[4] Between the publications of the 1960s and the later ones, the program had been updated from FORTRAN II to FORTRAN IV. Fortunately for current users of Fortran, the architecture of FORTRAN IV remained essentially intact in the next major update, FORTRAN 77, which runs on most modern Fortran compilers. The remainder of this discussion is based on the FORTRAN IV version of the program.[5]

The code alone is insufficient for interpreting the program's output. To this end, Xenakis provided figures regarding essential details of instrumentation, dynamics, and texture. The most complete set of these figures is found in *Formalized Music*, which will be the source referenced here. Additionally, it is important to point out that most of the figures as well as all of the input data provided in *Formalized Music* refer specifically to *Atrées*, which will therefore be the only stochastic work discussed here.

Timbre and Texture

Free Stochastic Music relies upon a precise classification of timbres and the instruments that produce them. Figure 6.1 shows a portion of the list of timbres and instruments for *Atrées*.[6] The timbres are organized into classes, the first five of which are shown in the figure. To the right of the class numbers, the timbre classes are named, followed by the instruments that are used to produce those timbres and the numbers of the instruments within the timbre classes. It is important to note that an instrument may appear in more than one timbre class. For example, in addition to the *glissando* timbre class shown in the figure, the violin also appears in the following classes not shown in the figure: tremolo, plucked strings, struck strings (*col legno*), and bowed strings. To manage the multiple classifications of some instruments, the program identifies each sound source both by its timbre class and by the instrument producing that timbre.

2 Xenakis, 1963, p. 175.
3 Xenakis, 1965a, p. 71–5, 78.
4 Xenakis, 1992, p. 145–52.
5 A revised version of Free Stochastic Music, adapted for use on modern Fortran compilers, may be found at https://github.com/ronsquibbs/Free_Stochastic_Music_rev_1
6 Figure 6.1 is excerpted from Xenakis, 1992, p. 137.

Composition of the Orchestra for *Atrées* (ST/10–3,060962)
Timbre classes and instruments as on present input data

Class	*Timbre*	*Instrument*	*Instrument No.*
1	Percussion	Temple-blocks	1—5
		Tom-toms	6—9
		Maracas	10
		Susp. cymbal	11
		Gong	12
2	Horn	French horn	1
3	Flute	Flute	1
4	Clarinet	Clarinet *B♭*	1
		Bass clar. *B♭*	2
5	Glissando	Violin	1
		Cello	2
		Trombone	3

Fig. 6.1 Timbre classes in *Atrées* (excerpt) © Pendragon Press 1992, reprinted with permission.

The list of timbre classes in Figure 6.1 may imply that instruments are chosen freely from within their respective timbre classes. The choice of instruments, however, is constrained by the program according to probabilities that were predetermined by Xenakis and encoded in the program's input data. An excerpt from the program's output, shown in Figure 6.2, provides some information about the instruments in timbre classes 4 and 5, representing clarinet and *glissando* sounds. In the figure, the labels "HAMIN," "HAMAX" etc. indicate minimum and maximum pitches (*hauteurs* in French).[7] The reference pitch, 0, is equivalent to lowest A on the piano keyboard.[8] "GN" indicates the maximum duration, in seconds, for each instrument. "PN" represents the probability with which, among the instruments in a timbre class, a given instrument will be chosen. For timbre class 4, for example, the probability that a note for B-flat clarinet will be chosen is sixty percent in comparison with the probability for the bass clarinet, which is forty percent.

```
IN CLASS NUMBER  4
FOR INSTRUMENT NO.  1 HAMIN = 29., HAMAX = 71., HBMIN =  0., HBMAX =  0., GN = 20., AND PN =  0.600
FOR INSTRUMENT NO.  2 HAMIN = 17., HAMAX = 54., HBMIN =  0., HBMAX =  0., GN = 10., AND PN =  0.400

IN CLASS NUMBER  5
FOR INSTRUMENT NO.  1 HAMIN = 34., HAMAX = 85., HBMIN =  0., HBMAX =  0., GN = 15., AND PN =  0.400
FOR INSTRUMENT NO.  2 HAMIN = 15., HAMAX = 63., HBMIN =  0., HBMAX =  0., GN = 15., AND PN =  0.400
FOR INSTRUMENT NO.  3 HAMIN = 19., HAMAX = 53., HBMIN =  0., HBMAX =  0., GN = 10., AND PN =  0.200
```

Fig. 6.2 Program output showing timbre classes 4 and 5. Figure created by author (2024).

7 The "HA" categories are used by most instruments in most timbre classes. A few instruments (not in the timbre classes shown in Figure 6.2) use the "HB" categories instead.

8 Xenakis, 1992, p. 138, associates pitch 0 with the lowest B-flat on the piano but, for *Atrées*, the reference pitch appears to be the lowest A. In Figure 6.2, timbre class 5, instrument 1, for example, "HA = 34" indicates G3, the lowest pitch of the violin.

In addition to timbre, textural density—the thickness or thinness of the instrumentation in the ensemble—is another important characteristic of the music that is managed in the Free Stochastic Music program. As in other works by Xenakis, textural density is quantified in the program in terms of the average number of sounds per unit of time. The minimum density he chose for *Atrées* was 0.05 sounds per second, equivalent to one sound every twenty seconds.[9] He then constructed a logarithmic scale of densities, using *e*, the base of the natural logarithm (approximately 2.71) as the base for the scale. As the exponent for *e* varies from zero to six, seven levels of density are produced as shown in Figure 6.3. It should be noted that these density levels are thresholds and not the only values used in Free Stochastic Music. The actual densities produced by the program vary continuously between these thresholds.

Formula: density = $0.05 * e^{U}$, for $U = 0, 1, 2, \ldots, 6$
Density levels (in sounds per second):

Level 1:	0.05
Level 2:	0.14
Level 3:	0.37
Level 4:	1.00
Level 5:	2.73
Level 6:	7.42
Level 7:	20.17

Fig. 6.3 Levels of textural density used in *Atrées*. Figure created by author (2024).

The heart of the Free Stochastic Music program consists of the coupling of textural density with instrumental timbres. This is illustrated by the excerpt from the program's output shown in Figure 6.4. The figure shows timbre classes 1 (percussion) and 2 (horn) along with the probabilities that sounds from this timbre class will be chosen for inclusion in the ensemble when the textural density of the entire ensemble falls within levels 1–7, whose precise threshold values are shown in Figure 6.3. Note that the probabilities do not vary in a predictable pattern from level to level: this is because these probabilities are assigned by the composer as part of the compositional process, likely chosen in order to generate a complex and varied instrumentation rather than a steady increase or decrease in probability for each timbre.

9 This differs from the minimum density of 0.11 sounds per second given in Xenakis, 1992, p. 136. That minimum density is used in *ST/10-1, 080262*, as shown in the caption to Figure V-2, Xenakis, 1992, p. 139. The value of 0.05 sounds per second is given in the input data for *Atrées*, Xenakis, 1992, p. 152, line 18, spaces 4–6: "050." This value is read into variable V3 of Free Stochastic Music, Xenakis, 1992, p. 146, at line XEN 99 of the program listing.

```
CLASS NUMBER  1
IN DENSITY LEVEL  1 HAS A PROBABILITY OF   0.25
IN DENSITY LEVEL  2 HAS A PROBABILITY OF   0.08
IN DENSITY LEVEL  3 HAS A PROBABILITY OF   0.04
IN DENSITY LEVEL  4 HAS A PROBABILITY OF   0.08
IN DENSITY LEVEL  5 HAS A PROBABILITY OF   0.01
IN DENSITY LEVEL  6 HAS A PROBABILITY OF   0.13
IN DENSITY LEVEL  7 HAS A PROBABILITY OF   0.09

CLASS NUMBER  2
IN DENSITY LEVEL  1 HAS A PROBABILITY OF   0.08
IN DENSITY LEVEL  2 HAS A PROBABILITY OF   0.07
IN DENSITY LEVEL  3 HAS A PROBABILITY OF   0.16
IN DENSITY LEVEL  4 HAS A PROBABILITY OF   0.02
IN DENSITY LEVEL  5 HAS A PROBABILITY OF   0.01
IN DENSITY LEVEL  6 HAS A PROBABILITY OF   0.01
IN DENSITY LEVEL  7 HAS A PROBABILITY OF   0.10
```

Fig. 6.4 Program output showing probabilities of sounds from timbre classes 1 and 2. Figure created by author (2024).

Note List

Once the general properties of a section have been determined—such as its length, the number of notes it will contain, and the probabilities of the timbres it will contain—the program moves on to determine the characteristics of the section's individual notes. The image in Figure 6.5 is an annotated note list for the first section of the output from a run of the Free Stochastic Music program from 1 July 2022.[10]

```
 Fri Jul  1 17:58:58 2022

JW=  1    A=   77.21    NA=    12    Q(I)=0.08/0.08/0.03/0.05/0.32/0.09/0.02/0.02/0.08/0.14/0.07/0.02/

      N        START     CLASS    INSTRM    PITCH      GLISS1    GLISS2    GLISS3        DURATION     DYNAM
      1         0.00        10         1     35.8         0.0       0.0       0.0          0.21        27
      2         1.31        10         1     40.6         0.0       0.0       0.0          3.70        52
      3         3.93         6         7     11.6         0.0       0.0       0.0          5.06        31
      4         4.52         5         1     47.3        19.0      23.0     -38.0          4.40        42
      5         5.84         1        10      0.0         0.0       0.0       0.0          3.88         8
      6        16.05        12         2     15.0         0.0       0.0       0.0          0.83        46
      7        22.84         6         1     69.9         0.0       0.0       0.0          9.12        62
      8        43.71        10         1     40.9         0.0       0.0       0.0          2.24         8
      9        45.61         9         1     62.6         0.0       0.0       0.0          4.76        51
     10        48.60         5         1     43.6        -4.0      -7.0       9.0          0.00        48
     11        51.62         1         1      0.0         0.0       0.0       0.0          4.90         7
     12        51.88         5         1     67.9       -15.0      24.0      28.0          6.03        15
```

Fig. 6.5 Note list from program output (excerpt). Figure created by author (2024).

The first line below the time stamp provides the values of several variables used in the program. JW is the name given to the number of the section (or sequence, as it is called in the program). To the right of this is the section's duration, variable A, with a

10 A time stamp, which is included in the output in Figure 6.4, does not appear in the output of the original program. I have included it here to distinguish between different runs of the program. Its inclusion is in the spirit of the subtitles of the ST works that Xenakis composed with the program, which specify the day of the program run.

value of 77.21 seconds. This is followed by the number of notes, NA, which is twelve. Dividing the number of notes, NA, by the duration of the section, A, gives the section's textural density: NA/A = 12/77.21 = 0.155 sounds per second. This value is very close to the threshold value for density level 2, which is 0.14 sounds per second.

The item to the right of the value for NA is Q(I), which gives an array of values representing the probabilities of the occurrence of sounds from timbre classes 1–12. The values for timbre classes 1 and 2, both 0.08, may be compared with the values for these classes for density level 2 in Figure 6.3: 0.08 for timbre class 1 and 0.07 for timbre class 2. The match between the values for class 1 and the proximity of the values for class 2 between Figures 6.3 and 6.4 makes sense because the actual density of the section whose data are shown in Figure 6.4 is so close to the value given for level 2 in Figure 6.3. Given the slight increase in density from 0.14, the threshold value for level 2, and the density of section 1, 0.155, the probability of sounds from timbre class 1 has not noticeably begun its decrease from 0.08 at level 2 to 0.04 at level 3 while the probability of sounds from timbre class 2 has already begun its increase from 0.07 at level 2 to 0.16 at the level 3, arriving at 0.08 when the actual density is 0.155.[11] A perusal of all of the values in the Q(I) array indicates that the highest values are for classes 5 and 10, at 0.32 and 0.14, respectively. These values lead us to expect a greater frequency of sounds from class 5, *glissando* sounds, and class 10, trumpet, than from the other classes. This is indeed the case, with occurrences of sounds from class 5 at notes 4, 10, and 12 and sounds from class 10 at notes 1, 2, and 8. Given a sample size of twelve notes, the frequency of sounds from class 5 is a little lower than expected (3/12 = 0.25 versus 0.32) while the frequency of sounds from class 10 is a little higher than expected (0.25 versus 0.14). These differences are not unexpected, however, given the small sample size of twelve notes.

A transcription of the first five notes from the note list in Figure 6.5 is shown in Figure 6.6. The first two notes belong to the trumpet (class 10, instrument 1). The pitches are the closest integer approximations of the pitches shown in the note list: note 1, pitch 36 (A3), an approximation of the given value of 35.8, and pitch 41 (D4), an approximation of the given value of 40.6. The third note is a flutter-tongue articulation on a pedal tone of the tenor trombone (class 6, instrument 7) on pitch 12 (A1). This is followed by a *glissando* on the violin (class 5, instrument 1) beginning on pitch 47 (G#4). (As before, the pitches are the closest integer approximations of the given values.) Three values are given for each *glissando*, representing three methods of calculation.[12] The composer chooses one of the values. In this case, I chose the value for "GLISS2," a rising *glissando* of twenty-three semitones. (Falling *glissandi* are shown with negative values.) The endpoint of this *glissando* is pitch 70 (G6), 23 semitones above the starting pitch, 47. No pitch is given for note 5, which is for maracas (class 1, instrument 10).

11 The formula for calculating the changes in probability in relation to textural density is provided in Xenakis, 1992, p. 138.

12 The details of the functions are given in Xenakis, 1992, p. 140.

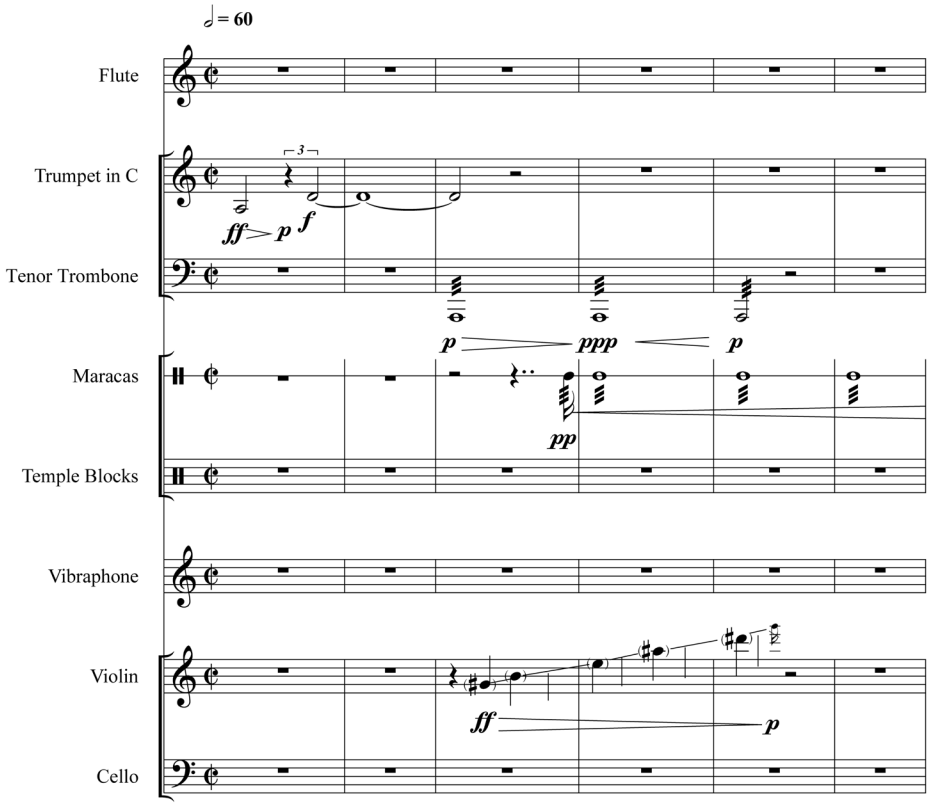

Fig. 6.6 Transcription of the first five notes from the note list in Figure 6.5. Figure created by author (2024).

The values in the column for durations give suggested note lengths in seconds, which may be increased or decreased to conform to whole numbers of beats or to their standard metrical divisions, or for other musical reasons. I have chosen to extend the duration of note 5 for maracas because there is a gap of more than ten seconds between the start of that note and the start of note 6 (not shown in Figure 6.6). The values for dynamics vary from 0 to 63, of which a representative selection is shown in Figure 6.5. The sixty-four dynamic values represent the possible combinations of four dynamic levels—*ppp*, *p*, *f*, and *ff*—taken three at a time. The table of forty-four intensity forms given in *Formalized Music* is a condensation of the longer list from which duplicates have been removed.[13] For example, the crescendo from *ppp* to *p*, the second value on the list of Xenakis's intensity forms, may be formed in two ways: as a succession of *ppp*, *ppp*, and *p*, or *ppp*, *p*, and *p*. Since both successions begin with *ppp* and end with *p*, they are both represented in Xenakis's table by the same crescendo from *ppp* to *p*. The dynamic markings in the score excerpt Figure 6.6 are based on a hypothetical correlation between the values for dynamics on the program output and Xenakis's table of intensity forms.

13 Xenakis, 1992, p. 143.

Toward an Analysis of *Atrées*

Armed with some basic knowledge of the characteristics of the output from Free Stochastic Music, we may now approach a passage from Xenakis's *Atrées* analytically, focusing on the structural features that are shaped by the program's mode of operation. Figure 6.7 shows a hypothetical note list for the first movement of *Atrées* which, as indicated in the score, is a transcription of the data for sections JW 1 and JW 2 of output that was produced on 6 September 1962.[14]

Movement 1

JW= 1 A= 4.00 NA= 2 DA= 0.50 observed Q(I)= 0.00/0.00/0.00/0.00/0.00/0.00/0.00/0.00/0.00/0.00/1.00/0.00/ U = LN(DA/0.05)
U= 2.3 expected Q(I)= 0.05/0.12/0.09/0.10/0.07/0.03/0.02/0.02/0.07/0.15/0.20/0.09/

N	START	CLASS	INSTRM	PITCH	GLISS	DURATION	DYNAM	
1	0.00	11	2	10.0	0.0	3.13	16	
2	3.13	11	1	26.0	0.0	0.88	1	

JW= 2 A= 52.00 NA= 12 DA= 0.23 observed Q(I)= 0.08/0.17/0.00/0.00/0.25/0.17/0.17/0.00/0.00/0.08/0.08/0.00/ U = LN(DA/0.05)
U= 1.5 expected Q(I)= 0.06/0.12/0.04/0.04/0.19/0.07/0.02/0.02/0.06/0.17/0.17/0.07/

N	START	CLASS	INSTRM	PITCH	GLISS	DURATION	DYNAM	
1	0.00	1	5	0.0	0.0	2.00	20	
2	0.20	10	1	53.0	0.0	3.80	7	
3	0.33	2	1	34.0	0.0	17.67	16	
4	0.50	5	1	43.0	16.0	1.50	41	
5	8.00	5	1	35.0	3.0	7.00	22	
6	16.88	7	2	39.0	0.0	0.00	34	
7	17.25	6	6	51.0	0.0	16.75	1	
8	25.00	5	2	46.0	-7.3	4.00	22	
9	38.13	2	1	20.0	0.0	5.38	4	
10	40.13	11	1	26.0	0.0	2.38	3	changed to p > pp
11	45.40	7	1	46.0	0.0	0.00	18	
12	50.67	6	9	25.0	0.0	1.33	22	changed to mf > p

Fig. 6.7 Hypothetical note list for *Atrées*, movement 1. Figure created by author (2024).

There are a few differences to note between the note list in Figure 6.7 and the list in Figure 6.5. The first difference is that two arrays, Q(I), are shown for the timbre classes in Figure 6.7 rather than the single array that appears in Figure 6.5. This is because the finished composition presents an observed distribution of timbre classes that may be compared with the expected distribution that emerges from the design of the program. The variable U that appears in Figure 6.7 is equivalent to the level of density minus 1, e.g. U = 2.3 indicates that the level of density is slightly higher than the threshold for density level 3. For both sections JW 1 and JW 2, given the small sample sizes of two and twelve notes, respectively, the expected distributions of the timbre classes are reflected reasonably well in the observed distributions: where fewer notes in a timbre class are indicated in the expected distribution, fewer appear, and where more notes are indicated, more appear. This is true even for JW 1, for which the greatest number of notes is expected for timbre class 11 (trombone) and, in fact, both of the notes in this extremely brief section are for trombone. Another difference between the note lists is that pitch values are given in Figure 6.7 with only 0 after the decimal point since, unlike in Figure 6.5, the pitch values have already been rounded to the nearest integer prior to being notated in the score. In Figure 6.7 only one column of values is shown

14 See Xenakis, 1968.

for the *glissandi* since only the value chosen for transcription is included in the score. Finally, the values for dynamics in Figure 6.7 match those in Xenakis's condensed table of forty-four intensity forms.[15] Two of the dynamic forms in the score—for JW 2, notes 10 and 12—are different from the prototypes in Xenakis's table. Since the values in these dynamic forms each differ by one level from one of the prototypes, however, it is possible to associate them with the prototypes they match most closely.

What does analysis of the hypothetical note list tell us about the structure of *Atrées*? First, at least in the movement examined here, the association between the timbre classes and the level of density follows the program's theoretical premises to a reasonable approximation. Second, looking at *Atrées* and the other works in the computer-generated stochastic corpus more broadly, Xenakis's judicious choice of which sections of music to transcribe and assemble into finished compositions resulted in varied, aesthetically engaging works. Within these works, the variations in textural density, along with their associated blends of timbre, made for a satisfying degree of contrast and variety on the musical surface. In this respect, the thesis that drove Xenakis's development of this approach to composition was borne out in the final results.

Further Research

Further exploration along the lines of what has been demonstrated briefly here, using *Atrées* as a test case, may confirm that the compositional implementation of timbres as a function of density remains fairly faithful to the expected distributions that are inscribed into the Free Stochastic Music program throughout the composition. Once an examination of hypothetical note lists for the remaining movements of *Atrées* has been accomplished, its general musical characteristics—melodic, harmonic, and rhythmic—may be analyzed independently of the theoretical premises of the program. General analysis of this kind will allow the structural features of *Atrées* and other works from the Free Stochastic Music corpus to be compared to works by Xenakis and others that proceed from different theoretical premises.

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7. *Continuum versus Disruptum*: A Poetic-philosophical Approach to the Instrumental and Vocal Works of Iannis Xenakis

Pierre Albert Castanet
(*translated by Sharon Kanach*)[1]

For my dear friend, Márta Grabócz,
on the occasion of the centenary of Iannis Xenakis.

The more one becomes a musician, the more one becomes a philosopher.
(Friedrich Nietzsche)[2]

The twentieth century has generated many elements of musical "modernity," both experimental and speculative. It must be said that, long before their spectacular advent at the end of World War II, Charles Baudelaire (1821–67) had identified that modernity represented "the transitory, the fugitive, the contingent, whose other half consists of the eternal and the immutable."[3] At the dawn of this modernist era, which would become increasingly turbulent (until the *decrescendo* of postmodern obedience—in music—initiated in the early 1980s), a few composers of the twentieth century modified our spatial-temporal vision of the acoustic world, engendering in their parametric wake the unusual meanders of an artistic discourse with prodigious vocabularies and novel syntaxes.[4] Among these pioneers, Iannis Xenakis—who was fascinated by nature as well as by light, as much by sound as by numbers, by music as much as by architecture,

1 This chapter was translated in January 2023. A previous version of this article was originally written in French for an edited collection, see: Castanet, forthcoming. We thank Éditions universitaires de Dijon for authorizing its publication in English in the present volume.

2 Nietzsche, 2007, § 1 [*Plus on devient musicien, plus on devient philosophe*]. All translations of cited excerpts are by Sharon Kanach, unless otherwise noted.

3 Baudelaire, 1980, p. 797 [*le transitoire, le fugitif, le contingent, dont l'autre moitié est l'éternel et l'immuable*].

4 After 1945, one may cite the works of Giacinto Scelsi (1905–88), John Cage (1912–92), Karlheinz Stockhausen (1928–2007), György Ligeti (1923–2006), and La Monte Young (b. 1935).

 https://doi.org/10.11647/OBP.0390.09

as much by "outside time space" as by "the temporal flux,"[5] as much by undulatory movement as by currents of particles, as much by intellectual gnosis as by operational physics—displayed the beams of a real "poetic vision"[6] and a philosophical one, on the sound horizon of a typically sovereign "art-science."[7] In short, as Gaston Bachelard (1884–1962) stated in 1938, "all that philosophy can hope for is to make poetry and science complementary, to unite them like two well-made opposites."[8]

While marvelously toying with various physical and metaphysical notions of the world, Xenakis cleverly conceived some unsuspected laws directed towards the so-called "contemporary" sound universe. For sure, at the helm of numerous successful projects (from instrumental solos to spatialized orchestras, and from vocal compositions to his electroacoustic opus, sometimes multidisciplinary…), he has often been recognized as the cantor of unexpected cascades or of violent shock.[9] Nevertheless, apart from his significant process characterized by a global approach to sound phenomena,[10] we will try to show that, through this somewhat hasty presupposition, he was a great pragmatic initiator of the artistic upheaval in what we could call the "continuist/discontinuist" order (we know how much this relation was valued by the master as "a positive source of conceptual innovation").[11] However, under such circumstances, the concept of continuum has often been evoked in relation to Xenakis's electroacoustic corpus[12] because, objectively, it is quite clear that it is easier to let a sound flow in a continuous way if the support is fundamentally electro-machinic. This is why we have insisted on taking the examples of this present study exclusively from his instrumental and vocal works.

It is also important to add to these introductory remarks that the term continuum appeared regularly in the work of scientists, since the beginning of the 1920s (particularly in the language of physicists), as a set of elements arranged in such a way that one can pass from one to the other in a continuous way. Hence the recovery by relativistic theories[13] of the expression of the space-time continuum as a four-

5 Xenakis, 1994, p. 101 [*l'espace hors-temps; le flux temporel*].

6 Cf. Castanet, 2014, p. 15–16 [*vision poétique*].

7 Stemming from Varese's philosophy, this expression of *art-science* was used by Xenakis in the last sentence of his essay entitled "Towards a philosophy of music" (Xenakis, 1971, p. 119; in English, Xenakis, 1992, p. 241). Furthermore, the publication of Xenakis's 1976 defense for his *Doctorat d'État* was titled *Arts/Sciences: Alliages*, (Xenakis, 1979; in English, Xenakis, 1985).

8 Bachelard, 2017, p. 12 [*tout ce que peut espérer la philosophie, c'est de rendre la poésie et la science complémentaires, de les unir comme deux contraires bien faits*].

9 "The public is *struck by lightning* when hearing a work by Xenakis" [*Le public est foudroyé lorsqu'il entend une œuvre de Xenakis*], his teacher, Olivier Messiaen (1908–92), confessed (remark published on 14 February 2011 on the blog "Le regard de Claude Samuel," which is no longer active). As for his student at the University of Paris 1 (Panthéon Sorbonne, Saint-Charles), Pascal Dusapin (b. 1955), noted that "all the 'pedagogical art' of Xenakis consisted in *upsetting* the complicity of his listener" [*tout "l'art pédagogique" de Xenakis consistait à mettre en désordre la complicité de son auditeur*] (Dusapin, 2001, p. 90).

10 Cf. Solomos, 2013, p. 1058–70.

11 Matossian, 1981, p. 108.

12 See, for example Weibel, Brümmer, and Kanach, 2020, p. 417–57.

13 It should be noted that Albert Einstein (1879–1955) is often credited with having the audacity to reduce time to a fourth dimension (cf. Einstein, 2001).

dimensional space (the fourth being Time).[14] As for the *disruptum*, etymologically speaking, it concerns the phenomenological data of rupture, break, and fracture[15].

A Movement of Flux in the Space-time Artifex

First, it is appropriate to apprehend the peripheral question of the advent of so-called "contemporary" music, an elective register for which Xenakis was a remarkably unequalled representative. For, "what has happened to music since Varèse (1883–1965)?" [*qu'arrive-t-il à la musique depuis Varèse*?] asked the acousmatic composer François Bayle (b. 1932): "To be interested in the modulation of the breath of energy. To be fascinated by the continuum" [*De s'intéresser à la modulation du souffle de l'énergie. D'être fascinée par le continuum*]. "What happens to energy?" [*Qu'arrive-t-il à l'énergie*?] he continues providentially:

> To be finely distributed along the veins of time. No longer only the range of shocks, successive blows, local and discontinuous decisions. No more words, no more notes. But what are possible are the flow, a wind, a temperature, a movement that traverses the space, defines it, envelops it, represents it.[16]

All these parameters—in general primarily fortuitous regarding avant-garde sound art, but now authentically acknowledged—reflect a good part of the elementary ingredients of the Xenakian artifex.[17] Moreover, at the heart of this new palette capable of imagining a musical composition under unsuspected auspices, the idea of a continuum relying on an inevitably elusive temporal management has been fundamentally tested, summoned, explained, negotiated, implied, circumvented, impeded on purpose... Henceforth, driven by a scheme (elaborated more than endured) entirely dedicated to the law of continuity of musical time and to its corollary accomplice discontinuity, the sono-artistic opus of this bold and audacious polymath was offered, out of principle,

14 "We live in a four-dimensional space-time continuum" [*Nous vivons dans un continuum espace-temps à quatre dimensions*], he liked to conclude his various demonstrations (Einstein, quoted by Barnett, 1951, p. 97). More poetically, did not Arthur Koestler (1905–83), the Hungarian-born novelist, demonstrate that, like Van Gogh's (1853–90) unfolding of the skies, Einstein's notion of space ultimately suggested a true "act of creation"? (Arthur Koestler, 1964).

15 This term, which corresponds perfectly to Xenakis's temperament, is also used in the field of nuclear fusion as an abrupt interruption of the current generated by thermonuclear plasma (cf. Reux, 2010). We will also note that in the twenty-first century, the word *disruption* has been used by diligent shareholders of global marketing and has been abundantly taken up by the international media to circumscribe "a dynamic methodology oriented towards creation" [*une méthodologie dynamique tournée vers la création*]. Challenging conventional uses, the general idea of disruption would then aim to "give birth to a creative 'vision' of radically innovative products and services" [*accoucher d'une "vision" créatrice de produits et de services radicalement innovants*] (Pezet, 2017).

16 Bayle, 1993, p. 235–36 [*D'être distribuée finement le long des nervures du temps. Plus seulement la gamme des chocs, des coups successifs, des décisions, locales, discontinues. Plus de mot, de note. Mais possibles le flux, un vent, une température, un mouvement qui parcourt l'espace, le définit, l'enveloppe, le représente*].

17 "This term 'Art,' for Xenakis, refers to the *artifex*, to the creator" ["*L'art," ce terme renvoie chez Xenakis à* l'artifex, *au créateur*] (comment by Olivier Revault d'Allonnes, 1975, p. 29).

in the pure combinatorial apparatus of a legitimated movement which permeates, articulates, structures, orients and gives it, at the same time, sense and meaning—original or metaphorical.[18]

Through this order of thought with a strong orthonormal scope, Xenakis followed—mutatis mutandis—in Varèse's (and sometimes Scelsi's)[19] footsteps by composing for example—among some memorable masterpieces—*Naama* (1984) for amplified harpsichord.[20] But why focus on this work (which is not one of the best known)? Quite simply because its Greek title immediately suggests the notion of "flux." Moreover, at the time of the Luxembourg premiere, the program note mentioned that the score called for "periodic constructions" [*constructions périodiques*] realized thanks to a "group of hexahedral transformations as well as stochastic distributions" [*un groupe de transformations–exahédriques–ainsi qu'à des distributions stochastiques*]. The presentation text of this solo, dedicated to the harpsichordist Elisabeth Chojnacka (1939–2017), also mentioned that (predictable) "fluxes of regularities" [*flux de régularités*] were opposed to irregularities, to contrary predicates, sometimes distributed on several planes simultaneously, "which requires the soloist's mastery of the architecture, of techniques specific to the harpsichord, and an exemplary determination" [*ce qui exige de la part du soliste, la maîtrise de l'architecture, de la technique spécifique au clavecin et une détermination exemplaire*].[21] In this solo work, rhythmic passages played on the two keyboards strike percussive patterns (the sporadic addition of incisive stops providing a palette of subtle accents). "It's as if he were writing for the two hands of a percussionist" [*C'est un peu comme s'il écrivait pour les deux mains d'un percussionniste*], the virtuoso dedicatee confessed.[22]

In music, the notion of flux can generate various aspects of the parametric distribution of materials: for example, from the impressionist "subtle fluidity" [*subtile fluidité*] (cherished by Stéphane Mallarmé (1842–98)) to an infinite melody, the mind has the capacity to inform and control the sound, hence this "flux context" [*contexte flux*] intervening as soon as the "time factor" [*facteur temps*] is deployed, provided that a point freely stretches to move in a line of flow.[23] In philosophy, the "continuistic"

18 Cf. Bujic, 1997.

19 In Giacinto Scelsi's obituary in *The Guardian* on 23 August 1988, an unnamed journalist noted that the Italian composer-poet had said of his relationship to Iannis Xenakis: "We are both digging a tunnel. But we began far apart from each other. Neither knows exactly where he's going, but perhaps one day, we will meet in the middle." (cf. Castanet, 2023, p. 287).

20 Xenakis, *Naama* (1984) (24 September 2014), Elisabeth Chojnacka (harpsichord).

21 Program note (anonymous) of the creation of *Naama*, Luxembourg, Studio RTL, 20 May 1984. The composition of this work by Xenakis certainly is due to a "clever mixture of entrepreneurial spirit and new technologies" [*astucieux mélange d'esprit entrepreneurial et de nouvelles technologies*]. Metaphorically speaking, showing strategic marks of "radical innovation" [*innovation radicale*], its aesthetics can thus be akin to one of the definitions of "*disruption*" given by Régnauld, 2018, p. 6.

22 Chojnacka, 2008, p. 145.

23 We addressed this point in the conference entitled "Flux de forces et forces de flux dans la musique de Tristan Murail" [Fluxes of forces and forces of fluxes in the music of Tristan Murail], at the international conference *Messiaen/Murail, Voyage à travers le son*, La Grave, Festival Messiaen au Pays de la Meije, 27 July 2017 (significantly elaborated, this text was later published in Castanet, 2018 and

[*continuiste*] idea can also take on multiple guises: from transcendental meditation to the quest for immortality, via Zarathustra's doctrine of "eternal return," [*l'éternel retour*] understood as "absolute and infinite repetition of all things." [*répétition absolue et infinie de toutes choses*].[24] For example, for the philosopher Ferdinand Alquier (1906–85) (Gilles Deleuze's (1925–95) teacher), "the mind cannot engender time. But it can dominate it, reach eternity from which time becomes thinkable."[25] Unceasingly eager to approach the shores of the unapproachable, sown with ineffable feelings, Xenakis courted, within this dual context with the promising prescriptions, the elements of "imaginary dynamology" [*dynamologie imaginaire*], formerly defined by Bachelard.[26]

Thus, throughout the phases of creative utopia that marked his career as a composer, Xenakis voluntarily wanted to inhibit the monodirectional flux of the desired sound discourse (a sort of horizon of expectation, agreed upon a priori) in order to always privilege a field paved with "insecurity" [*insécurité*] and "uncertainty" [*incertitude*].[27] Furthermore, willingly using Valéry's (1871–1945) relationships embracing abruptness and shock, expectation and surprise[28] as principial preferences, artifacts taking the appearance of mysterious barricades were indeed systematically crystallized by the musician, the operation finally engaging the idea of sporadic detour (sometimes of dendritic order).[29] Be it through a "happy" *Naama* or an "unhappy" *Roàï* (1991),[30] the holding tension of a more-or-less disseminated flux is then convincing thanks to the character of the resulting relational duality governing the various directional elements of force that are present. It is important to remember that, for Xenakis, the experimental notion of a "continuous" line was put to work in multiple ways, on the visual level (see, for example, the lines drawn in space by laser beams integrated in the audiovisual spectacles of certain polytopes),[31] on the sound level (consider the various lines resulting from graphic gestures feeding the functions of acoustic representation offered by the UPIC).[32]

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developed in Castanet 2024).

24 Nietzsche, [1908] 1993, p. 1156.

25 Alquié, 1987, p. 106 [*l'esprit ne peut engendrer le temps. Mais il peut le dominer, atteindre l'éternité à partir de laquelle le temps devient pensable*].

26 Bachelard, 1948, p. 303.

27 Cf. Delalande, 1997, p. 126.

28 Cf. the chapter "Temps" in Valéry, [1894] 1973.

29 See, for example, the beginning of the score of *Mists* (1981) for piano, the more or less licentious apparatus rendering the sometimes canonical and sometimes arborescent arrangements technically realized from numerical sequences. (cf. Castanet, 1986). See also Chapter 19 in this volume.

30 Dorian title of a work for large orchestra composed in 1991 by Xenakis. Obviously, *Roàï* invites one to interpret its generic expression in a gigantic way, embracing—etymologically speaking—the universal idea of "flux" and "reflux." Similarly, *Sea-change* (1997) for orchestra refers to the "return of the tide." In the same vein, animated by a flux with a spellbinding aura—a pulsating current highlighting the essential qualities of the protagonists—*N'Shima* (1975), written for two mezzo-sopranos and instrumental quintet, attempts to legitimize the etymological character of its title ("breath" in Hebrew).

31 Cf. Revault d'Allonnes, 1975.

32 Equipped with a computer system to assist music composition through drawing, this mini-computer was conceived by Xenakis at the end of the 1970s. Titled *Mycènes Alpha* (1978), his first work for

Fig. 7.1 Iannis Xenakis demonstrating the first version of his UPIC. Archives du Centre Iannis Xenakis / CIX—Université de Rouen Normandie, Després collection.

An Alternative Order of Temporal Metaphysics in the Context of the Xenakian Habitus

"To name is to isolate within a continuum,"[33] Antoine Compagnon (b. 1950) indicated as an aside. Certainly, the ability to define the local while thinking of the global perspective seduced a good number of composers with a theoretical spirit[34] during the twentieth century. In fact, only the elements of sensation and cognition seem to be able to acknowledge the discrete pertinences of the "continuous/discontinuous" [*continu/discontinu*], or even "periodic/aperiodic" [*périodique/apériodique*][35] systemic binomial, even if the semioticians judged the qualities of this domino as belonging

stereophonics and projection was based on a whole network of diverse lines stemming from very inventive spatio-linear drawings (cf. Xenakis, 1987, p. 12–15).

33 Compagnon, 1998, p. 143 [*Nommer, c'est isoler dans un continuum*].

34 We have in mind Arnold Schönberg (1874–1951), Ivan Wyschnegradsky (1893–1979), Pierre Boulez (1925–2016), Iannis Xenakis, Giacinto Scelsi, Claude Ballif (1924–2004), Jean-Claude Risset (1938–2016), Gérard Grisey (1946–98), Tristan Murail (b. 1947), François Leclère (1950–2015), and many others.

35 For the composer and conductor Gilbert Amy (b. 1936), "continuous/discontinuous" [*continu/discontinu*] and "periodic/aperiodic" [*périodique/a-périodique*] are equivalent. Cf. Michel (ed.), 2002, p. 119.

to a pertinently and reasonably "undefinable" [*indéfinissable*][36] element. Conversely, it is undoubtedly the idea of immanence and permanency of state (real or slightly warped) in the space-time framework that can legitimize the notion of continuity (in fact, sometimes thanks to the aspectual relief reminiscent of the shape of a volubilis, a spiral, a typhoon or nebula). For, a bit like the matrix icon represented by the continuum, cannot the helical form of the spiral constitute a "universal glyph" [*glyphe universel*][37] in the "*habitus*"[38] of the musical temporality?

Is it necessary to mention that as an ornamental figure, the idea of the spiral has illuminated many compositional projects in music after 1945,[39] its "evolving" and "involuting"[40] principles being subject to the experiential rite of establishing reference points managed by the laws of space-time?[41] While the generic symbolic representation of the labyrinth has frequently served to confront the solitary walker with blind spots and dead ends with opaque sides (generating in fact a discontinuous multicursal place)[42], the cliché of the spiral has, on the other hand, systematically referred to the application of a smooth, regular, continuous, ordered and above all unicursal becoming.[43] Between tangible mechanism and abstract conceptualism, for example, Xenakis tried his hand at the spiral vortex in the last section of *Persephassa* (1969), a piece for percussion sextet surrounding the public (premiered in Iran during the Festival of Shiraz).[44] Consequently, this kind of relief, skillfully designed for spatialized listening, sought to keep the spectator informed on the spot of this ex- or con-centric circumvolutionist model (a paragon continuously implying a modulated non-blunt curve). Besides, we will note in the margin that the musician had committed himself to denote poetically[45] the strangeness of the place occupied by the spiral as an

36 Greimas and Courtès, 1979, p. 101.

37 On this topic, see Durand, 1982, p. 338.

38 Ligeti's term referring to his own music, awakening "the impression of flowing continuously, as if there were neither beginning nor end" [*l'impression de s'écouler continûment, comme si il n'y avait ni début ni fin*] (Cf. Ligeti, 1974, p. 110).

39 Works by Messiaen, Stockhausen, Boulez, Risset, George Crumb (1929–2022), Tōru Takemitsu (1930–96), Bayle, Emmanuel Nunes (1941–2012), Hugues Dufourt (b. 1943), Murail, Toshio Hosokawa (b. 1955).

40 Whereas the notion of evolution carries promising attributes of a "function of opening [...] involution signals, in some way, the closing of the discourse" [*fonction d'ouverture* [...] *l'involution signe, en quelque sorte, la clôture du discours*] (Miereanu, 1998, p. 38).

41 On this subject, see Castanet, 1998, p. 85–103; Castanet, 2000; Castanet, 2003.

42 "The function of any labyrinth is to abolish time in a magic space where duration merges with the landscape and the walk which crosses it" [*La fonction de tout labyrinthe est d'abolir le temps dans un espace magique où la durée se confond avec un paysage et la marche qui la traverse*] (Vidal, 1975, p. 23).

43 "Often, utopias guide us towards reality: a spiral-work, a labyrinth-work, such are the images that reflect the complexity and the infinitude of the relations of the system and the idea" [*Les utopies, souvent, nous guident vers la réalité : l'œuvre-spirale, l'œuvre-labyrinthe, telles sont les images qui reflètent la complexité et l'infinitude des relations du système et de l'idée*], noted the composer of *Poésie pour pouvoir* (Boulez, 1989, p. 390).

44 George N. Gianopoulos, composer, "Iannis Xenakis – Persephassa for Six Percussionists (1969) [Score-Video]," 20 April 2018, *YouTube*, https://www.youtube.com/watch?v=osw8Cr58cXs

45 In the manner of the semiologists, we prefer to give to the word "poetic" a sense close to its classical meaning. Umberto Eco (1932–2016) noted in this respect: "it is not a system of rigorous rules (the *Ars*

"aesthetic ornament" [*ornement esthétique*] in its geographical distribution (on earth, in some epochs of high Antiquity, during millennia before our era...).[46]

Moreover, convinced that the "intellectual representation" [*représentation intellectuelle*] of continuity was rather "negative" [*négative*], didn't Henri Bergson (1859–1941) find that, like immobility, intelligence was "clearly [represented] only by the discontinuous" [*clairement* [*représenté*] *que par le discontinu*]?[47] Disserting on free will and the isolation of the elements, Friedrich Nietzsche (1844–1900) showed that "in reality, the whole of our activity and our knowledge" [*en réalité l'ensemble de notre activité et de notre connaissance*] was not "a series of facts and empty intermediate spaces" [*une série de faits et d'espaces intermédiaires vides*] but "a continuous flux" [*un flux continu*].[48] As for Xenakis, he indicated in his way—anthropologically speaking and by leaning on the data of a Zenonian problematic—that man represented the symbol of the discontinuous: "it is a kind of perpetual struggle of our perception and our judgment to try to imagine the continuous movement" [*c'est une sorte de lutte perpétuelle de notre perception et de notre jugement que d'essayer d'imaginer le mouvement continu*], he had confided to us, on 7 May 1986, at the time of a conference at the Université de Rouen.[49] Let us also remember that Gilbert Amy foresaw with a certain good sense that "neither you, nor the best 'listener' can boast of not having a fraction of a second of distraction, and thus of introducing discontinuity in an apparently smooth listening."[50] In some respects, this idea is reflected in Xenakis's musical design as, already in the mid-1950s, the artist imagined, a new "morphology" of an acoustic order. The musician was then working on a composition for two trombones, forty-six string instruments, xylophone and woodblock which was entitled *Pithoprakta* (1955–6) (*in fine*, this score[51] implemented—"stochastically" speaking—action of probabilities).[52]

Poetica as an absolute law) but the operative program that the artist proposes to himself each time; the work to be done, such as the artist, explicitly or implicitly, conceives it" [*ce n'est pas un système de règles rigoureuses* (*l'*Ars Poetica *en tant que loi absolue*) *mais le programme opératoire que l'artiste chaque fois se propose ; l'œuvre à faire, telle que l'artiste, explicitement ou implicitement, la conçoit*] (Eco, 1965, p. 10).

46 Cf. Xenakis, 1994, p. 137 (first publication: *Le Nouvel Observateur*, 25–31 May 1984).

47 Bergson, 1994, p. 155.

48 Nietzsche, [1908] 1993, p. 834.

49 This idea had already been advanced in Xenakis, 1985, p. 104.

50 Amy cited in Michel, 2002, p. 105 [*ni vous, ni le meilleur "écouteur" ne pouvez vous targuer de ne pas avoir une fraction de seconde de distraction, et donc d'introduire de la discontinuité dans une écoute apparemment lisse*]. Xenakis had declared for his part: "the smooth continuum [...] abolishes time, or rather time in the smooth continuum is illegible, unapproachable" [*le continu lisse* [...] *abolit le temps, ou plutôt le temps dans le continu lisse est illisible, inabordable*] (Xenakis, 1996, p. 37).

51 Conducted by Hermann Scherchen, this work was boo-ed at its premiere in Munich in 1957. For the record, Xenakis calls this master of Gravesano "the midwife of music" [*l'accoucheur de la musique*]. Scherchen was also responsible for the premieres of two other works by Xenakis: *Achorripsis* (1956–7) (in Buenos Aires in 1958) and *Terretektorh* (1965–6) (in Royan in 1966).

52 Based on the principle of Brownian motion and on the law of large numbers bequeathed by Jacques Bernoulli, the principles of the work are founded on Maxwell-Boltzmann's statistics, Gauss's law (for the distribution of the speed of the *glissandi*) and Poisson's Law (for the minimum number of relations that can exist between the sound events present). Performed by the Orchestre national de l'ORTF, conducted by Maurice Le Roux. Recording available at Pour ceux que le langage a désertés, "Iannis Xenakis – Pithoprakta (1955–56) pour 49 musiciens" (25 September 2020), *Youtube*,

Exhibiting a wide range of sounds going from noise to pure harmonics and playing categorically on the "plastic modulation of matter" [*la modulation plastique de la matière*],[53] *Pithoprakta* became thereafter an emblematic work of "contemporary music" with its singular contours. This ten-minute work sought an audible confrontation of continuity and discontinuity through, on the one hand, the calculated use of *glissandi* (assimilated to straight lines in continuous transformation)[54] and, on the other hand, the use of pointillist *pizzicati* (groupings of sorts of acoustic pixels in view of the relevant granulation of the different sound volumes). However, generating a "sensation of unheard-of materials" [*un sensation de matières inouïes*][55] (especially by the turgid presence of more or less dense sound blocks), the palette of effects was enhanced by very brief bow strokes, strikes with the wood of the bow, and knocks by the hand on the body of the stringed instruments (*divisi* to the extreme).

Basically, on the strict conjectural level of this "continuum of discrete sensations" [*continuum des sensations discrètes*],[56] can't the principle of the localized or generalized *glissando* (despised by Boulez)[57] be related to the driving element of a "theory of the continuous field" [*une théorie du champ continu*]? Because for the architect-musician answering Michel Serres (1930–2019), "the *glissando* is precisely a modification of something in time, but imperceptible, meaning that it is continuous but cannot be grasped, because man is a discontinuous being."[58] (It should be noted that this idea joins the Bachelardian conception of musical experience.)[59] In fact, influenced by Euclidean geometry, the *glissando* effect can be treated as a signaling index of transition (or intermediate link between two distinct or similar materials): one might listen to the beginning of *Jalons* (1986) for fifteen musicians. Here, the *glissando* makes it possible to pass from abrupt textures (accentuated by blocks or points) to zones of microtonal oscillations. Similarly, between continuous and discontinuous, doesn't this same sliding artifice, placed within *Tetras* (1983) for string quartet, serve to

https://www.youtube.com/watch?v=yxAakHDWjrw

53 Xenakis, 1971, p. 120.

54 Let us note that the Xenakian practice of "continuous transformations" was especially present in his works between the years 1955–68. Jérôme Baillet has pointed out the paradoxical character of that process because, for him, they were not at all opposed to a feeling of "statism" [*statisme*] (Baillet, 2003, p. 241).

55 Cf. text for the CD, Xenakis, 2001, p. 8. In addition, the musician wrote in his unpublished preliminary notes that the score of *Pithoprakta* implemented a "set of energetic transformations" [*un ensemble de transformations énergiques*]. Cf. Archives Xenakis, Carnet 23, consulted by the author at the Bibliothèque Nationale de France in Paris in 2002.

56 As expressed by Wilhelm Wundt, taken from *Grundriss der Psychologie* [fourth edition of 1897] consigned in French by Lalo, 1939, p. 184.

57 Boulez, 1989, p. 366.

58 Xenakis, 1985, p. 73. The same idea can be found in "Entre Charybdis et Scylla" in Xenakis, 1994a, p. 88–93.

59 Cf. Lassus, 2010, p. 66.

maintain a link,[60] joining one pole to the other?[61] In this respect, two other questions arise simultaneously: doesn't this sectorial positioning have the mission of including a principle of elementary topics for which geometry would ostensibly tend to be reflected even in its very constitution? And then, between a feeling of relativity and a project of continuity,[62] would not this binary (and complementary) mesh correspond to the prominent elements of Taoist thought concerning the unity of opposites (Yin and Yang)?[63]

Elsewhere, in *Nuits* (1967–8) for twelve mixed voices, modulated *glissandi* offer the precise qualities of an indexed element cementing in three superimposed strata the extended significance of the melodic relief of the score, thanks to the technique of crossfading[64] and sometimes to that of evolution by overlapping; one might listen, for example, to the triple *forte* opening ostensibly colored by the timbres in the women's voices. Furthermore, the vocal and extra-vocal material[65] of the beginning of this *a cappella* work (premiered in 1968 at the Royan Festival), demonstrate a striking aural poetry, between purity and impurity, stemming from a symbolism aiming at the extension of the line[66] through a rhythmic-melodic design curved by a network of wavy slurs (cf. the "*très lié*" [*closely tied*] mentioned at the beginning of the score).[67] Chosen to easily accentuate the linear (or smooth) character of their respective relationships, the characteristic elements of the expressive palette[68] are

60 Note that the etymology of the title *Herma* (1961) refers to—among other things—the word "link." It should be noted that for this work for piano, Xenakis relied on a trilogy of algebras: first, by which the operations outside time, including pitches, are practiced; second, temporal algebra, in which the events are embodied on the basis of metric time, statistically organizing the durations; and third, algebra in time, combining the two preceding ones, putting in relation the sound movements in their evolution. Cf. Deliège, 2003, p. 521.

61 Xenakis, *Tetras* (1983) (28 April 2018), Arditti String Quartet.

62 Cf. Tonnelat, 1971, p. 436.

63 Analyzing Xu Yi's *Qing*, Tian Tian showed that, in the first section of that work, the *glissando* was related to the Yang and that the *pizzicato* represented the Yin (Tian, 2021). Before the study, the author revealed that the Chinese composer was inspired by the theorist Xu Shangying's book entitled *Artistic Conception of Xi Shan's Guqin Music*.

64 Looking at the notes on his "correspondence of the arts" [*correspondance des arts*], it is easy to see that the technique of the "process of linked events" [*processus d'événements enchaînés*] was already present in Xenakis's research at the end of the 1950s (cf. Archives Xenakis, Carnet 26, 1959, p. 75, consulted by the author at the Bibliothèque nationale de France, Paris in 2002. This document is reproduced in Castanet and Kanach, 2014, p. 8.

65 Apart from the musical presence of breaths and cries, the micro-interval elements are enhanced with phonemes of Sumerian, Assyrian, Achaean origin. Complementary reading in Zeller, 1987.

66 In this context, Christine Prost speaks of continuous "braids" [*tresses*] (Prost, 1989).

67 Xenakis, *Nuits* (1967), world premiere performance on 7 April 1967 by soloists of the ORTF chorus and conducted by Marcel Couraud. For recording, see vox_ritualis, "Xenakis—Nuits (phonèmes sumériens, assyriens, achéens et autres)" (27 July 2018), *YouTube*, https://www.youtube.com/watch?v=Nyg7tMV3oyQ

68 Márta Grabócz has notably worked on recurrent expressive elements within a work or on specific data that crystallize the language of this or that composer. For more information on this subject, see Grabócz, 1998, p. 77–8.

- Continuous *glissandi*: implies the singer will cover all the micro-intervals between the two written notes. This unified path in the continuum thereby offers an ascending or descending vocal siren effect.[69] This technique is present from the first pages of the score, but it also animates the rising and falling curves of the sixth, seventh, and eleventh parts. For the record, omnipresent in the great musical work of the polytechnician, the *glissando* was theoretically considered by Xenakis as "a particular case of continuously varying sound."[70]
- Brief *glissandi*: unlike the continuous *glissando*, this short effect resembles a very rapid "spurt of sound" [*jet sonore*][71] (a furtive, percussive impact) as compared to a siren's stretched sound (a vocalized type of sound line). Its spasmodic function nevertheless allows for a jump of an octave (ascending or descending). This same process, entrusted to the strings, is used in the first measures of *Tracées* (1987) for large orchestra.[72] Moreover, Xenakis had noticed that "a crowd of short string *glissandi* can give the impression of continuity and a crowd of *pizzicati* can also do so" [*une foule de* glissandi *courts de cordes peut donner l'impression du continu et une foule de* pizzicati *le peut également*].[73]
- Whistling sounds: it depends on a play of air (of the "colored noise" [*bruit coloré*] type) obtained from the tip of the lips (with the addition of a lot of air). Diversely timbred, this singular sound in fact results from an indeterminate pitch. Like the sound rendering of a siren (similar to a vocalization or a Larsen effect, or even the malleable sound of an electric guitar, a theremin, or ondes Martenot), this kind of acoustic arabesque shows a truly exemplary degree of continual fluidity (see especially the fifth and sixth parts of *Nuits*).

69 It should be noted that the howling sirens that Xenakis heard during the war in the streets of Athens during the unforgettable German air raids—were from the same type of siren dear to Edgard Varèse's instrumentarium (listen to *Ionisation* (1929–31)). The composer-architect also used them in some important pieces for orchestra (such as *Terretektorh*) or in *Persephassa* (for percussion sextet).

70 Xenakis, 1971, p. 27 [*un cas particulier de son à variation continue*]. See also note 78 of the present chapter.

71 This image may remind us of the etymology of the title of *Achorripsis* (1956–7), since it comes from the Dorian *ichos* (sound) and *ripseis* (spurts).

72 Performed by the Orchestre Philharmonique du Luxembourg, with Arturo Tamayo as conductor. See Feinbird, "Iannis Xenakis—Tracées (1987)" (10 June 2021), *YouTube*, https://www.youtube.com/watch?v=PXIYFOUKtDc

73 Xenakis, 1994a, p. 58.

From "Continuous" Smoothness to "Epic" Disruption

For Aristotle (384–22 BCE), "we perceive movement and time simultaneously" [*c'est simultanément que nous percevons le mouvement et le temps*].[74] Nevertheless, treated in a scientific or metaphorical manner, spatial movement and temporal animation can sometimes take on the appearance—a priori paradoxical—of balance within imbalance or order within disorder (for example, the final homogeneity in *Jonchaies* (1977) for orchestra is constantly confronted with the "disorder of a field of rushes" [*désordre d'un champ de joncs*]).[75] See the image reproduced in the catalog published by The Drawing Center of a sketch for the composition of *Jonchaies*:[76] at the top of this multicolored study, Xenakis shows an unequivocal desire to "interrupt" the flow initially drawn in six colored layers.[77]

Regarding this kind of process, which is conducive to the play of regulation/deregulation, Paul Ricœur (1913–2005) discussed the theme of the "rupture of an order for the benefit of a terminal situation, conceived as a restoration of order."[78] In any case, Robert Francès (1919–2012) judged for his part that it was necessary to consider the relationships existing between "the main idea and its different appearances" [*l'idée principale et ses différentes apparitions*], and that it was useful to respect the relations manifesting themselves between "this idea and those that are interspersed between the different appearances" [*cette idée et celles qui s'intercalent entre les différentes apparitions*]. In his doctoral dissertation, this professor of psychology even mentioned a third manner, a synthetic one at that, aiming at the associations established between all "the intercalary ideas" [*les idées intercalaires*].[79] It is precisely within the framework of a global auditory apprehension that we could interpret these organizational signs associating—in a simple or complex way—the horizontal, oblique, and vertical values of Xenakis's musical writing. From this contingent of more or less instinctive or totally thought-out practices, we can then perhaps promulgate that, in any mathematical law, the parametric character (that we allow ourselves to apply here to the heuristic domain of music)[80] possesses a priori the property to alter the centrifugal deployment of the

74 Aristotle, 2015, p. 250.

75 According to conductor Pascal Rophé in Barthel-Calvet, 2011b, p. 6.

76 Kanach and Lovelace, 2010, p. 103, Pl. 81.

77 In 1986, Xenakis explained these alternating "abrupt caesura" [*brusque césure*], "arborescences of *glissandi*" [*arborescences de* glissandi], "idea of fluid" [*idée de fluide*], and "foreign element" [*élément étranger*] ... He also legitimized the structuring element of "'before-and-after' the cut" [*coupure "avant-après"*] (Xenakis, 1988, p. 133–7). Xenakis, *Jonchaies* (1977), performed by the Orchestre Philharmonique du Luxembourg, conducted by Arturo Tamayo. See Pour ceux que le langage a désertés, "Iannis Xenakis – Jonchaies (1977) pour grand orchestre" (10 January 2020), *YouTube*, https://www.youtube.com/watch?v=yxAakHDWjrw

78 Ricœur, 1980, p. 38 [*rupture d'un ordre au bénéfice d'une situation terminale, conçue comme restauration de l'ordre*].

79 Francès, 2002, p. 203.

80 In our opinion, Xenakis's mathematical formulas could be used as a kind of "compositional heuristics" [*heuristique de la composition*] (cf. Mandolini, 2012, p. 55).

"space-time" couple. As Gaston Bachelard liked to insist: "no space without music because there is no expansion without space."[81] Thus, it is undoubtedly interesting to think that, on both sides of the dividing line, taken in isolation, each moving parameter has the possibility of concealing the paradoxical osmosis of the "constant-flow" [*constant-coulant*],[82] (as Paul Valéry incidentally perceived it). In this sense, the score of Xenakis's *Mikka* (1971) for solo violin uses, as an indicated arrow towards the idea of continuum, quarter-tones—so many sample frequencies considered almost-touched landmarks, delimiting the layout of the elaborate audio-plastic curves to be realized with an extreme dexterity.

About *Mikka*, this peculiar solo where the *glissando* is king,[83] the instrumentalist can read that

> the continuous line below or above the notes means a continuous variation in pitch that passes through the notes inscribed, considered reference points, on which one must not stop, because the *glissando* must continue throughout the duration of the note. Therefore, it is useless to try to play according to a traditional fingering, because it is (one or) several fingers that must continuously slide on the strings without stopping, except where the continuous line does not appear, as well as where there is no indication of a *glissando*.[84]

Listen, in this respect to this monodic excerpt modeling a relief (of a melodic order),[85] sometimes elusive (in tied sixteenth-notes), sometimes static (pole notes in long values: in this case, tied whole-notes). Here, it seems, "it is the interior of time that counts, not its absolute duration; the content where time is articulated independently and simultaneously by various musical events."[86]

81 Bachelard, 1943, p. 62 [*pas d'espace sans musique parce qu'il n'y a pas d'expansion sans espace*].

82 Valéry, [1894] 1973, p. 1029.

83 This technique is also present in *Phlegra* (1975), *Jonchaies* (1977), *Dikthas* (1979), three scores—amongst many others—that weave a *continuum*, notably of pitches, thanks to this homogeneous technique of "non-break." Note that at the beginning of the 1970s, the dichotomy "break—continuous flux" [*coupure—flux continu*] was treated by Deleuze and Guattari, 1972.

84 Performance Notes, in French and English, Xenakis, 1971a. For the record, the notion of "continuously varying sounds" [*sons à variation continue*] has been deployed in many Xenakian demonstrations—see the elements of study that originally appeared at the heart of his formalization of music in 1963 (Xenakis, 1981, p. 27).

85 As Denis Diderot (1713–84) related it in his way: "There is, between unity and uniformity, the difference between a beautiful melody and a continuous sound" [*Il y a entre l'unité et l'uniformité la différence d'une belle mélodie à un son continu*] (Diderot, 1994, p. 760).

86 Xenakis, 1994, p. 13 [*C'est l'intérieur du temps qui compte, non sa durée absolue; ce contenu où le temps est articulé indépendamment et simultanément par divers événements musicaux*].

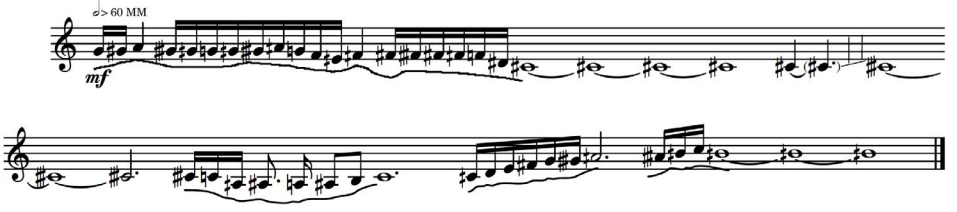

Fig. 7.2 *Mikka* (1971) by Iannis Xenakis for solo violin, p. 1.[87]

Similarly, in the score of *Mikka S*—a companion work completed by Xenakis in November 1975, published in 1976 by Salabert (the title of which is sometimes written *Mikka "s"*)—the mostly two-staved notation (except for the monodic coda, played *ffff*), sometimes introduces eighth-tone oscillations. A general performance note—not a simple one, at that—informs the solo violinist that

> the glissandi are to be played in such a way that, to the ear, the pitch change will be absolutely uniform (a progressively slower ascending movement, a progressively faster descending one) and must be executed and completed precisely according to their indicated durations.[88]

Dedicated to his publisher, Mica Salabert, this piece—which can complement the performance of *Mikka* in an interesting, albeit dizzying diptych—demonstrates, from its start, the idea of a laminated continuum, in relay with overlapping of voices (on two strings, bars 2 and 3), leading to a bifid ribbon (end of bar 5) sharing dynamics (synchronized crescendo from *ppp* to *fff*, bars 8–11).

Fig. 7.3 The first 11 bars of *Mikka S* (1976) by Iannis Xenakis for solo violin, p. 1.

87 Irvine Arditti on violin. For a recording, see belanna000, "Iannis Xenakis – Mikka (w/ score) (for violin solo) (1971)" (3 August 2015), *YouTube*, https://www.youtube.com/watch?v=Ifxs3TBSSAs

88 Quoted from the composer's Performance Notes (in both French and English) in Xenakis, 1976, p. 5.

In these two violin examples, Xenakis—who in this circumstance willingly compared sounds to molecules[89]—installed a degree of flexibility in the sliding continuum thanks to the transfer of the prolific nature of Brownian movement.[90] Thus, whether it is about a monist sphere or a pluralist universe, the conclusion is always the same, according to Bachelard: "a homogeneous process is never evolutionary. Only a plurality can withstand, can evolve, can become. And the becoming of a plurality is polymorphic as the becoming of a melody is, despite all simplifications, polyphonic."[91]

Therefore, to make the phenomenon relevant, scholarly musicians often have recourse to the "epic" technique (to borrow an expression from Roland Barthes (1915–80)[92] of breaking the established order[93] (on the global level) and of the rupture of the legendary linearity of the continuum (on a more local level). Thus, artfully installed, this principle tends to establish breakable points or segments of derailment that divert listening, for a while. In this respect, in the context of a generalized overview, let us consider the role of micro-intervallic details integrated into the polyphonic treatment enveloping—between coherence and incoherence[94]—the sometimes archaic, sometimes avant-garde arrangement of the piece entitled *Embellie* (1981) for solo viola—this work being the composer's last solo work.[95] About this point, one might listen also to *Keren* (1986) for trombone. In this unusual solo, Xenakis placed *glissandi* and micro-intervals at the service of a melodic ribbon sporadically interrupted by disruptive elements (irregular rhythms and accents, varied timbres, register leaps, sudden contrasting dynamics…).[96] In this framework, where appreciation of the local

89 It will be remembered that, after having addressed the notion of "seizing" [*capture*] of energy, Deleuze and Guattari put forward the notion of "molecular flickering" [*clapotement moléculaire*] (Deleuze and Guattari, 1980, p. 326–7). This idea had already been advanced by Deleuze in 1978 during a conference relating to "musical time" [*le temps musical*]. During his lecture, the philosopher then evoked the "molecular becoming of music" [*le devenir moléculaire de la musique*] (Deleuze, 2015, p. 241). Xenakis's reference was made in the previously mentioned lecture on 7 May 1986 at the Université de Rouen Normandie.

90 Cf. Solomos, 1996, p. 66–7. In this book, arguing that the that *glissando* originated from a "gestural character" [*caractère gestuel*], the musicologist postulates that "the Xenakian gesture par excellence is the linear *glissando*" [*le geste xenakien par excellence est le* glissando *linéaire*] (p. 155). Concerning the idea of the *glissando* representing the "refusal to make" [*le refus d'opérer*] a "choice" [*choix*] in the "continuum," see Cazaban, 2000, p. 133–4. Concerning the temporal virtues of sound art, see Xenakis, 1981, p. 9–11.

91 Bachelard, 1989, p. 123–4 [*un processus homogène n'est jamais évolutif. Seule une pluralité peut durer, peut évoluer, peut devenir. Et le devenir d'une pluralité est polymorphe comme le devenir d'une mélodie est, en dépit de toutes les simplifications, polyphone*]. With regard to the thinking of Bachelard with that of Xenakis, see Lassus, 2010.

92 Barthes, 1995, p. 263.

93 In a preliminary note written in view of his composition of *Metastasis*, Xenakis writes: "The repetition of a rhythmic unit is impossible because I break the order" [*La répétition d'une unité rythmique est impossible car je brise l'ordre*]. Archives Xenakis, Carnet 13, dated 30 January 1954, p. 10, consulted by the author at the Bibliothèque nationale de France in 2002.

94 Cf. Hasegawa, 2012, p. 231–43.

95 Garth Knox on viola. Recording available at George N. Gianopoulos, composer, "Iannis Xenakis – Embellie for Viola (1981) [Score-Video]" (14 May 2018), *YouTube*, https://www.youtube.com/watch?v=I6hW0R7Nrw0

96 Benny Sluchin on trombone. Recording available at belanna000, "Iannis Xenakis – Keren (w/

perception of temporary misalignment is diligently sought, we could certainly try to delve into the fundamental technique that governs the "breaking points" [*points de rupture*] of the continuity of the "serial" [*sérielle*] writing of *Metastasis* (1953–5).[97] However, an attentive listener can more easily notice the arrival of the agitating strokes (with acerbic pointillism) performed by the wood-blocks in this work for orchestra (sixty-one performers). It is also possible to fully grasp impacts of the same kind occurring in *Rebonds B* (1987–9),[98] a piece conceived for solo percussion. Similarly, one may try to locate the rhythmic sections (not embedded) attributed to the passages with a punctuated character in *Nuits* for vocal ensemble (see on this point the treatment of the vocal material in a "striated" [*striée*] temporal form).[99]

Between constraint and freedom, arduous calculations and mere feelings, formalization and abstraction, the alternation of modes of fluidity (smooth/choppy) are then attached to an original way of orienting the discourse from the one to the multiple (and vice versa). It is then possible to suspect that the composer's intention resides in a subtle play of contrasts bearing witness to the strategic idea of change, detachment, diversion, derivation, divergence... interruption, cut, break, caesura, rupture... and more poetically of "*embellie*" [embellishment], upstream and downstream from an imaginary "storm" [*tempête*][100]... Incidentally, does not this form of hiatus resemble in some respects what Boulez called "*incise*"[101]—in this case, in the introduction to *Incises*

score) (for trombone solo) (1986)" (3 August 2015), *YouTube*, https://www.youtube.com/watch?v=NCBclgx_Jvc.

97 Cf. Barthel-Calvet, 2011a, p. 10.

98 If the first part (called "*A*") of *Rebonds* progressively installs a kind of "perpetual movement" with an expressly continuous dominant, the second part (called "*B*") animates a rhythmic apparatus galvanized by the bongos. The latter are play in regular cells that are often destabilized by heavy bass-drum strokes, thanks to consciously shifted accents. Within this last phase of relatively primitive aesthetics, Xenakis was preoccupied, using a faster *tempo*, with imposing a quintet of woodblocks to break the discursive flow on several occasions.

99 In fact, playing as much on the micro-detail as on the macro-structure, the abundant arsenal put in place in different sections of *Nuits* confirms the shaping of a stylistic relief placed entirely under the generic aegis of the continuous-discontinuous—what Joëlle Caullier calls "the intermingling of immobility-directionality" [*l'entremêlement immobilité-directionnalité*] or "the conjunction of perennity-temporal transience" [*conjonction pérennité-fugacité temporelle*] (Caullier, 1988, p. 64).

100 Xenakis used this image when presenting his work *Embellie* for viola, a solo dedicated to Geneviève Renon-McLaughlin (Xenakis, 1981a, p. 1). In addition, the composer confided: "According to the *Petit Larousse* dictionary, an 'embellie' is a clearing that occurs during or after a gust of wind" [*D'après le* Petit Larousse*, "l'embellie" est une éclaircie qui se produit pendant ou après une bourrasque*] (remarks reported after the premiere of the work by Claude Samuel in *Le Matin*, 2 April 1981). The dynamic metaphor of the storm is also referenced in the context of his composition *Terretektorh*: indeed, on one of the preparatory sketches of the work, one can read "storms of maracas" [*des tempêtes de maracas*]: Cf. Xenakis Archives, Paris, consulted by the author at the Bibliothèque nationale de France in 2002; document reproduced in Kanach and Lovelace, 2010, p. 18.

101 Originally derived from the Latin *incisa*, the French word "*incise*" means "cut." But if in music, the term denotates "a group of notes forming a fragment of a rhythm" [*un groupe de notes formant un fragment d'un rythme*], it can also mean "a phrase of little scope, forming a sort of parenthesis in a longer phrase" [*une phrase de peu d'étendue, formant une sorte de parenthèse dans une phrase plus longue*] (according to the *Dictionnaire de la langue française-lexis*, Paris, Larousse, 1979, p. 945) One must bear in mind that Boulez, who obviously borrowed some notions from Henri Poincaré (1854–1912) without quoting him (cf. Poincaré, 1913, p. 137–41), considered that the continuum could be manifested

for piano[102]—a work that Boulez began in 1994—the composer symbolically placed a "supple" [*souple*] element between two "very fast" [*très rapides*] passages? In Xenakis's output, an illustration of such a process oriented towards a clear derivation is found in *Knephas* (1990).[103] Linking held notes (or melodic material based on a vocalization) to phases nourished by brief rhythms sung homo-rhythmically, this dark work for mixed *a cappella* choir was written by Xenakis after the death of his friend Maurice Fleuret (1932–90). In the same manner, if we return to *Tetras*, we notice that the avant-garde musician insisted on judiciously placing some efficient noise effects (of non-smooth, *pizzicati* of various sorts) in transitional zones where continuous *glissandi* sections predominate (these eruptive intermediate data go, for example, from a simple vibrato wave to the fluctuation of complex trills).[104]

For the record, on the first page of the score symbolically entitled *Metastasis*, dedicated to Maurice Leroux (1923–92), is it not expressly requested that the players of the bowed strings interpret "*glissandi* of a rigorously continuous movement" [glissandi *d'un mouvement rigoureusement continu*] (these controlled curves with a sliding trajectory directly based on the graphics[105] of the work of the architect Xenakis)?[106] The project of this carefully thought-out score was in fact intended to favor the full qualitative development of the spatial-temporal reference point: "the harmonics, the *glissandi*, the *pizzicati* hammer out the serial rounds by creating perspectives and multidimensional sound volumes,"[107] the composer was keen to explain. Moreover, in the program note

by the possibility of "cutting" [*couper*] space according to certain laws: "the dialectic between the continuous and discontinuous passes by the notion of 'cutting'; I will go so far as saying that the continuum 'is' this very possibility, because it contains both the continuous and the discontinuous: the cut, if one wants, changes the continuum's sign." [*la dialectique entre continu et discontinu passe donc par la notion de "coupure" ; j'irai jusqu'à dire que le continuum "est" cette possibilité même, car il contient, à la fois le continu et le discontinu : la coupure, si l'on veut, change le continuum de signe. Plus la coupure deviendra fine, tendra vers un epsilon de la perception, plus on tendra vers le continu proprement dit*…] (Boulez, 1964, p. 95).

102 Cf. Castanet, 2009.

103 Performed by the New London Chamber Choir, conducted by James Wood. Recording available at Ryan Power, "Iannis Xenakis – Knephas (Audio + Full Score)" (5 April 2022), *YouTube*, https://www.youtube.com/watch?v=U4azcZ2zd6M

104 A list of such examples could be very long (notably on the level of the segregation of auditory flow, as applied specifically to pitches, registers, intensities, dynamics, rhythms, textures, masses...): from Xenakis, listen to *Aroura* (1971) for twelve string instruments, a work for which the *glissandi* and the *col legno* are considered as tension-active agents linked to each of the dynamics of textures put in space. The same is true for *Kottos* (1977), where the solo cellist alternates between salient *toccata* elements and smooth *glissandi* gestures. For the duet *Dikhthas* (1979), the composer also wished to vary the flow of dynamics by exploiting kinetic gestures specific to the violin (asynchronous *glissandi* on two strings) and dynamic outbursts for the piano (ascent of a non-octaviating scale that later accelerates in a descent leading to a remarkable expressive *glissando*)....

105 I was able to consult the preparatory sketches and graphic tracings of the curves of *Metastasis* in the Dossier O.M. 1.4, f. (p.) 16, 18, 22, 29, as well as in folders 1 and 2 (1954) of the Dossier 10/1 and 1/5 (Paris, Archives Xenakis, consulted by the author at the Bibliothèque nationale de France in 2002).

106 As a reminder, when composing *Metastasis*, Xenakis used the hyperbolic curves drawn for the architectural preparation of the Philips Pavilion for the Brussels World's Fair (in 1958). See also Xenakis, 2008, Chap. 1.25–1.28.

107 Barthel-Calvet, 2003 p. 161 [*les harmoniques, les glissandi, les pizzicati martèlent les rondes sérielles en*

accompanying the premiere of the work at the Donaueschingen Festival,[108] didn't the composer note that "the 'linear category' of contemporary musical thought had been overtaken and replaced by surfaces and masses"? [*la "catégorie linéaire" de la pensée musicale contemporaine se trouve débordée et remplacée par des surfaces, des masses* ?][109] Let us also note that the title *Metastasis* comes from the ancient Greek *μετάστασις (μεθίστημι* meaning "I'm changing places" [*je change de place*]. In addition, this word is also the etymological origin of "*metastasis*," a medical notion that implies the idea of moving the locus of a disease, but above all, implies the corollary concept of its continuous evolution.

In the same vein, *Thallein* (1984) for instrumental ensemble refers to the slow metamorphosis of plants[110] (with their almost invisible transitions at a given time).[111] Indeed, the Greek title chosen by Xenakis refers to the natural idea of budding, suggesting notions of discrete growth, of the quiet blossoming of a given organic life.[112] This dreamlike (extra-musical) context of inspiration subsequently triggered a desire to put natural phenomena into his scores. Thus, musically speaking, the family of *glissandi* seems to offer here free-floatings, describing sensitive zones to the ear of wayward activities with blurred and impalpable reliefs. Let us distinguish once more that in the historical masterpiece that is *Metastasis* (as well as in *Mikka* and *Mikka S*, in some passages of *Embellie*, and in many other works for strings), vibrato is totally proscribed.[113] Given the technique of elusive transformation of pitches, the syntactic context of this singular corpus does not operate at all through the tempered scale of the twelve tones of the classical chromatic scale, but opens up a whole galaxy of sounds with circumstantial micro-intervallity.

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créant des perspectives et des volumes sonores multidimensionnels].

108 This work caused a memorable scandal at its premiere at the Donaueschingen Festival on 16 October 1955. The orchestra was conducted by Hans Rosbaud (1895–1962).

109 Program for the premiere of *Metastasis*, Historical Archive of the Südwestfunk, Donaueschingen Musiktage, 1955 (folder PO 66260).

110 One is reminded of the famous "original plant" [*plante originelle*] described by Johann Wolfgang von Goethe (1749–1842), which served as a model for the principle of "natural growth" [*croissance naturelle*] defended by Anton von Webern (1883–1945) through his *Reihenkomposition*... (cf. Galliari, 2007, p. 562).

111 Performed by Ensemble Intercontemporain, conducted by Pierre Boulez. Recording available at Belanna111, "Iannis Xenakis – Thallein (w/ score) (for chamber orchestra) (1984)" (2 October 2015), *YouTube*, https://www.youtube.com/watch?v=QdMLAR4fb9s

112 Similarly, if the sound textures of *Aroura* (1971) for twelve strings refer to the "land of Homer" [*la terre d'Homère*], the flux in *Anemoessa* (1979) for choir and orchestra evokes the various movements suggested by Aeolus (the title translates as "exposed to the wind"). In addition, *Persephassa* refers to Persephone, the goddess of the rebirth of nature in Spring. *In fine*, approaching the sensory aspect of sound art, Xenakis advocated—in the middle of the 1950s—so that "a constant current between the biological nature of man and constructions of intelligence" [*qu'un courant constant entre la nature biologique de l'homme et les constructions de l'intelligence*] is established, "otherwise the abstract extensions of current music risk to be lost in a desert of sterility" [*sinon les prolongements abstraits de la musique actuelle risquent de s'égarer dans un désert de stérilité*] (Xenakis, 1994, p. 143).

113 In the same way, in the epigraph on the score of *Nuits* for twelve mixed voices, Xenakis wrote: "Everywhere, absolutely without vibrato, dry voices, rough, full-throated" [*Partout, absolument sans vibrato, voix plates, rudes, à gorge déployée*].

When Xenakian Philosophy Embraces an (Inaccessible) Idea of the Continuum

Concerning the relation to Homeric reverence, didn't Barthes prosaically affirm that "the epic is what cuts (shears) the veil, breaks down the tar of mystification"?[114] Therefore, the behavior of musical discursivity (inevitably evolutionary, due to associating the virtues of the continuum and of the discontinuum) depends, for Xenakis, more on the immanent complementarity of the presence of dynamic materials than of the properly elementary negation of an intentionally and mono-directionally limited path. Among the many zealous metaphors attached to varied contexts of energies,[115], "euphoric" [*euphoriques*] as well as "dysphoric" [*dysphoriques*], Milan Kundera (1929–2023) underlined that the starting point of Xenakis's music is situated "in the noise of the world, in a 'sound mass' which does not spring from the inside of the heart, but arrives at us from the outside like rainfall, the din of a factory, or the shout of a crowd."[116] In the same manner, when praising the nonconformism of creation, the philosopher Stéphane Lupasco (1900–88) once demonstrated that "the logic of the aesthetic must evolve, and be centered inversely of a rational or irrational process; in other words, inversely of a process of non-contradiction. The logic of aesthetics must proceed from the non-contradictory to the contradictory; its goal is contradiction."[117]

In the end, both as a virtuous indication favorable to the most diverse interferences (positive and negative) and as a convincing guarantee of general dynamics (both local and global), the Xenakian dichotomous approach seems to show—even if we listen blindly to his works—a polyagogical sense.[118] Indeed, we could argue that, with this composer, the completion of a work depends, most of the time, on the purely aesthetic ingredient that is this *influxus imperfectus*. Should we then remember that this absolute system incriminating a certain idea of contrast can "topically" [*topiquement*] show, on

114 Barthes, 1995, p. 263: [*l'épique, c'est ce qui coupe* (*cisaille*) *le voile, désagrège la poix de la mystification*].

115 On this interpretative aspect, see Grabócz, 1999, p. 110.

116 Kundera, 2009, p. 115: [*dans le bruit du monde, dans une "masse sonore" qui ne jaillit pas de l'intérieur du cœur, mais arrive vers nous de l'extérieur comme les pas de la pluie, le vacarme d'une usine ou le cri d'une foule*]. Xenakis himself liked to evoke hailstorms, the sound of rain on hard surfaces, murmurs in pine forests, songs of cicadas in a summer landscape, political crowds gathering tens or hundreds of thousands of people... (cf. Xenakis, 1981, p. 27). Not to mention the "parable of gases" [*la parabole des gaz*] evoked in Xenakis, 1971, p. 18–19), we again noticed in his pre-cited Carnet 13 (p. 67) consulted by the author at the Bibliothèque nationale de France in 2002, that he mentions "galactic clusters" [*amas galactiques*] in connection with Metastasis...

117 Lupasco, 1947, p. 162 [*la logique de l'esthétique doit évoluer, être axée inversement d'un processus rationnel ou irrationnel, autrement dit, inversement d'un processus de non-contradiction. La logique de l'esthétique doit procéder du non-contradictoire au contradictoire ; elle vise à la contradiction*].

118 In the sense defined by Patrick Saint-Jean during his lecture entitled "Des musiques formelles à la polyagogie: une stochastique de Iannis Xenakis" (From Formalized Music to Polyagogy: A Stochastic by Iannis Xenakis), Université de toutes les cultures (UTLC)/Centre Iannis Xenakis (CIX) cycle, Université de Rouen Normandie, Maison de l'Université, 5 April 2017, https://webtv.univ-rouen.fr/videos/05-04-2017-183703-partie-1/

various levels[119], "two fundamental aspects of sound" [*deux aspects fondamentaux du son*]? On this subject, the composer of *Eonta* (1963–4)[120] continues:

> The discontinuous is easier to understand, because everyday life teaches us to distinguish phenomena like day and night, seasons, and years, etc. Continuous evolution is much more difficult to grasp because it refers to the very transformation of a phenomenon, to its intensity and speed. It is very difficult to be conscious of it because any change is supposed to be infinitesimal.[121]

Attempting to gather some synthetic data to approach the concluding elements of this study, we could contextualize, on the one hand, the words of the Belgian philosopher Pascal Chabot (b. 1973) who reminds us that "humanity now lives at the rhythm of disruption."[122] More simply, on a psychological level, between "substantive parts" [*parties substatives*] and "transitive parts" [*parties transitives*], the American psychologist and philosopher William James (1942–10) shows, on the other hand, that various "currents of consciousness" could be linked to some informational flows "like the life of a bird, [its flux] seems to be made up of alternating flights and perches [...],"[123] as the erudite philosopher remarks with a touch of pedagogical imagery. As the idea of unraveling some braided links of intuitive conviction[124] and intimate necessity[125] comes to mind, we might dare to establish a (admittedly adventurous) connection between an introspective listening to the self and the extrinsic dynamics of animated sound, terms finally understood as coming from the classical domain of "kinesthesia" [*kinesthésie*] (or "sense of movement" [*sens du mouvement*].[126] If Plato (428/27–348/47 BCE) was fundamentally interested in seeking an exclusive judgment of the deep

119 In fact, these perspectives concern above all the planes of *energêtikos* (in the Greek sense of the term meaning: "which seems to have an innate energy") and of *dunamikos* (dynamic character relating to "transformations" in general and to "movements" in particular) (cf. Castanet, 2021a, 2021b).

120 Composed in Berlin, *Eonta* (1963–4) for piano, two trumpets, and three trombones remains Xenakis's key testimonial work with respect to a metaphorical relationship to the sound model. One might listen, for example, to the very long notes of the muted brass instruments (tied whole-notes, *pianississimo*, suspended time), which form the foundation of the piano part with an ambitus that favors the extreme registers (*appoggiaturas*, very short values, *staccato*, irregularly striated time). Callithumpian Aki Takahashi on piano, with the Callithumpian Consort and conducted by Stephen Drury. Recording available at Aki Takahashi – Topic, "Eonta" (22 June 2018), *YouTube*, https://www.youtube.com/watch?v=J-w3HNrPmpo

121 Xenakis, 1994b, p. 14 [*Le discontinu est plus facile à comprendre, parce que la vie de tous les jours nous apprend à séparer les phénomènes, comme le jour et la nuit, les saisons et les années, etc. L'évolution continue est beaucoup plus difficile à saisir parce qu'elle se rapporte à la transformation même du phénomène, à son intensité et à sa vitesse. Il est très difficile d'en être conscient parce que le changement est censé être infinitesimal*].

122 Chabot, 2018, p. 6 [*l'humanité vit désormais au rythme de la disruption*].

123 James, 1909, p. 205 [*comme la vie d'un oiseau, [le flux] semble être fait d'une alternance d'envols et de perchages* [...]].

124 Let us remember that Xenakis stated in the preface to his score of *Embellie* that he had written this solo piece "in a more or less intuitive way" [*d'une façon plus ou moins intuitive*]. On the other hand, he declared, in 1989, that he was "always working haphazardly, blindly" [*toujours cahin-caha, à l'aveuglette*] (Xenakis, 2006, p. 50).

125 On this subject, read Castanet, 2021a, 2021b.

126 Berthoz, 2013.

knowledge of every person,[127] wasn't Xenakis's epistemological project a deepened philosophy of the external consciousness of the governance…of sounds? We find ourselves at the crossroads of "*enstasis*" [*enstase*] (noted by Satprem (1923–2007)[128] as the fruit of the supreme experience found in the depths of our being) and of "*ek-stasis*" (cited by Xenakis[129] as a way out from oneself—for creative purposes). In this context, the artist-philosopher Richard Shusterman (b. 1949) shows, more recently, that certain "conditions" or even certain "stimuli" [*stimulations*] could provide an individual with both the "formative energies and the guidelines for expressive movement, as well as for self-knowledge and self-cultivation."[130]

Now to conclude, we invite researchers to venture further into these musicological regions not yet truly explored, as we are aware that there are still many points to be raised and clarified in the field of human sciences regarding Xenakian music philosophy. The epistemologist Gilles Gaston Granger (1920–2016) believed in a philosophy whereby one of the active links would preside over the field of hermeneutics, naturally keeping "its place at the edge of science, whatever progress it makes, but it could only substitute itself by imposture, just as an equal imposture would suppress philosophy for the benefit of science."[131] Furthermore, didn't Nietzsche consider the "philosopher" as being 'a terrible explosive that puts everything in danger"?[132] In this context, let us remember that in June 1966, Xenakis published, in the twenty-ninth and last issue of the *Gravesaner Blätter* (Gravesano Review),[133] an extensive article precisely entitled "Towards a Philosophy of Music."[134] In addition, as a fighter against conventions, as much as a pioneer of the unheard of, didn't the artist-engineer want to create music "without following known paths or being trapped by them"?[135] This is how he reminded us on so many occasions that he wanted to "open the windows

127 In this regard, we must remember that the ancient Greek philosopher often quoted the precept of the oracle of Delphi: "Know thyself" [*Connais-toi toi-même*] (Plato, 1849, p. 9).

128 Satprem, 1970, p. 222. Furthermore, the notion of "*enstasis*" was touched upon halfway when Xenakis replied to an interviewer: "Movements are created in you, you can be conscious of them or not, control them or not, they are there in you. This is how music influences man" [*Des mouvements sont créés en vous, vous pouvez en être conscients ou non, les contrôler ou non, ils sont là en vous. C'est ainsi que la musique a une influence sur l'homme*] (cf. Lyon, 1974, p. 133). Satprem's given name was Bernard Enginger.

129 Xenakis, "La voie de la recherche en question," Paris, *Preuves*, no. 177 (1965), reprinted in Xenakis, 1994a, p. 67. Elsewhere, evoking the virtues of an individual strategy, the composer demonstrated that it was necessary "to be both inside and outside" [*être à la fois dedans et dehors*] (Xenakis, 1997, p. 123).

130 Shusterman, 2020, p. 79.

131 Granger, 1967, p. 131 [*sa place aux côtés de la science, quels que soient les progrès de celle-ci, mais elle ne saurait s'y substituer que par imposture, tout de même qu'une imposture égale supprimerait la philosophie au bénéfice de la science*].

132 Nietzsche, [1908] 1993, p. 1161 [*le philosophe* [*comme étant*] *un terrible explosif qui met tout en danger*].

133 Cf. *Gravesaner Blätter*, no. 29, 23–56 (this specialized review was initiated by the arts patron and conductor Hermann Scherchen); reprinted in Xenakis, 1971 and also in Xenakis, 1992.

134 Demange (1991) noted moreover that a work by Xenakis could resist "philosophical analysis in reality essentially because philosophy remained idealistic, suspended on old *a priori* categories...." [*à l'analyse philosophique en réalité essentiellement parce que la philosophie est restée idéaliste, suspendue à de vieilles catégories* a priori…].

135 Xenakis, 1963, p. 295 [*sans emprunter aux chemins connus ou être piégé par eux*].

to the unprecedented."[136] As Francis Ponge (1899–1988) emphasized, "things have to disturb you. They must force you to get out of the rut; that is the only interesting thing because that is the only thing that can make the mind progress."[137]

In fine, within these preoccupations of intellectual obedience, it would be possible to once again quote a remark by Satprem because, in a synthetic way, this "researcher of worlds to come" [*chercheur des mondes à venir*] admitted without blushing that "not everyone is a philosopher, nor poet, and even less a fortune teller."[138] Nevertheless, because of this utopian idea of continuum in filigree throughout his numerous music compositions and aesthetic reflections, wasn't the follower of set theory someone who finally practiced "philosophy, as an inaccessible thought of totality"?[139] Moreover, didn't the composer François-Bernard Mâche (b. 1935)—a long-time friend of Xenakis—point out that "a true musician is always a philosopher of sounds, and his aesthetic conceptions always carry their glances beyond simple considerations of craft and emotion"?[140] Faced with such questions remaining to be solved (in the long run), one of the answers perhaps resides in what Xenakis initiated in 1965 when he declared with solemnity that "the era of Scientific and Philosophical Arts has begun. From now on, a musician will have to be a maker of philosophical theses and global architectures, of combinations of structures (forms) and sound matter."[141]

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136 Xenakis, 1986, p. 160–2 [*ouvrir les fenêtres sur l'inédit*].

137 Ponge, 1961, p. 211 [*il faut que les choses vous dérangent. Il s'agit qu'elles vous obligent à sortir du ronron ; il n'y a que cela d'intéressant parce qu'il n'y a que cela qui puisse faire progresser l'esprit*].

138 Satprem, 1970, p. 4 [*tout le monde n'est pas philosophe, ni poète, et encore moins voyant*].

139 Foucault (1926–84), 1971, p. 77 [*la philosophie, comme pensée inaccessible de la totalité*]. For his part, Xenakis affirms: "I attain the inaccessible through my music" [*l'inaccessible, je l'atteins par ma musique*] (Xenakis, 1972, p. 58).

140 Mâche, 2001, p. 14 [*un vrai musicien contient toujours un philosophe des sons, et ses conceptions esthétiques portent toujours leurs regards au-delà de simples considérations de métier et d'émotion*].

141 Xenakis, reprinted in 1994a, p. 74 [*l'ère des Arts Scientifiques et Philosophiques est commencée. Désormais, le musicien devra être un fabricant de thèses philosophiques et d'architectures globales, de combinaisons de structures (formes) et de matière sonore*].

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8. Iannis Xenakis's Materialism: On the Dialectic of Real-time Computation

Ramón del Buey Cañas and Oswaldo Emiddio Vasquez Hadjilyra

Introduction

Xenakis's lifelong preoccupation with physical matter's contingent properties, and his singular interpretation and adaptation of these for the purposes of music composition are well-established in various Western narratives of post-war music history. Informed by physical principles, on the micro scale, Xenakis postulated grains of sound as limiting quanta of sonic energy to be used *en masse* in composition, a postulate whose digital implementation is still alive and well in the techniques of granular synthesis. On the macro scale, he proposed stochastics as an arrangement principle derived from material motion by painstakingly transcribing statistical computations, making use of the computer well before others did, and crucially, after assessing the aesthetic qualities of the computation's results, he would accordingly adjust them in his compositions. In live performances, he welcomed free and non-human variables to play an active role in his works and when considering computers, he wrote code for software like GENDY where stochastic processes were implemented on both micro and macro scales, modulating dynamically both timbre and the composition's temporal structure with dynamic variations taking place at every register. These instances capture a more general trait in Xenakis's work: that of a contingent matter subject to perpetual motion on multiple scales.

Yet any desires to assign to Xenakis a naive fascination for the clamor of a vibrant matter that evades anthropocentric mastery or control would be quickly refused by Xenakis himself in his revised preface to *Formalized Music*, in which he asserts that for a composer it "is absolutely necessary to free oneself, as much as possible, from any and all contingencies."[1] Such assertions are frequent in Xenakis's writings and exemplify one

1 Xenakis, 1992, p. xi.

 https://doi.org/10.11647/OBP.0390.10

of the main challenges to engage with his work in philosophical terms, since, for him, music was one of his ways of dealing with the philosophical problematics of matter. As an avid reader of dialectics (Plato and Marx) but also the materialists of antiquity (Parmenides, Heraclitus, and Lucretius), and a practitioner of applied mathematics with a concrete understanding of the development in physics and information theory of his time, he poses a challenge to his readers who would need to familiarize themselves with all fields to engage properly with the philosophical implication of his propositions. When considering these compositional and philosophical tenets, as well as Xenakis's political commitment to materialist politics, and in the context of an ongoing revival of materialism, it is worth asking: what is Xenakis's materialism and how do we speak about it in the present moment?

In one of the most comprehensive summaries on what new materialism is and what its future beholds, Christopher Gamble, Joshua Hanan, and Thomas Nail in their 2019 essay "What is New Materialism?" identify at least three strands of new materialism: vital, negative, and performative.[2] Without going into great detail about each of the strands, it suffices to state that these authors favor the performative strand as the candidate with the potential to "radically undermine a discrete separation between humans and matter" with "an understanding of science in which every act of observing also constitutes, at once, a transformation of what is being observed." For that strand they coin the term "pedetic materialism," where the criterion of pedesis is defined by an irregular, partly unpredictable motion in matter, that is iteratively related to its immediate past but not determined by it. This aspect, a focus on transformation one step at a time, has some important implications that will be addressed later, especially in relation to real-time computation.

Our purpose, however, is not to carry out an exercise of historicism that traces back to Xenakis these recent developments according to a hermeneutics of retroprojection, but rather to think alongside Xenakis from our own present moment in order to elaborate a better insight about the theoretical and practical impasses in which we find ourselves. Theoretical impasse, in the first place, because the latest advances in the natural sciences invite philosophy to reconsider its positions on fundamental concepts of accounting for the cosmos. Practical impasse, because it is not only a question of bringing theory down to the material reality and its human and non-human problems, but also a challenge in terms of composing: of doing things with art, of arranging new conditions of perception that become a transformative experience. How could a materialistic perspective help to achieve this double objective? How can Xenakis's work contribute to contemporary philosophical reflection on performativity from a materialist perspective? How to avoid the frequent practice of theoretical collage, which merely joins two autonomous fields of study not only without contributing anything valuable to either of them, but even subtracting the complexity of their respective problematics?

2 Gamble et al., 2019, p. 111–34.

In order to put forward our hypothesis, we think it is necessary to go beyond the ambiguous generality of abstract terms and explore a particular problem from a specific framework, pointing out the aspects of Xenakian thoughts and practices that inform and materialize this case study. Then our premise for providing an answer to these questions, as we have argued elsewhere, could be formulated as follows: the reflection on performative matter will have to take into account the material transformations that take place in time-based media and their techniques, as they carry out their specific modes of computation.[3] In this sense, we take as inspiration a series of characteristic features of UPIC (Unité Polyagogique et Informatique de CEMAMu), especially its pioneer, real-time computation, and defend this kind of materiality as a relevant contribution for contemporary music making and philosophical discussion on materialism.

Composition and Performance

Before examining the case of the UPIC, it is useful to outline how real-time computer music can be accounted for from the viewpoint of performative materialism, and to what extent the way Xenakis understood computation is in line with this philosophical paradigm.

If we look at the most general use of the word "performance" in the context of music we find a valuation in terms of how well a person, machine, etc. does a piece of work or an activity. This perspective is not only limited to the quality of the performed action, but, as Le Mardi Gras Listening Collective has pointed out, it also has a complex and obvious link with the economic process: how to "make music make money."[4] However, these restricted senses of performance in music do not correspond to the approach of performative materialism, according to Karen Barad's claim of a performativity that is not reduced to the narrowness of the representationalist framework: "Performativity, properly construed, is not an invitation to turn everything (including material bodies) into words; on the contrary, performativity is precisely a contestation of the excessive power granted to language to determine what is real."[5] In this sense, how can we speak of performativity in computer music going beyond the aforementioned valuation or its economic profitability? What would such a performativity consist of, and to what extent can we recognize it in Xenakis's practice?

According to Barad, the approach of performative materialism marks an important conceptual shift, altering modern metaphysics and its understanding of matter:

3 Vasquez Hadjilyra, 2022, p. 107–24.
4 Le Mardi Gras Listening Collective, 2020, p. 133–51.
5 Barad, 2003, p. 802.

> *matter is substance in its intra-active becoming—not a thing, but a doing, a congealing of agency. Matter is a stabilizing and destabilizing process of iterative intra-activity* [...] That is, *matter refers to the materiality/materialization of phenomena*, not to an inherent fixed property of abstract independently existing objects of Newtonian physics.[6]

Here it is important to note that the notion of "intra-action" replaces the "interaction" of modern metaphysics, which presupposed the prior existence of independent entities/relata. On the contrary, the approach of performative materialism considers that it is through specific intra-actions that the limits and properties of the "components" of phenomena are determined. In this regard, as Gamble and Hanan have pointed out, "matter's only essential feature, then, is its ontological indeterminacy [...] which enables it to continually undergo iterative yet creative transformations through novel and creative relations that provisionally resolve that indeterminacy in particular ways."[7] In the case of computer music, this perspective completely overturns the understanding of the creative process, in the sense that composition and performance become material determinations of indeterminacy, computationally mediated.

At this point, it is worth saying a few words about Xenakis's ideas on music materiality, computation, and indeterminacy. Two crucial texts in which Xenakis's materialist perspective in this regard can be detected are, on the one hand, "Subtended Philosophy,"[8] the preliminary statement of Xenakis's thesis defense in 1976, and, on the other hand, "Determinacy and Indeterminacy,"[9] a 1996 edition of Xenakis's notes for a series of lectures delivered in Poland in the 1980s and not previously published.

It is not by chance that the question that guides Xenakis's reflection on "subtended philosophy" is directed towards the form and architecture of the materials involved in music making. In this sense, the recurrence of vocabulary from the natural sciences to characterize this creative process informed by philosophy and mathematics is striking: "fossilizations," "solidification, materialization," "expression of the billions of exchanges, reactions and energy transformations of the body and the brain cells," "cellular condensations and movements," "vibrations," "coagulations," "colored pebbles which are my musical, architectural and visual works and my writings," etc. According to Xenakis, these manifestations are always imbricated in "continuous formations and transformations," and it is precisely the materiality of this process and its modes—Xenakis distinguishes three, "indispensable and coordinated": the inferential (rational), the experimental (technical) and the revelatory (intuitional)—the last being what interests us most here. In this, motion always participates in the philosophical impulse "which pushes us toward truth, revelation, research, general quest, interrogation, and harsh systematic criticism [...] in all possible domains,"

6 Author's italics. Ibid., p. 822. For a more detailed discussion of the notion of "iterative intra-activity," see: Barad, 2011, p. 121–58.
7 Gamble and Hanan, 2021, p. xiii.
8 Xenakis, 1985, p. 1–10.
9 Xenakis, 1996, p. 143.

and mathematics "as a philosophical catalyst, as a molding tool for forming auditory or visual edifices, but also as springboard toward self-liberation." Computer music materiality, therefore, would be a "necessary solidification, materialization of this intelligence."[10]

Regarding this dialectic between determinacy and indeterminacy, Xenakis's 1996 article is suggestive: "The problem encompassed by determinacy and indeterminacy is a permanent one in music, both for composition and also for performance." Here it is not necessary to delve too deeply into the complexity of performative materialism and its pedetic aspect to discover this back-and-forth motion constituting one of its most important cores: "Without any radical exteriority between things, moreover, performative materialism refuses any ultimate or unchanging totality of what is possible. Instead, a generative "ontological indeterminacy" prevails at the heart of such an account."[11] It is interesting that, in the aforementioned text, Xenakis considers determinacy and indeterminacy together, as if they were two aspects of the same totality: "To be and not to be is the same."[12] But from our point of view, there is another key aspect of the article's approach: the invitation to consider the "very important and deep question" about determinacy not only from a philosophical perspective, but also "against a background of physics and computer science."[13]

To understand this computational materiality, we could establish a relationship with Georges Bataille's (1897–1962) critique of modern metaphysics, when he states that the focus should be placed not on meaning but on uses, and on how uses condition matter, with matter remaining formless.[14] Real-time computer music, in this sense, would not be distinct from such a conception, but a material composition and performance of indeterminacy. In this way, we could say that the discrete separation between "composing music" and "performing music" is dissolved, and, as we will see in the case of UPIC, such dissolution or at least its intention would be encapsulated by and through real-time computation technique. But this transformation is not without theoretical problems. Any linguistic formulation of this performativity is inevitably an abstraction, and we must take care, as Isabelle Stengers has warned, that its aim will not be "to produce new definitions of what we consensually perceive and name, but to induce empirically felt variations in the way our experience matters."[15]

In this sense, another historical precedent of interest would be the unfinished project by Th. W. Adorno (1903–69), outlined in his lecture *Vers une musique informelle*. According to Adorno, "*musique informelle*" denotes:

10 Xenakis, 1985, p. 1.
11 Gamble et al., 2019, p. 121.
12 Xenakis, 1996, p. 155.
13 Ibid., p. 143.
14 "Formless," in Bataille, 1985.
15 Stengers, 2008, p. 96.

> a type of music which has discarded all forms which are external or abstract or which confront it in an inflexible way [...] should be completely free of anything irreducibly alien to itself or superimposed on it, it should nevertheless constitute itself, and not in terms of external laws.[16]

In our view, the most interesting aspect of this position is its difference with respect to other of Xenakis's coetaneous proposals centered on reduced listening (Pierre Schaeffer (1910–95)) and self-referentiality of sounds (John Cage (1912–92)), since, contrary to these, "*musique informelle*" would sustain the critical function of the sound material as opposed to the abstraction of the form without incurring the metaphysical and positivist assumption that sound devoid of all meaning would be its own meaning: rather, what is irreducible in this case would be the dialectical relation between determinacy (form) and indeterminacy (formlessness) as such.

In the case of real-time computer music, this dissolution of the border between composing and performing can be addressed from what Sharon Kanach has pointed out as a "dialectical merger" in Xenakis's creative process:

> Although Xenakis searched for universal structures that not only permeate but also govern our natural world, he was never interested in simply replicating such structures as literal translations, nor did he proceed by means of metaphor [...]. Even though each of his works can be appreciated without previous knowledge of its underlying philosophical question, that question's mere—albeit hidden—existence may explain why his music never leaves one indifferent. Each of his creations represents a point of dialectical merger between, on the one hand, mathematical and scientific thought and, on the other hand, intuition.[17]

The characterization of this art/science alloy as dialectical is relevant and points towards new directions in the development of performative materialism: a conception, at times, too focused on encouraging closer attention to the sciences by the humanities and neglecting relevant artistic contributions, and at other times, too focused on idolizing technological achievements and neglecting the possibilities of uses informed by alternative forms of computation. At this point, we would like to warn that, as Fredric Jameson has pointed out, the adjective "dialectical" constitutes one of the three names for dialectic (the others being "the dialectic" and "dialectics") and brings with it idiosyncratic complexities and potentialities. We believe that it is this modality of dialectics, i.e. "dialectical," that can contribute the most to philosophical reflection and artistic creation based on alternative forms of computation, but we must leave the detailed treatment of this idea for another time.[18]

In a similar line of thought, a suggestive conception of "doing" or "use" has been analyzed by Peter Nelson with regard to UPIC, by drawing attention to the way in which this apparatus fuses its formations:

16 Adorno, 1962, p. 272.
17 Kanach, 2010, p. 126–7.
18 Jameson, 2009, p. 3–70.

> The seeming simplicity of the arrangement of these elements belies the openness of the apparatus to multiple reconfigurations. Its productions figure not as score and performance, but as simultaneous manifestations of the same productive impulse. Thus, the drawings rendered in the production of Xenakis's work for UPIC, *Mycenae Alpha* are as important as the sound they produce.[19]

Perhaps the attributes described in this fragment are not too far removed from the characteristics that "pedetic materialism" has identified as the fundamental features of matter, where the criterion of pedesis is defined by an irregular, partly unpredictable motion in matter, that is iteratively related to its immediate past but not determined by it. But now the question would be: how is this indeterminacy or *informelle* condition composed and performed in the context of Xenakis's real-time computer music, and in what ways can this "doing" or "use" be inspiring for a performative, material understanding of our computational instruments? We believe that the UPIC real-time version offers a powerful starting point for addressing these questions. In this sense, paraphrasing Stengers again, our working hypothesis consists in arguing that we need to feel variations empirically, in the way that performativity matters, by attending to a specific way in which Xenakis's computational praxis operates. But before addressing the case of UPIC, let us first turn towards the materialist perspective from which Xenakis understood information theory and computation.

Physics, Information Theory, and Computation

Recent publications on the historical nexus of information and computation theory and their role in shaping Xenakis's compositional decisions indicate a close affiliation with the work of French polymath and information theorist Abraham Moles (1920–92).[20] Anne-Sylvie Barthel-Calvet, in her text "Iannis Xenakis and the Men of Information Theory," provided new information on the relationship of affinity between Moles and Xenakis, such as the frequency of the meetings they had in Paris, or the praise that Moles dedicated to Xenakis in Gravesano and in generous gestures, as when he inscribed an offprint of his article "Some Basic Aspects of an Information Theory of Music" (1958) with the words "To Xenakis, who achieves what others talk about."[21]

Even if many of Xenakis's ideas were already formulated and deduced intuitively from his studies of quantum physics, both his time in Gravesano and the relationship with Moles developed thereafter—including the formation of MIAM, a study group

19 Nelson, 2022.

20 Olga Touloumi and Makis Solomos have made valuable contributions on the importance of physics and thermodynamics for Xenakis. See Touloumi, 2012, p. 101–25; Solomos, 2021, p. 179–92. Jennifer Iverson and Anne-Sylvie Barthel-Calvet have shed much light on the influence of information theory and cybernetics on Xenakis's work. See Iverson, 2019; Barthel-Calvet, 2022. Peter Hoffmann and Inigo Wilkins have made crucial contributions on the relationship between computation and indeterminacy in Xenakis's work. See Hoffmann, 2009; Wilkins, 2016.

21 Barthel-Calvet, 2022.

for mathematics and music founded in 1960 by Abraham Moles with Iannis Xenakis, Alain de Chambure (1922–2010), and Michel Philippot (1925–96)—enriched further his engagement with information theory and played a critical role in the way he interpreted and applied different computations in his own work, some of which can be witnessed in some of UPIC's design decisions and computation capabilities. Due to a shared translation of concepts from science to sound, but also a disjunction between different strands in information theory, we begin by considering some of Moles's propositions. Far from being congruent to Xenakis's own adaptation and compositional decisions, Moles's approach to information theory was nevertheless indicative of a possible alternative to Claude Elwood Shannon's (1916–2001) dictum, of information stripped of meaning, which grants us better access to Xenakis's own computational thinking.

Starting with entropy, a concept found in both physics and information theory, Jennifer Iverson, in *Electronic Inspirations: Technologies of the Cold War Musical Avant-Garde* summarizes Xenakis's rendition:

> [The] equations that Xenakis adapted—the Maxwell–Boltzmann and Gaussian distribution functions—are relatable to the paradigms of information theory. He may have known these equations from engineering and physics, but they connect mathematically to Shannon's information theory around concepts such as entropy, albeit from somewhat different angles. In information theory, entropy is a measure of the amount of information in a message; as Shannon theorized, all possible information (the highest entropy value) is constrained by linguistic redundancies and statistical predictions. In physics, entropy is a measure of randomness within a system, such as the relative disorder of molecules within a gas. The concept of entropy is not used in exactly the same way in cryptography and thermodynamics, for example, but Xenakis's dual information-theoretic and physical-science experiences do intersect on certain shared or translatable concepts: randomness, statistical modeling, and predictability.[22]

The inexactitudes of translating and applying these adaptations in music composition, along with Xenakis's critical commentaries on the more dominant implementation of information theory, help us frame one of his main objections: any analysis based solely on bits or quanta of information transmitted and received is incapable of determining the aesthetic value of music. By that same token, Xenakis asserts that a composer's responsibility lies in assessing value while remaining skeptical of its outcome, which is why, despite his recourse to scientific method and the certainties that it affords, time and again Xenakis insists on "the supreme criterion [...] the aesthetic efficiency of the music which resulted."[23] This may ring as platitude, as too obvious to state, but given the ongoing automation of music creation, molding both attention and appreciation of music experience, with datasets prefiguring the training of future AI-assisted techniques in composition, questions concerning agency and control over aesthetic

22 Iverson, 2019, p. 132.
23 Xenakis, 1992, p. xi.

value should be resurging, even if the present discourse on materiality aspires to direct them towards agency of the non- or other-than-human.

Nevertheless, it is precisely that sense of aesthetic value in informational processes that Moles tried to recuperate in his theorization of information in *Information Theory and Esthetic Perception* ([1958] 1966). By directly modulating sonic material and deducing principles from its perception, Moles tried to extend information to aesthetics by tracing it back to the material substratum of their media, marking in that way an important digression from the more pragmatic program of reductive precision and efficiency that was laid down by Claude E. Shannon and Warren Weaver (1894–1978) in their dematerialized conception of information that would ultimately dominate its discourse. In the case of music, even if Shannon considered the cases of continuously transmitted sound, the aim was still predominantly directed towards its discrete case employed in communication and was thus postulated in a limited form which assumed much of the Western canons of music and its means of signification, i.e., a discrete notation system[24].

For Moles, however, information theory entailed an investigation into the material histories of technologies and media, in which writing, printing, transmitting, and computing, all delineate different moments of what has been all along a material process of communication. "The invention of printing led the materiality of writing to be discovered" which, with the increase of signs and symbols, and their ability to be transmitted through radio, telegraphy, and television, made it possible to conceive "the existence of a materiality of communication no matter what the mode of communication"[25] was. Music, with its information, holds a unique position here in that its dematerialization through recording and transmission is what accounts for its substantiation. In Moles's words, "'materia musica' is born of recording," lending itself to be observed and studied, as a manufactured, temporal item, as "a mapping of *time into space*."[26] Its once elusive temporal structures, in their new coagulated forms, assume qualities that used to be preserved for objects that occupy space. With the advancements in digital reproduction of music, with a mode of transmission that is currently undergoing a new phase of dematerialization, it is worth keeping in mind Moles's proposition that since communication entails the complexification of the space-time medium between transmitter and receiver, then information, as a measurable quantity, describes the process of communication as such. According to Moles, an information "message is a complex *form*, and its rate of information measures the complexity of the form [...] The message transfers complexity from one point of the world to another."[27] As the delta between transmitter and receiver diminishes, communication and its complexification now takes place in a new register, that of the transformation of

24 Shannon and Weaver, 1964, p. 25.
25 Moles, 1966, p. 192.
26 Ibid., p. 106.
27 Ibid., p. 197.

information in communication, and this is where Moles's theorization offers a unique perspective to recuperate and implement in our understanding of computation: unlike his predecessors, for Moles, information is always a coagulation of semantic and aesthetic information, comprised of a universal logic that renders it transmittable but that is always confronted with diffracting interpretations unique to every single receiver. Hence, the semantic and aesthetic, as virtual extremes, subtend a dialectical dipole of several non-exhaustive dualities (order/disorder, predictable/unpredictable, banal/original, redundant/informative, intelligible/novel, simple/complex), which cannot exist in isolation and which can never be reduced to their complementarity. Instead, they all fluctuate and operate *together* in the performances where both communication and computation exist. With this in mind, then, the role of a composer's agency within the constraints and potentials of instrument design acquires a more fruitful meaning.

UPIC: Real-time Composition and Computational Performance

At this point, we can address the peculiarity of the late 1980s and 1990s versions of UPIC and its real-time computation. Although the exploration of UPIC's potentialities continues today with several versions of UPISketch developed at the Iannis Xenakis Center, the first real-time version dates from 1987, improved in the 1990s, and was the most advanced version of UPIC that Xenakis worked with (earlier, Xenakis had also worked with the first generation of UPIC, with which he composed *Mycènes Alpha*). We owe to the CEMAMu team (Gérard Marino, Jean-Michel Raczinski and Cornelia Colyer, among others) and composer Brigitte Robindoré the explanation of the synthesis methods implemented in it, including additive synthesis, subtractive synthesis, graphical synthesis, resynthesis, frequency modulation, amplitude modulation, synthesis by aliasing or granular synthesis. Here the so-called Frequency Table should be highlighted. This tool enabled, by means of four superimposable tables or grids invisible to the eye, the placing of arcs within different frequency spaces determined by the user, with a range as wide as 0.01–22,050 Hz. This computational development, with its capacity to transform the invisible into the visible, and frequencies below 20 Hz into highly complex waveforms audible in the infrasonic range, is an extraordinary case of materiality, in which formless matter is "condensed" to the threshold of aesthetic perception.

Moreover, UPIC's real-time computing capacity not only offered a material mediation between the *informelle* and the *formelle* on the sound and visual level, but also on the conceptual level. As Robindoré points out:

> Interestingly, the Frequency Table further introduced a concept that was potentially as impactful as the continuum: *the tempered discontinuum*. With a function called "discrete/non-discrete," the user could define how the frequency space was to be moved through. If non-discrete, then a diagonal arc would sound like a *glissando*, the classical use of the continuum with the UPIC. However, if "discrete" were chosen, the user could create

> equal temperaments between 1–99 divisions per octave. The same diagonal arc would then sound like discrete steps in a defined temperament. For those who wished to utilize non-tempered scales, the arcs would have to be drawn individually within a non-discrete frequency table. These features were almost never used, although they contained very intriguing possibilities of exploration into tempered scales beyond 12-tones, for those who wished to compose with determined pitches.[28]

In this sense, we consider the discrete/non-discrete function a computational contribution belonging to the same family of material answers that Xenakis offered to the philosophical question of continuity, some of them examples of what we could call a "computation without computers," such as the *glissando* technique, and other examples of a paradigm shift in our understanding of the nature of sound and the nature of music, such as granular synthesis. The use in real-time of this computation opens up a whole field of creative possibilities, establishing forms of continuity between the traces drawn and the sounds heard that are revolutionary, not only if we compare them with the relationship between the composition of a score and its performance, but also with respect to the understanding of sonic matter itself as intra-active becoming and pedetic motion, according to the terms of performative materialism:

> an envelope could share the same visual description as a waveform yet retain its own time-varying amplitude function. In real-time use, these parameters could be swapped or redrawn almost instantaneously, extending the concept of synthesis to a type of sonic metamorphosis in real time—a continuum in its own right.[29]

Finally, a third inspiring element for the artistic use of materialistic developments appears when we look at the first performance of UPIC's real-time capacities, carried out by Xenakis himself in 1987, with *Taurhiphanie* (1987), for UPIC, light effects and amplified bulls and horses.[30] In this sense, as Raczinski has pointed out, Xenakis was a pioneer not only in revolutionizing music composition with an interface such as UPIC, but also in diverting (*détourner*) his own invention from its primary goals.[31] In the original concept of *Taurhiphanie*, the bulls were to be equipped with high frequency (HF) microphones to capture their breathing and roaring, and the UPIC would then have been used by Xenakis to improvise with these materials. It is worth noting here that such controlled integration of a non-anthropocentric indeterminacy resonates with other previous works for UPIC, such as the *Polytope de Mycènes* (1978), where "children or goats carrying electric torches draw in the fields or on the mountain luminous tracings that merge at night with the celestial constellations."[32] Although lack of rehearsal time and technological limitations frustrated the realization of this idea (during the *Taurhiphanie* concert of 13 July 1987, Xenakis finally manipulated pre-

28 Condorcet (Robindoré), 2020, p. 406–8.
29 Ibid., p. 408.
30 In 1988, Xenakis created a concert version of this same work.
31 Raczinski, 2001.
32 Xenakis, 1982, p. 202.

recorded sounds), its spirit points to interesting possibilities of musical determination with respect to one of the fundamental tenets of performative materialism, concerned with radically undermining a discrete separation between humans and matter, and in our contemporary concerns: the role of the non-human. As Xenakis himself stated, by reintroducing animals into compositions and materializing real-time computation, "music became then Nature."[33]

Conclusions

Following the dialectical movements of the aesthetic theory of information that Moles proposed as well as the characteristics in UPIC, we can now begin to understand some of the computational thinking in Xenakis's work (even if some of processes do not even entail a computational method at all) and its philosophical implications. Xenakis's criticisms of certain developments, as well as of the assumptions of his contemporaries, become crucial for understanding his relationship to computation and materialism. So, to conclude, we briefly condense these as concrete philosophical problems that Xenakis addressed, both directly and indirectly, that can be further pursued when considering the role of information in music composition, the role of real-time computation in performance, and are available to be tested against the various strands of materialist thinking.

1. UPIC's use of *gestural* drawing offered a primordial and prelingual condensation of time and space that challenged the symbolic order of musical notation. At the level of sonic physical matter, Xenakis's postulate of quanta, as vectorial *glissandi*, that condense and complexify the spatio-temporal form resists its discretization into symbolic abstraction.
2. Xenakis's well known critique of the serialist school, and their assumption of the twelve-tone technique, can now be understood also as a critique against the reductionism imposed by information theory upon the transmission of aesthetic messages, whereby the restriction to twelve tones is nothing but an informatic compromise to which music has no reason to conform or to exhaust itself in banal permutations.
3. Xenakis's critique of Harmonic Analysis based on Fourier functions is both a problem of construction and presupposition of temporality. Much like computation that presupposes the construction of information as one comprised of discrete abstracted symbols to be encoded along an infinite, unidirectional tape (Turing machine), the Fourier series assumes the circular form (which evades, categorically, matter itself) in order to reconstruct the complexity of that evasion by assuming the very infinity of its own temporal timeline.

33 Xenakis, 1988, p. 105. Authors' translation.

4. The role of agency and decision-making by the composer is reconfigured once again, but not as one where humans seek to dominate nature with their computational tools. Instead, that new relationship is one that acknowledges the irreducibility of contingency in the compositional process by constructing instruments that resist the all-too-easy danger of becoming subject to the determination of the tool itself. Unlike ongoing trends in materialist thinking and posthumanist thought that seek to decenter the human role in decision-making, given the recent developments in automated processes and AI techniques in composition, whereby intention and aesthetic content are diffused and distributed across datasets, the role of choice and intention calls upon a newly formed set of responsibilities and challenges, to which Xenakis's work has been attuned all along.

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9. Iannis Xenakis's Philosophy of Music, Stochastics, and the Postmodern Sublime

Nathan Friedman

In "The Total Rejection of Heritage, or Iannis Xenakis," an article originally published in 1980, Czech author Milan Kundera (1929–2023) wrote, "faced with Xenakis's music I was completely unprepared, unschooled, uninitiated, an utterly naïve listener. And yet I felt genuine pleasure at hearing his works, and I would listen avidly. I needed them: they brought me some strange consolation."[1]

After the invasion of his country by the Soviet Union in 1968, Kundera sought out not "the patriotic music of Smetana"[2] but the "world of noises in Xenakis's works,"[3] because of a profound disenchantment with "man as man, man with his cruelty but also with the alibi he uses to disguise that cruelty, man always quick to justify his barbarity by his feelings."[4] For Kundera, Western music, based on "the artificial sound of a note and of a scale,"[5] was inexorably bound up with the sentiment of subjectivity, which he considered to be "part and parcel" to the brutality of European history[6] and it took Xenakis's rejection of this "insurmountable convention"[7] in order to produce a beauty "washed clean of affective filth, stripped of sentimental barbarity."[8]

Kundera's assessment of the traditions of Western music and the effect of the musical avant-garde prefigured by several years similar arguments that form the cornerstone of Jean-François Lyotard's (1924–98) *The Inhuman*, originally published in 1988. Lyotard contrasts the principles of humanism (especially that since the Enlightenment) with two types of what he calls the "inhuman": the logic of capital (which he refers to as

1 Kundera, 2010, p. 74.
2 Ibid.
3 Ibid., p. 78.
4 Ibid., p. 75.
5 Ibid., p. 77.
6 Ibid., p. 75.
7 Ibid., p. 77.
8 Ibid., p. 78.

 https://doi.org/10.11647/OBP.0390.11

development), and "the infinitely secret one of which the soul is hostage."[9] The latter he explains as an infant-like state, an "initial misery" that requires programming by "the institutions which constitute culture" in order to transition to the truly human.[10] The primary difference between these two forms of the inhuman is one of temporality: capital goes quickly, retaining information just long enough for it to be of use, and then forgetting it again; whereas the process of attaining the inner inhuman is slow. Both forms, however, converge on what Lyotard refers to variously as the event (Heidegger's *Ereignis*), the now, the instant, or the moment, which constitutes the essence of what he refers to as the *postmodern sublime*.

As an aside, in discussing the postmodern sublime, Lyotard is adamant that he does not use the word "postmodern" in the popular sense,[11] but rather in the sense of something that the trajectory of modernity makes inevitable. He writes:

> we have to say that the postmodern is always implied in the modern because of the fact that modernity, modern temporality, comprises in itself an impulsion to exceed itself into a state other than itself. And not only to exceed itself in that way, but to resolve itself into a sort of ultimate stability.[12]

In other words, modernism's "narrative of emancipation"[13] contains the seeds of its own undoing.

Lyotard's "postmodern" sublime is contrasted with the "Romantic" sublime of Edmund Burke (1729–97)[14] and Immanuel Kant (1724–1804),[15] whereby the human subject, faced with something that is ungraspable by the senses, feels pain from its inability to imagine the object that it faces, yet also feels pleasure from its ability to rationalize that which it can neither sense nor imagine. This conception of the sublime, though it is applicable to works of art, is usually discussed only as present in the mind of the observer. Lyotard uses the postmodern sublime explicitly to refer to the engagement of an observer with artworks, and that it is something immanent to the works themselves. Using the paintings of Barnett Newman (1905–70) as an example, Lyotard proposes that when faced with an avant-garde artwork, one that eschews all notions of representation or allusion, the observer, unable to use any received model to determine what will happen "next" (while this essay discusses music, the perception of a work of visual art still happens in time), is faced with the real possibility that nothing will happen, that the work will not continue. The observer must constantly ask themselves "is it happening, is this it, is it possible?"[16] Lyotard ascribes to this uncertainty a feeling of anxiety, but also positive feelings: the "pleasure in welcoming

9 Lyotard, 1991, p. 2.
10 Ibid., p. 3.
11 Ibid., p. 34.
12 Ibid., p. 25.
13 Ibid., p. 68.
14 Burke, 2009.
15 Kant, 2000.
16 Lyotard, 1991, p. 90.

the unknown," and "the joy obtained by the intensification of being that the event brings with it."[17] Subsequently, the "next" event happens, or does not, but the observer finds themselves in an identical position to that which they were prior to the "previous" one. Thus, the commingling of pleasure and pain in the experience of each moment of avant-garde art is the postmodern sublime.

In Xenakis's writings, it is clear that he shares Lyotard's consideration of the event as the crux of avant-garde art. Examining Xenakis's thoughts on the matter, however, requires a brief investigation of his foundation in ancient Greek philosophy. The Presocratic philosopher Parmenides (fl. 475 BCE) was particularly influential on Xenakis, who dedicated his 1964 work *Eonta* to him. Parmenides was the earliest proponent of the notion of *being*, in which "what is" is "one, spherical, indestructible, eternal [...] ungenerable and imperishable, indivisible and unchanging."[18] In 1958, Xenakis took Parmenides's verse "for it is the same to think as to be" and paraphrased it thus: "for it is the same to be as not to be."[19] How exactly these statements are equivalent is of some controversy to Xenakis scholars,[20] but it suffices to note that, for Xenakis, the paraphrased version brings his philosophy of music into the realm of the event. To his paraphrase, he adds "In a universe of nothingness. A brief train of waves, so brief that its end and beginning coincide (time in nothingness) disengaging itself endlessly. *Nothingness resorbs, creates. It engenders being*."[21] He imagines the universe as a sort of flux that transcends the temporal, "open to spontaneous creation, which could form or disappear without respite, in a truly creative vortex."[22] Xenakis goes on to describe the process of composition in terms clearly belonging to the sublime:

> the choices that I make when I compose music, for example. They are distressing, for they imply renouncing something. Creation thus passes through torture. But a torture which is sane and natural. That is what is most beautiful: to decide at any moment, to act, to renounce, to propose something else. It's great. The joy is the fulfilment of living. That's what it means to live.[23]

In fact, Lyotard's postmodern sublime describes this experience, previously only understood to be available to the creator of a work, as becoming accessible also to the listener. This is the "misery" faced by the creator: "not only faced with the empty canvas or the empty page, at the 'beginning' of the work, but every time something has to be waited for, and thus forms a question at every point of questioning, at every 'and what now?'"[24] In the postmodern sublime, this occurs at every moment.

For Lyotard, the event produces a highly specific kind of temporality in the mind

17 Ibid., p. 92.
18 Antonopoulos, 2005, p. 3.
19 Xenakis, 1987, p. 44.
20 See Antonopoulos, 2005; Chrissochoidis, Mitsakis, and Houliaras, 2005; Solomos, 2004.
21 Italics in original.
22 Xenakis, 1987, p. 44.
23 Ibid., p. 45.
24 Lyotard, 1991, p. 91–2.

of the observer. In the ordinary perception of time, he describes events as "sentences" which are each "a 'now'" that are strung together with other sentences "on a single diachronic line" in our consciousness.[25] Through the action of the "objectifying synthesis" that produces this line, however, the observer forgets that each "now" must be mediated by memory as it transits from present to past, it cannot be "synthesized *directly* with other presents," since they have become pasts.[26] He also writes that the present itself "cannot be grasped: it is *not yet* or *no longer* present. It is always too late or too soon:"[27] too late because each present is "dragged away by what we call the flow of consciousness' in which 'it never stops fading away;"[28] too soon because a perception of the present would require a conscious mode of anticipation, "the intention to identify, the project of seizing and identifying [...] the thing itself"[29] of the present, which is not perceiving it in the moment.

Another aspect of the temporality of the event relates to the questions that one asks oneself in the moment. I have already discussed above the question *is it happening*? as it relates to the event, which Lyotard calls *quod*. Another question asked by oneself is *what is it*?, what does the event signify, which he calls *quid*. *Quid* must necessarily happen after *quod*, since one must recognize that something has happened in order to examine it. The temporal gap between *quid* and *quod* is a central concern of Lyotard, which he places at the core of the inhuman. In its typical rapidity, the inhuman of development seeks to answer the *quid* as quickly as possible. However, answering the *quid* in this way reduces all events to their utility, changing their information to "an environmental given" and then "'all is said,' we 'know.'"[30] Lyotard writes that "complete information means neutralizing more events" because "what is already known cannot, in principle, be experienced as an event."[31] In music, when we already "know" the answer to *quid*: the event undergoes a process that Brian Kane, drawing from the study of rhetoric, calls *figuration*, whereby the listener imports musical metaphors into the aural experience, where "all *sounds* become *tones*, and all *tones* are metaphorical."[32] What the postmodern sublime describes is an event that resists such figuration, by achieving the "other inhuman," where the *quid* is delayed as long as possible (or even indefinitely) by a "now" that "dismantles" or "deposes consciousness," that accesses "what consciousness cannot formulate, and even what consciousness forgets in order to constitute itself."[33]

The event, as described by Lyotard and Xenakis, is clearly an ideal to which they aspire, but the postmodern sublime is somewhat (or completely) inaccessible in

25 Ibid., p. 59.
26 Ibid. Italics in original.
27 Ibid. Italics in original.
28 Lyotard, 1991, p. 24–5.
29 Ibid., p. 25.
30 Ibid., p. 105.
31 Ibid., p. 65.
32 Kane, 2004, p. 126. Italics in original.
33 Lyotard, 1991, p. 90.

the process of listening because of intrusions by the human mind and its powers of figuration. Lyotard notes that the inhuman of childhood is tamed by the acquisition of a "second" nature that instills humanistic values in us, along with language, enabling us to reason and participate in communal life. The issue is that these humanistic values are generalized and sedimented into institutions (in which he includes literature, the arts, and philosophy), which cause us to forget most of the inhumanity of childhood.[34] In the arts, these institutions take the form of "the School, the programme, the project" that "proclaim that after this sentence comes that sentence, or at least that one kind of sentence is mandatory, that one kind of sentence is permitted, while another is forbidden." These introduce prejudice into the mind of the listener, causing them to "forget the possibility of nothing happening."[35]

This spirit of figuration was already evident in discussions of the romantic sublime. Burke noted that painting is relatively ineffective in the production of the sublime, since, as Lyotard writes, it is "doomed to imitate models, and to figurative representations of them," these models being institutionalized humanism as enshrined in the techniques of art. However, Burke considered combinatory arts such as poetry or music to be superior in their ability to represent the sublime, since they are media where "the power to move is free from the verisimilitudes of figuration."[36] Though music is free of the pictorial figuration of painting, the specter of its own types of figuration haunted modernist composers such as Xenakis. In the context of dealing with the complexities of modern life, Xenakis acknowledges that figurations, models, and simplifications (which he refers to as "abbreviations, names, formulae,"[37] "beliefs, myths, good or bad gods. Or elegant theories of physics … be they legitimate or not"[38]) can be useful, calling them "branches" that "you have to hold onto" in order to "get across quicksand,"[39] as well as "our bunkers, our mental machines, veritable automata interconnected with our defensive tactics," used for "mental self-protection."[40] He emphasizes the need for some forgetting in order to function: "For, if we should remember, what with the acuity of reality, of all the past instants, marvels and transformations, we could never take the shock. Memory, nothing but the trace of these instants, equalizes, cushions, lulls. Another self-defense."[41]

In terms of music, however, Xenakis is adamantly against such simplifications and forgetting: he writes that without the "theoretical domain" to inform our work, "we are slaves, trapped by clichés, by inherited structures that we manipulate without knowing them perfectly,"[42] and in a bulletin promoting the 1963 publication of his

34 Ibid., p. 3.
35 Lyotard, 1991, p. 91.
36 Ibid., p. 100.
37 Xenakis, 1987, p. 22.
38 Ibid., p. 47.
39 Ibid., p. 22.
40 Ibid., p. 47.
41 Ibid.
42 Ibid., p. 42.

book *Musiques formelles*, he referred to "a clean sweep of so many subconscious or acquired traditions."[43]

The desire to resist the figurating burden of the musical past was, of course, not unique to Xenakis, and was central to the high modernism of the post-World War II "zero hour." The chief strategy used by composers to attempt to do this was one of *formalization* (used by Xenakis in a similar, but not quite a synonymous sense[44]), which Kane defines as a process of abstraction that reduces the meaningful content in a sound to "sheer noise."[45] Rather than the excesses of romanticism, Lyotard writes that the postmodern sublime of the avant-garde is accessed by way of a state of privation through which "thought must be disarmed," by art that short-circuits the attempts by the consciousness to figurate the event.[46] In visual art, he describes the devices used in painting by Paul Cézanne (1839–1906), who sought "the elementary sensations" that are "hidden in ordinary perception which remains under the hegemony of habitual or classical ways of looking."[47] As Jacques Rancière writes, for the painter Maurice Denis (1870–1943)

> the painting is an assemblage of coloured flat surfaces assembled in a certain order *before* being a representation of nude women or battle horses. The anti-representative break, which replaces the figures with fields of colour, supposes that the figures themselves were *already* in their essence fields of colour, and that the modern rupture thus only releases the eternal essence of art.[48]

As painting was formalized to "fields of colour" by the Impressionists, music's melodies and harmonies were formalized by the serialists to notes or tones. Kundera notes that "European music is founded on the artificial sound of a note and of a scale; in this it is the opposite of the *objective* sound of the world."[49] Xenakis agrees, and argued in his 1955 article "La crise de la musique sérielle" that the serialists do not go far enough, that they forget the "sensorial aspect" of music, since they are only interested in an "abstract system" of notes.[50] His implication is that tones are still human creations, and thus cannot be the endpoint of the process of formalization.

Kundera describes Xenakis's "starting point" as

> not the artificial sound of a note separated from nature [...] but in the noise of the world, in a "mass of sound" that [...] comes to us from outside, like the fall of the rain, the racket of a factory, or the shouts of a mob.[51]

43 Kanach, 2003, p. 157.
44 See especially Xenakis, 1992.
45 Kane, 2004, p. 131.
46 Lyotard, 1991, p. 90.
47 Ibid., p. 102.
48 Rancière, 2019, p. 341–42. My emphasis.
49 Kundera, 2010, p. 77. Italics in original.
50 Xenakis, 1955, p. 4. My translation.
51 Kundera, 2010, p. 79.

While it is true that Xenakis took inspiration from "natural" sounds such as these, he did not use them as such in his work. What he instead sought as the endpoint of formalization, as his "starting point," were "simple notions of sensation, of message-signals to those sensations, and of thoughts conveyed by those signals. Therefore the point of both departure and arrival is mankind."[52] Xenakis insists on the primacy of the perception of the listener to determine the fundamentals of musical formalization. He defines music as "a message (conveyed by matter) between nature and mankind or between men."[53] His use of the word "matter" is telling, creating another commonality with Lyotard. Kiene Wurth discusses Lyotard's use of "matter 'in itself'" as being "not yet subjected to [the] forms and categories" that regulate perception and cognition, and it "bypass[es] or resist[s]" them. "Matter can only 'exist' when these faculties are momentarily suspended."[54] Thus, whatever constitutes the raw "matter" of music is contingent on both the work in which it is contained and on the listener perceiving it.

For Xenakis, serialism fails to engage properly with the listener because its "linear polyphony destroys itself by its very complexity; what one hears is in reality nothing but a mass of notes in various registers."[55] In works such as *Metastasis* (1953–4) and *Pithoprakta* (1955–6), Xenakis cuts out the intermediary and addresses the sound masses of serialism directly. His widespread use of *glissandi* in these works defines a sense of pitch-space that transcends the note, and it is in these pieces that he first uses stochastic techniques. His use of these techniques reached a climax with *Achorripsis* (1956–7) and the *ST* pieces (1956–62), where Xenakis tries to create his ideal of a musical universe in a constant of flux of being and non-being. He does this by defining a variety of elementary sonic units and distributing them through probability functions into pre-established structural units, in order to avoid all traditionally inherited behavioral frameworks.[56] In his works *Analogiques A & B* (1958–9), his elementary unit becomes even smaller, namely that of *grains*: musical quanta[57] made up of very short notes whose distribution into ordered clouds[58] is controlled by stochastic means. This technique became known as granular synthesis, and the infinitesimal nature of its grains represents possibly the closest music can reach to the timescale of the Lyotardian event.

As this paper has descended to the level of microsound, we reach the bottom of a hierarchical diagram created by Xenakis for the Preface to the second edition of *Musiques formelles*.[59] By applying stochastic techniques that he originally developed for macrocomposition on the fourth level of the diagram to microsound, on the

52 Xenakis, 1955, p. 4.
53 Ibid.
54 Wurth, 2009, p. 113.
55 Xenakis, 1992, p. 8.
56 Ibid., p. 25.
57 Harley, 2004, p. 22.
58 Xenakis, 1992, p. 103.
59 Ibid., p. viii.

first, Xenakis is able to generate the novel timbres of granular synthesis. He refers to these new sounds as "second-order sonorities" and Agostino Di Scipio points out that they represent what we now call the "emergent properties' of sound structure."[60] Xenakis speculates that third and higher level sonorities are possible and notes that his mixing of techniques from each level of his table of coherences creates music that is automatically homogenized and unified.[61] While Xenakis's appraisal of the possibilities of his compositional system may be somewhat overoptimistic, his usage of these techniques undoubtedly blurs the lines between temporal micro and macro levels. The combination of novel timbres in unpredictable sequences disorients the listener and produces a sensation analogous to Lyotard's postmodern sublime. But I argue that it need not stop there. The phenomenon of emergence is what allows for Kane's tropological process of figuration, and it can continue to the higher levels of Xenakis's table. As François Delalande and Évelyne Gayou point out, listening, for Xenakis, always means understanding,[62] and that he encourages the process of novel figuration, especially through repeated listening.

Above timbre, we reach what Jean-Luc Hervé calls "sonic images," which he defines as

> an imagined concrete musical situation, in point form or sequence, which has an autonomous musical significance. ... One could say that the sonic image is the smallest element that holds the signature of the composer, from which we can see emerge his style.[63]

For Xenakis, these are the raw materials that so clearly distinguish his works: *glissandi*, clouds of sounds, and the like. Di Scipio goes further, arguing that, in principle, timbre and form are inseparable notions in Xenakis.[64] We can thus imagine a parallel series of constructed phenomena that replace the traditional materials of music: tone, gesture, melody, phrase, structural unit, and composition. Interestingly, we have returned to notions that approach the Romantic sublime: Delalande and Gayou relate the experience of listening to a work such as *Terretektorh* (1966) to perceiving an anamorphosis, that is, an object that appears radically different depending on one's perspective.[65] Repeated listens from different perspectives allow the listener, even though they may be initially disoriented, to create an enormously complex mental image of the piece by means of their powers of perception and reason. Thus, the sublime in Xenakis's work comes full circle. While acknowledging Lyotard's inhuman at the very lowest level, Xenakis guides the listener and seeks to create in his music an alternative humanism to that of the bourgeois Enlightenment that so appalled Kundera.

60 Di Scipio, 2001, p. 72.
61 Xenakis, 1992, p. vii.
62 Delalande and Gayou, 2001, p. 36.
63 Hervé, 2001, p. 99. My translation.
64 Di Scipio, 2001, p. 82.
65 Delalande and Gayou, 2001, p. 36.

At the very opening of *Formalized Music*, Xenakis states that if a work of art succeeds in causing an individual to lose "his consciousness in a truth, immediate, rare, enormous, and perfect [...] even for a single moment, it attains its goal."[66] Kundera recalls that his experience of listening to Xenakis after 1968 helped him to realize that everything that exists, even that which is most familiar, even his own nation, can also not exist. The music of Xenakis proved to be both a catalyst and a balm for these feelings: "his music reconciled me to the inevitability of endings."[67] What is that but the postmodern sublime? Lyotard asks, "what else remains as 'politics' except resistance?" Resistance to the inhuman in the form of development, which he assigns to "the tasks of writing, thinking, literature, arts, to venture to bear witness to it," by channeling the other inhuman within each of us.[68] I think it is clear that, at least in the case of Kundera's encounter with his music, Xenakis accomplished his own goals and those of Lyotard.

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10. Jean-Étienne Marie and Iannis Xenakis: The Vision of an Artistic Engineer and a Theorist of Microtonal Music

Judith Romero Porras

Jean-Étienne Marie and Sound Installations

Born in the north of France, Jean-Étienne Marie (1917–89) moved to Paris to study at the National Conservatory of Music with Olivier Messiaen (1908–92). In 1947, he founded *Le Cercle Culturel du Conservatoire de Paris* to promote the music of living composers of that time. Beginning in 1949 he worked as an artistic engineer at the Radio Télévision Française.[1] A critical moment in his development was his 1950 meeting with the Mexican composer Julián Carrillo (1875–1965) whose microtonal theory "Sound 13" helped Marie understand the evolution of European music.[2] After having analyzed and carried out a comparative study of the microtonalists Ivan Wyschnegradsky (1893–1979), Alois Hába (1893–1973), and Carrillo, Marie concluded that microtonality was the transition from acoustic instruments to electronics. That is why Marie considered microtonality the common axis of acoustic instruments (the past) and electronics (the future).

After the death of Carrillo in 1965, Marie carried out a first cultural mission in Mexico in 1966. His goal was to restore the microtonal pianos of Carillo and give lectures about his research. He wanted to share Carrillo's music as well as the European avant-garde with the young composers of that time. Specifically, Marie's intention was to make known the importance of microtonal theory in western musical evolution.

1 For a brief biography, cf. "Biographie de Jean-Etienne Marie" (22 May 2018), *CIRM: Centre National de Création Musicale*, https://www.cirm-manca.org/fiche-artiste.php?ar=29

2 Cf. Armando Nava Loya, "Julián Carrillo and the Sound 13" (January 2010), *Sonido13*, https://sonido13.com

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Due to doctoral research later conducted on Marie's life as well as the influence of his teaching on Mexican composers at the end of the 1960s, we are able to understand Marie's knowledge of the post-war European avant-garde. His work as an artistic engineer allowed him to know Iannis Xenakis and Xenakis's music from two different perspectives: from the perspective of sound realization, that is to say, the practical questions of sonorization with respect to *Bohor* (1962), and from the perspective of his micro-intervallic theory contained in *Oresteïa* (1965–6).

Regarding the first perspective, Marie's work as an artistic engineer consisted in solving the problems of music retransmission as it differed from live listening. The music critic, Claude Rostand (1912–70), defines Marie's work as that of someone "who makes sound recording, creating the necessary balance for a good broadcast of a concert. But he is also a musician, who has a musical, scientific, historical and musicological culture."[3]

Thanks to this experience acquired in the radio, Marie began to participate in the sound realization of electroacoustic works from the 1950s. He specialized in sound recordings and their projection through a fundamental pairing: the microphone and the loudspeaker.

As for the second perspective, Marie's interest in microtonal music came from his relationship with Julián Carrillo and his "Sound 13" Theory. Marie alludes to Xenakis and the generalization of the notion of temperament, called "crible," which could be translated into English as "sieve." He compares Xenakis's theoretical process to that of Hába, which results in a certain practice of micro-intervals.

Marie's experience in the field of sound installations dates back to 1952, when he organized two concerts of concrete music at the National Conservatory of Music in Paris, using three recorders linked to three independent circuits. The effect produced was "a spatial relief either preset or instantly calibrated by means of a device, which allowed a sound motion of extreme freedom."[4]

These technological devices gave music a previously unsuspected spatiality. In the *Revue Musicale* of 1968, Marie recounted these first electroacoustic experiences:

> From a single speaker and with two microphones, one close to the sound source, another capturing the reverberations, moving away from the sound source or moving to an echo chamber, effects or spatial structures can be obtained in terms of depth as a continuum of more or less fast *travellings*; discontinuous static planes (comparable to American planes), originating a very elaborate spatial language.[5]

3 Rostand, 1967 [*Les fonctions de musicien-metteur en ondes* […] *désigne le preneur de son qui créé l'équilibre nécessaire à la bonne diffusion du concert mais qui est aussi un musicien, c'est-à-dire, un homme qui a une culture musicale, scientifique, historique, musicologique, etc.*]. All translations are my own, unless otherwise specified. Transcription of fragments of the interview and presentation of the piece *Hommage à Julián Carrillo* by Jean-Étienne Marie.

4 Marie, 1968, p. 129 [*un relief spatial soit préétabli, soit réglé dans l'instant par un dispositif permettant une cinématique du son d'une extrême liberté*].

5 Ibid., p. 130 [*A partir d'un seul haut-parleur et en jouant à l'enregistrement avec un micro de proximité et un micro captant des sons réverbérés, soit par éloignement, soit par passage dans une chambre d'écho, on peut*

Following in this same order of ideas, Marie emphasizes:

> From 3 or 4 speakers placed in a concert hall, we can foresee displacements of sounds, either continuous (thanks to a potentiometer passing the sound of one of the tracks over another), or discontinuous: another possibility of effects or structures. The combination of possibilities on the plane of the cardinal points and the zenith, and those that tend to the depth, offer the composer a true celestial dome [...]. We would be surprised how rudimentary [...] these experiences from 20 years ago are.[6]

In 1954, Marie participated in the sound realization of *Déserts* (1950–4), by Edgard Varèse (1883–1965) at the Théâtre des Champs-Elysées in Paris, where he used four speakers, forming a vertical sound wall from a single track. Varèse himself wrote to Marie several years later, in November 1963, when the work was performed, to give him a more precise idea of *Déserts*: "Please, note that the instrumental parts represent the human side, and the electronic interpolations should suggest the naked, impersonal, inflexible desert... dialogue between human and nature. The speakers must offer the maximum voltage and dynamic level."[7] Marie's idea was to put the orchestra at the center, the audience around, and the last circle would be made up of the loudspeakers.

Marie himself, as a composer, knew the challenges of realization involved in contemporary music. In 1958, during the Paris Music Weeks based in UNESCO, he carried out a concert dedicated to micro-intervals (inherited from Carrillo), electronic music, audiovisual, and concrete music. He premiered his work *Polygraphie Polyphonie* for violin in quartertones (live music), tape (concrete music) and visual rhythms projected on a wall.[8]

In 1961, he premiered *Images Thanaïques*. For this work, the orchestra is divided into three sectors: a two-track tape of five so-called sound domes, music in semitones played by the orchestra, and a tape of concrete music with sounds in thirds, fifths, and fifteenths of a tone, of instrumental origin making the link between the orchestra and the concrete music.

In 1967, Marie premiered *Tombeau de Julián Carrillo*,[9] in honor of the Mexican

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obtenir des effets, ou des structures spatiales dans le sens de la profondeur : continu de travellings plus ou moins accusés et plus ou moins rapides, discontinu de plans statiques (*comparables aux gros-plans, plans-américains...*) *permettent un langage spatial déjà très élaboré*].

6 Ibid. [*A partir de 3 ou 4 haut-parleurs répartis dans une salle de concert, pour un même objet sonore situé dans le même plan de présence dans l'axe de la profondeur, on peut prévoir des déplacements de sons soit continus* (*par un jeu de potentiomètres faisant passer le son d'une des pistes sur une autre*) *soit discontinus : autre possibilité d'effets ou de structures. La combinaison des possibilités sur le plan des points cardinaux et du zénith et de celles qui ont trait à la profondeur offrent au compositeur une véritable voûte céleste* [...]. *On est surpris de voir combien rudimentaires,* [...] *restent toutes les expériences qui ont vu jour au cours de ces 20 dernières années*].

7 Ibid. [*Notez, je vous prie, que les parties instrumentales représentent le côté humain et les interpolations électroniques doivent suggérer le désert nu, impersonnel, inflexible... dialogue entre l'humain et la nature. Les haut-parleurs doivent offrir le maximum de tension et niveau dynamique*].

8 The recording of this work, as well as most of Marie's repertoire, is available at the INAthèque of the National Library of France in Paris.

9 Recording available on the CD *Musiques en tiers et en seizièmes de ton*, Société Nouvelle d'Enregistrement, Quebec, 2009.

composer, for two pianos, one in semitones and the other in thirds of a tone on stage, played along with a recording on which fifths and sixths of a tone had been previously played. The recording was made in Mexico with Carrillo's "metamorphosing" pianos.[10]

In the 1960s, Marie even collaborated with Karlheinz Stockhausen (1928–2007) at the Royan festival for the sound realization of the works *Mixtur* (1964) and *Hymnen* (1966–7). In *Prozession* (1967), Stockhausen uses:

> A piano, a viola with contact microphone, a tam tam [...] amplified by a microphone, and a trautonium[11] connected by a Hohner provided with an echo chamber. The composer can manipulate on his console, by means of filters, the sound effects of the viola and tam tam. This random work was experienced in Royan as an ephemeral performance of great beauty.[12]

In 1967, Marie participated as a musical engineer in the concert of the Ensemble Instrumental de Musique Contemporaine of Paris held in Bordeaux, France. In this concert, works performed included *Volumes* (1960) by François-Bernard Mâche (b. 1935), *Atlas Eclipticalis* (1961–2) by John Cage (1912–92), and *Oresteia* (*1966*) by Xenakis. In this regard, Marie comments that "some fragments need the amplification of metallic sonorities. Thus, Xenakis would have wanted 12 channels of amplification. In a medium-size room, 12 microphones spread over three channels could give a more or less equivalent sound result."[13]

Following this first experience in Bordeaux, Marie invited Xenakis to the Music Weeks festival in Paris in 1968 where the former had the opportunity to be the technician responsible for a concert including *Bohor*. Regarding the work, he points out the following:

> We cannot express sufficiently how remarkable is this attempt to create a music beyond art whose evolution in time is so closely adapted to the curve of a meditation: it begins with the picturesque of indefinite and infinite bells [...]. 16 shells, [producing] 1000 watts; two spheres, two amplifiers: 1000 watts of bells [...]. The ear does not listen anymore, there is no more dynamic: the body becomes intoxicated.[14]

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10 Pianos built by Sauter. Carrillo registered the patent in 1940 for its construction. Carl Sauter and his company, established in Spaichingen, Germany, carried out the project. Information obtained from the auction brochure of the "metamorphoser" piano of sixths of tone and the grand piano of thirds of tone. Private collection of Fernand Vandenbogaerde.

11 Electronic instrument created by Friedrich Trautwein in 1924.

12 Marie, 1968, p. 145 [*un piano, un alto avec micro de contact, l'immense tam-tam* [...] *amplifié par un microphone tenu à la main et un trautonium branché sur amplificateur Hohner muni de chambre d'écho. Le compositeur règle lui-même à son pupitre, muni de filtres, les effets sonores de l'alto et du Tam-tam. Cette œuvre très aléatoire vécut à Royan une réalisation éphémère d'une très grande beauté*]

13 Ibid., p. 140 [*certains fragments nécessitent l'amplification de sonorités métalliques. A cet effet Xenakis aurait souhaité 12 chaînes d'amplification. Dans une salle de moyenne importance, 12 micros répartis sur trois canaux pouvaient donner un résultat sonore à peu près équivalent*].

14 Ibid., p. 147 [*nous trouvions remarquable cette tentative d'une musique au-delà de l'art dont l'évolution dans le temps s'adapte si étroitement à la courbe d'une méditation : On commence dans le pittoresque de cloches indéfinies et infinies* [...]. *16 conques,* [*qui produisent*] *1000 watts ; deux sphères éclatées, deux amplis brûlés : 1000 watts de cloches* [...]. *L'oreille n'entend plus, il n'y a plus de dynamique : le corps s'intoxique*].

Artistic Engineering: The Microphone and Sound Capture

This professional work would not have been possible without the exhaustive study of the technique involved in sound production. In this regard, Marie had extensive knowledge of the microphone as a tool for sound collection, understanding its possibilities and limitations. In his first book *Musique Vivante. Introduction au langage musical contemporain* (Living Music. Introduction to Contemporary Musical Language) (1953), Marie made a distinction between sound perception made by the ear and by the microphone.[15]

The ear	***The microphone***
• Two ears form, two circuits	• The binomial microphone (relay medium) speaker forms a circuit
• The ear creates a steering sensation thanks to both circuits	• The microphone does not give the illusion of a certain direction with respect to itself
• The ear is not very sensitive to distance	• The microphone has a great sensitivity to distance: notion of "sound planes" that determines a certain "color of sounds," typical of the concert hall (creating a certain "environment")
• The ear is versatile in terms of detection faculty	• The microphone is univocal. There are microphones that have different characteristics, thus allowing each to detect the sound in a different way

Table 10.1 Table of the differences in sound perception between the ear and the microphone according to Jean-Étienne Marie.

In this sense, Marie confronted two phenomena. The ear has two circuits that give the human being the sensation of direction. On the contrary, according to Marie, the ear is less sensitive to distance, while, in the microphone, the phenomenon is reversed. In addition, the ear has a determining factor in the capture of sound: the environment. Marie then inferred that the microphone is more sensitive than the ear to the "environment" of a concert hall, since it has a great sensitivity to the distance that separates it from a sound source, and also because of a psychological factor in the mechanism of hearing.

However, Marie also recognized the technical limitations of microphones, such as adapting to the needs of sound pick-up. In this sense, this is where Marie located the role of the artistic musician-engineer: he had to find the sound balance to capture the

15 Marie, 1953, p. 183–4.

music in all its harmonic and sonorous richness, adapting and arranging microphones in the concert hall or studio. This task could only be performed by "an intelligence provided with a sensitivity that gives it this faculty of adaptation: this intelligence, driven by the artistic sensitivity that the microphones need, determines an essential function in the retransmission of music."[16]

With this statement, Marie dissociates himself from the role of sound engineer since:

> A sufficiently astute and sufficiently artistic person must realize *what he wants* in the sound field (i.e. be able *to imagine* a certain color of the room... and do it). Because there are styles for sound pick-up, styles determined mainly by the following factors: the dynamics, the environment, and the relationships of the elements of a musical ensemble.[17]

To create a "sound pick-up style," Marie defined these factors[18] as follows:

- Dynamics is an essential element in transmission: for a given work, it is possible to "collect" sounds, depending on the proximity and location of the microphones, with great sensitivity in terms of intensity. From this point of view, there can be bright, nervous, round, intimate, and warm sound pick-ups. This activity thus implies a great sensitivity of the musician to be able to perceive the almost imperceptible nuances.
- As for the environment, Marie addressed the sound recording methods practiced in France at the time. He called them "mixed method," consisting of a central microphone and other lapel microphones, which give great freedom for sound pick-up. Thus, Marie named the environment "color."
- The third element is calibrated by the sound pick-up console, which determines the *balance of the sound masses*. Marie was convinced that it was the new reference instrument as the first experimental musicians moved from the piano to the console.

Thus, the artistic musician-engineer or musico-technician is a performer, comparable to an instrumentalist or an orchestra conductor, who deals with a certain number of problems such as difficulties imposed by the sound recording where the *dynamics*, i.e. the style of the piece, the *environment*, the style of interpretation, and the *balance*

16 Ibid., p. 186 [*une intelligence* [*munie d'*] *une sensibilité qui lui donne cette faculté d'adaptation : cette intelligence, poussée par les forces affectives de la sensibilité artistique dont le micro a besoin,* [*détermine*] *une fonction essentielle dans la retransmission de la musique*].

17 Ibid., p. 187 [*Le musicien metteur en ondes suffisamment averti et suffisamment artiste* [*doit*] *réaliser ce qu'il veut dans le domaine sonore* (*c'est-à-dire, capable d'imaginer une certaine couleur de salle... et réaliser celle-ci*) [...]. *Car il y a des styles de prise de son, styles déterminés principalement par les facteurs : dynamique, ambiance, rapports des éléments d'un ensemble musical*].

18 Ibid., p. 188–90.

of masses, i.e. the musical temperament of the musician-engineer intervene. Marie concluded by affirming that "the material necessary for sound recording introduces new possibilities of writing and sonorities."[19]

Xenakis and the Aspiration to a "Meta-Music" through the "Cribles"

Marie approached Greek music and the practice of Xenakis's micro-intervals from the perspective of the "crible" (sieve), defined as "the equidistant partition of any reference interval, for example, [...] the octave."[20] In his book *L'homme musical*, published in 1976, Marie pointed out that "Xenakis insists on the fact that Greek music was based, not on octave modes, but on tetrachords. However, it is a hierarchical structure in 4 ranges."[21] The four ranges used by Xenakis based on the *cribles* are:

1. Primary. The tone and its subdivisions: semitone (1/2 tone), thirds (minimum chromatic diesis) and fourths (minimum enharmonic diesis).
2. Secondary. The tetrachord, whose two extreme sounds have a distance of fourth, and whose other sounds are mobile; its place characterizes:
   a. *The enharmonic*. Xenakis defines the intervals in aristogenic segments of a value of a twelfth of a tone. Thus, we have:
      $$3 + 3 + 24 \text{ segments} = 1/4 + 1/4 + 2 \text{ tones}$$
   b. *The chromatic*. Xenakis subdivides it into:
      - Mou: $4 + 4 + 22 = 1/3 + 1/3 + (1/3 + 3/2)$
      - Hemiola: $4{,}5 + 4{,}5 + 21 = 3/8 + 3/8 + 7/4$[22]
      - Tonin, which is subdivided into:
        * Mou: $6 + 9 + 15 = 1/2, 3/4, 5/4$
        * Syntonon: $6 + 12 + 12 = 1/2, 1, 1.$
3. System or assemblage of tetrachords with or without a tone (hence the pentachord).
4. Modo, trope, or particularization of the systems by cadential, melodic formulas.

19 Ibid., p. 196 [*Le matériel nécessaire à une prise de son ou à un enregistrement introduit de nouvelles possibilités d'écritures autant que des sonorités*].

20 Marie, 1976, p. 39 [*une équipartition d'un intervalle de référence quelconque, par exemple* [...] *l'octave*].

21 Ibid., p. 64 [*Xenakis insiste sur le fait que la musique grecque se basait, non sur des modes octaviants, mais sur des tétracordes. Il s'agissait toutefois d'une structure hiérarchisée en 4 rangs*].

22 Marie clarifies, with regard to the indication of alteration of the microtones: "Xenakis did not define writing in the field of micro-intervals, other than the one he needed: 1/4 and 1/3 of tone. To write the examples above, we resort to our writing where the 1/4 of tone are defined by a vertical stripe |, the 1/8 by 2 ||...". Ibid., p. 65 [*Xenakis n'a pas défini d'écriture dans le domaine des micro-intervalles, que celle dont il a eu besoin :* 1/4 *and* 1/3. *Pour noter les exemples ci-dessus, nous avons donc eu recours à notre écriture où les* 1/4 *sont définis par une seule verticale* |, *les* 1/8 *par* 2 ||...].

Subsequently, Marie explains that Xenakis:

> Turns to the study of Byzantine music which amalgamates Pythagorean (multiplicative, division of strings) and Aristogenic (additive, in the manner of musicians) calculus. These additive and multiplicative languages were mixed through the centuries, causing many confusions in interval calculations and theories. Thus arose the supposed scale of Aristogenes, [...] modified by Ptolemy in the third century and characterized by "three tones."[23]
>
> $^{9}/_{8}$ = 12 segments, $^{10}/_{9}$ = 10 segments, $^{16}/_{15}$ = 8 segments, distributed as follows:
>
> 1, $^{9}/_{8}$, $^{5}/_{4}$, $^{4}/_{3}$, $^{3}/_{2}$, $^{27}/_{16}$, $^{15}/_{8}$, 2
>
> 0, 12, 22, 30, 42, 54, 64, 72 segments

By this presentation of the constitutive elements of the micro-intervallic organization or the *cribles*, Marie shows:

> Xenakis's purpose was not musicological. For him it is rather a question of giving new importance to structures "outside of time,"[24] and to do so he seeks a formalizable language capable of accounting for all structures. But under the novelty of language, we find research processes close to those of Wyschnegradsky or Hába... that appear as constants in the discovery of the domain of intervals.[25]

In Xenakis's language, le *hors-temps* (out of time) refers to "essences," that is to say to the attempt to restore the notion of scales. Theorists have always reduced the discussion to this expression because it is simple, quantifiable. In this regard, Makis Solomos (b. 1962), a French-Greek musicologist, considers that Xenakis returns to the teaching and influence of Olivier Messiaen, a period marked by the study of traditional Greek music, but with the aim of creating, constructing his own, original modes.

Regarding the micro-intervallic developed by Xenakis, Marie concluded:

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23 Marie, 1976, p. 65 [*Xenakis passe ensuite à l'étude de la musique byzantine qui amalgame le calcul pythagoricien (multiplicatif, voir plus haut, division des cordes) et aristoxénien (additif, à la manière des musiciens). Ces langages additifs et multiplicatifs se sont mélangés à travers les siècles, créant des confusions multiples dans les calculs d'intervalles et dans les théories. C'est ainsi qu'a vu le jour la prétendue gamme d'Aristoxène,* [...] *et modifié par Ptolomée (IIIe siècle) et caractérisée par "3 tons"*].

24 Marie explains the notion of "scale": "A scale exists independently of the vertical or horizontal combinations that are likely to be used; this is called 'out of time'. Melody and harmony that are derived are 'in time' but do not become temporal until they are inserted into an axis of time, that is, 'during their actual occurrence'".

25 Marie, 1976, p. 66 [*Le propos de Xenakis n'est pas d'ordre musicologique. Il s'agit pour lui de redonner toute leur importance aux structures 'hors temps' et pour ce faire il recherche un langage formalisable susceptible de rendre compte de toutes ces structures. Mais sous la nouveauté du langage nous retrouvons des processus d'investigation proches de ceux de Wyschnegradsky ou de Hába... qui apparaissent comme des constantes dans la découverte du domaine des micro-intervalles*].

> [a] One notes that, in practice, [Xenakis] makes of micro-intervals a desire to integrate Greek and Byzantine music (1/4 and 1/3 of tone) and to apply the *glissando* to instruments little suited to realize them naturally (woodwinds, brass with valves) in Western technique. But these melodic concerns led him to a harmonic exploration in which he is very cautious [with respect to Carrillo].[26]
>
> [b] The chromatic total can be "sieved" in various ways [...]. It is observed then that this notion of module or *crible* is similar to that of the equidistant "division" that we find in Wyschnegradsky,[27] Hába[28] or Carrillo.[29] But Xenakis brings something new through logical operations, starting from these *cribles*, defining any irregular scale.[30]

For Marie,

> the *glissando* was nothing more than a sound effect. Xenakis gave it a structure value, specifying the velocities—starting point, arrival point and *glissando* time at a uniform velocity. Beyond a linear algebra, any mathematical function, or simply its graphical representation, can describe a certain type of continuous evolution of a sound (*glissando*) or visual (travelling – film object) phenomenon.[31]

The idea of the *crible* was later studied by Solomos, who says in this regard:

> With the crible, it is not only a matter of assembling notes of such and such pitches, but they are subjected to an order, to a periodicity. A crible is thus what the musical tradition calls a scale. Its constitution goes through a logical-arithmetic formula [...]. Xenakis' purpose with the crible is not to analyze existing scales but to generate surprising scales, using periodicities other than the octave and even other units beyond the semitone, (for example, the 1/4 of tone). Thus, we can easily imagine that the obtained scales can be very rich in sonorities, respecting the basic idea, i.e., the existence of symmetries—even if they are not detectable to the ear.[32]

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26 Ibid., p. 68. In this sense, Marie recognized in Carrillo, the figure of the creator-researcher, who theorized the "Sound 13," conceived the instruments for the production of micro-intervals, and created and recorded his most representative microtonal works. In addition, Carrillo founded and wrote the magazine *el Sonido 13* to disseminate his own ideas about microtonality.

27 To listen to Wyschnegradsky's music, contact the Ivan Wyschnegradsky Association, which keeps the composer's sound archive: https://www.ivan-wyschnegradsky.fr/en/

28 Regarding Hába, Marie writes: "In Moravia, [his birthplace], he listened to folk songs that constituted 1/4 and 1/6 of tone [...]. [Hába] was very sensitive to the influence of the Vienna School (atonal). It was not until after the Second World War that he turned to the 1/12 of tone." Op. cit., p. 52 [*En Moravie il entendait des chants populaires qui comportaient des intervalles de 1/4 et 1/6 de ton* [...] [*Hába*] *a été très sensible à l'influence de l'école de Vienne* (*atonale*). *Ce n'est qu'après la Deuxième guerre mondiale qu'il se penche véritablement sur le 1/12 de ton*].

29 The French composer and musicologist Francis Bayer analyzes the processes of Wyschnegradsky, Hába, and Carrillo. In the first two, he observes that their theories are harmonic rather than acoustic. Bayer considers Carrillo's process to be more of an empirical study. Bayer, 1981, p. 114.

30 Marie, 1976, p. 66.

31 Ibid., p. 179 [*le glissando n'était qu'un effet sonore. Xenakis lui a conféré une valeur de structure en spécifiant les vitesses* (*point de départ, point d'arrivée, temps de glissement à vitesse uniforme*). *Au-delà de l'algèbre linéaire, toute fonction mathématique, ou plus simplement sa représentation graphique, peut décrire un type déterminé d'évolution continue d'un phénomène sonore* (*glissando*) *ou visuel* (*travelling*)].

32 Solomos, 2004, p. 65 [*avec les cribles, les ensembles de notes ne sont plus une réunion quelconque de hauteurs, ils se plient à un ordonnancement, à une périodicité. Un crible constitue donc ce que la tradition musicale nomme échelle. Leur construction passe par une formule logico-arithmétique* [...]. *Le but principal de Xenakis*

This theory is part of the general logic of the composer's evolution. Xenakis noted in 1988 that "when, in a given piece the problem of scale has been satisfactorily solved, half of the problems of composition have been solved."[33] The theory of scales occupies a preponderant place in the production of the Greek composer. Solomos placed its development in the early 1960s, but this theory was overshadowed by Group Theory. Marie, having had contact with the Greek composer, introduced the theory of scales in his courses at that time.

Solomos mentioned that sieves were already used, along with other techniques, in pieces such as *Akrata* (1964–5), *Nomos Alpha* (1966), *Nomos Gamma* (1967–8), *Anaktoria* (1969), *Metastasis* (1953–4), *Pithoprakta* (1955–6), *Nuits* (1967), *Eonta* (1963), *Psappha* (1975), and *Oresteïa*, among others, considered as "sound halos."[34] The first three, according to Solomos, "are, in general, very complex and often integrate quartertones."[35] In *Embellie* (1981), for viola, Xenakis uses what Solomos called the archaic *cribles*, based on the *pelog*.[36] Solomos noted that Xenakis generalized its use from 1977 with the piece *Jonchaies* (1977), finding its full expression in the works of the 1980s.

Xenakis wrote about the *cribles* in his book *Musique. Architecture* of 1971.[37] This theory was the expression of a fundamental preoccupation of Xenakis throughout his life: the search for the foundations of music; what he will define as "meta-music." For Solomos, the ultimate phase of this search was the *crible*, as an attempt to restore an order, a discontinuity, and a periodicity. Solomos quotes an article by Xenakis, in which he expresses his concerns about the pillars on which music should rest:

> The question of symmetries (spatial identities), or of periodicities (identities in time), plays a fundamental role at all levels, from the sample, for its synthesis by means of the computer, to the architecture of a piece. It is therefore necessary to formulate a theory that makes it possible to construct such complex and desired symmetries and, conversely, from a series of events or objects in space or time, to find symmetries that constitute them. I name this "cribles". All that may be applied to any well-ordered set of sound characteristics or sound structures, and especially to any group provided with

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n'étant pas d'analyser des échelles existantes, la théorie des cribles aura pour tâche de générer des échelles inouïes, en utilisant d'autres périodicités que l'octave et/ou d'autres unités que le demi-ton (par exemple le quart de ton). On l'imagine aisément, les cribles obtenus peuvent être alors très riches, tout en respectant l'idée de base, c'est-à-dire l'existence de symétries – même si celles-ci ne sont pas nécessairement détectables à l'oreille].

33 Ibid., p. 65 [*Quand, pour une pièce donnée on a résolu le problème de l'échelle de manière satisfaisante, on a alors résolu la moitié des problèmes de composition*].

34 Solomos, 2004, p. 64. Solomos explains that "the halos [...] dominate scales and parallel movements over the cribles, homorhythms, as well as dialogues between standard groups of timbres" [*les halos n'occupent qu'une petite partie et dominent des gammes et mouvements parallèles sur cribles, des homorythmies ainsi que des dialogues entre groupes standards de timbre*].

35 Solomos, 2004, p. 69 [*Les premiers cribles* [...] *sont, en général, très complexes et intègrent souvent les quarts de ton*].

36 *Pelog* is one of the two scales of gamelan music native to Bali and Java in Indonesia.

37 Xenakis, 1971, *Musique. Architecture*, Tournai, Casterman; (1976) New enlarged edition: Tournai, Casterman.

> an additional operation and whose elements are multiples of unity, i.e. belonging to the set N of natural numbers. Examples: pitches, instants, intensities, densities, degrees of order…, timbre locally, etc.[38]

Solomos concluded that the ultimate ambition of the *cribles* is to found music; to unify its particular fields thanks to a single axiomatization. As an observation, the musicologist pointed out that Xenakis applied the *crible* more to the pitches. His ultimate, unrealized aspiration was to transfer this theory to the field of sound synthesis. Finally, Solomos distinguishes two periods of the *cribles*:

> In the first one, Xenakis builds complex, highly differentiated (in the sense of a particular succession of intervals) *cribles* […]. Then, at the end of the 1980s, these same *cribles* are increasingly invaded by chromaticism, especially when the strings intervene. Thus, in 1987, in the piece *Tracées* for orchestra, a particular notation makes its appearance and then becomes generalized: with a bar linking two notes, the composer asks the string players to divide themselves to play all the pitches between these notes.[39]

As a tentative conclusion, it should be noted that Marie's work in the 1950s was determined by the sound and visual progress developing around radio and television. Being at the Radio Télévision Française, Marie was able to be at the forefront of musical and scientific innovations of his time, carried out by concrete music, electronics, and electroacoustics. This professional relationship with the great French and foreign composers, among them Xenakis, motivated his scientific and compositional spirit that pushed him to carve his own path, that of research and sound creation, thus undertaking the titanic task of the analysis and theorization of contemporary music.

Thus, his contribution to artistic engineering begins in 1954 when he participated in the Congress on the Sociological Aspects of Music on the Radio, organized by the Center for Radiophonic Studies. Marie exposed his aesthetic concerns with the paper "Broadcasting facing the problem of initiation to contemporary music." In it, he expressed the need for a work of initiation between the neophyte public and the contemporary composer, through the action of a musical connoisseur, so that the work

38 Xenakis, 1976, p. 75, cited in Solomos, 2004, p. 66 [*En musique, la question des symétries* (*identités spatiales*), *ou des périodicités* (*identités dans le temps*), *joue un rôle fondamental à tous les niveaux, depuis l'échantillon, en synthèse des sons par ordinateur, jusqu'aux architectures d'une pièce. Il est donc nécessaire de formuler une théorie permettant de construire des symétries aussi complexes qu'on les désire et, inversement, à partir d'une suite donnée d'événements ou d'objets dans l'espace ou dans le temps, de retrouver les symétries qui la constituent. On nomme ces suites des 'cribles.' Tout ce qui sera dit ici pourra s'appliquer à tout ensemble de caractéristiques du son ou de structures sonores bien ordonné, et spécialement à tout groupe muni d'une opération additive et dont les éléments sont des multiples d'une unité, c'est-à-dire qu'ils appartiennent à l'ensemble N des nombres naturels. Exemples : hauteurs, instants, intensités, densités, degré d'ordre, …, timbre localement, etc…*].

39 Ibid., p. 70 [*Dans un premier temps, Xenakis construit des cribles complexes, hautement différenciés* (*dans le sens d'une succession particulière d'intervalles*) […]. *Puis, vers la fin des années 1980, ces mêmes cribles sont de plus en plus envahis par le chromatisme, notamment lorsque interviennent les cordes. Ainsi, dans Tracées* (*1987, pour orchestre*), *fait son apparition une notation particulière qui se généralise par la suite : avec une barre qui unit deux notes, le compositeur demande aux musiciens à cordes de se diviser pour jouer toutes les hauteurs comprises entre ces notes*].

can be appreciated in its correct creative and performative dimension. In addition, he insisted on the need for an educational musical policy for the public wishing to discover the music of living composers.

His experience at the RTF as an artistic engineer materialized in the creation of the Applied Acoustics and Experimental Music class, to be based at the Schola Cantorum in Paris in 1959.[40] This class was one of the first of its kind, where Marie taught Architectural Acoustics based on the intrinsic relationship of the microphone to the loudspeaker. Starting from traditional writing, Marie questioned its validity, confronting it with experimental music (concrete and electronic music), graphic music, and micro-intervals.

With respect to media, Marie addressed in his classes the conservation, transmission, and reproduction of music, the role of microphones, loudspeakers, the record, and the role of radio and television as means of aural and sonorous diffusion. Marie's concern throughout his life was the lack of preparation of aspiring composers who were constantly being faced with the proliferation of technical and electronic media. For that reason, Marie dedicated his entire life to the proper training of future composers in technical production, the capture of sound, and the study of micro-intervals as a sound initiation with which to approach electronic music. In that sense, Marie taught music and mathematics and their practical application in music through a composer like Xenakis.

With regard to the *cribles*, Marie writes that:

> By means of a succession, arrangement of logical and mathematical structures (notions linked to the transformation group of the cube) catalyzes a triggering of sounds through the confrontation of structures. Each of Xenakis' works thus presents an aspect of meditation on human thought applied to sound. In the Xenakian logic, there is no intention to manipulate sounds, but to elaborate works.[41]

In terms of "knowing how to listen" in the twentieth century, Marie distinguishes three elements:

1. A deferred listening.
2. A new profession that emerges in radio and television: the artistic engineer.
3. Radio listening.

Marie's subsequent research focused on these three elements of communication: the transmitter, the receiver, and the message (whether verbal or not). This musical and technical richness gives him a place in musical teaching and broadcasting. His goal was to bring the neophyte public closer to the new music of that time.

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40 Marie was invited for two months, in 1966 and one month in 1968, to give seminars in Mexico City. His teaching left its mark on the young Mexican composers of that time.

41 Marie, 1976, p. 260 [*par un étagement de structures logiques en mathématiques* (*relié, ici, au groupe de transformation du cube*), *catalyse un déclenchement de sons par le jeu des structures confrontées. Chaque œuvre de Xenakis présente donc un aspect de médiation sur la pensée humaine appliqué au son. Il est dans sa logique d'élaborer des œuvres sans manipuler un seul son*].

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11. On the Link between the Exact Sciences and Music in Iannis Xenakis's Creative Work

Pablo Araya[1]

Introduction

I will offer here two lines of reasoning that allow me to propose that, in the creative work of the Greek composer Iannis Xenakis, the metaphorical and the analogical possess an important gravitational pull between the exact sciences and music.

First Reasoning

Xenakis was neither a physicist nor a mathematician; he was a civil engineer.[2] So Xenakis generated neither physics nor mathematics; rather, as he admitted in an interview, he only used them both.[3] Certainly this does not seem to be a decisive detail; however, it warns us about a question that, although obvious, is still relevant: using formulas or equations to compose music does not imply establishing a fusion between art and the exact sciences, nor does it guarantee, in artistic-expressive terms, an effective construction of the work.

This explanation leaves us in a difficult place if we wish to trace the link between music and science in Xenakis's creative work. However, to remedy this difficulty, we may think about what Raymond Nickerson explained, i.e., that one of the tasks of mathematics is to understand the structures and patterns underlying any phenomenon.[4] But we need more than just this understanding, because with mathematics one also obtains, among other things, the possibility of creating various structures that may

1 An earlier version of this article appears in Spanish in Araya, 2022. English translation by the author.
2 Varga, 1996, p. 19.
3 Bourgeois, 1969, p. 34, quoted in Solomos, 2004, p. 128.
4 Nickerson, 2011.

 https://doi.org/10.11647/OBP.0390.13

or may not be connected to physical reality.[5] Hence, it could be thought that all composers, in one way or another, have been amateur mathematicians, since music is also shaped (or configured) by patterns and structures with different degrees of complexity, and, more precisely, it is composers who generate those structures with sounds.[6] Therefore, if this perspective is taken into account, we understand that the use and the Xenakian application of mathematics in the field of the creative-musical (by the way, very much criticized by some specialists) does not seem to be the most admirable and remarkable.[7] But then, what is the most striking quality or characteristic of Xenakis's creative procedure, which, of course, has a very close relationship with the exact sciences? I will answer this in the following segment.

Second Reasoning

If the use of formulas or equations is not what gives a foundation to the connection between the exact sciences and music in Xenakis's creative work, then what does? If we confine our study to *Metastasis* (1953–4) and *Pithoprakta* (1955–6), we may observe that the interdependence between music and the exact sciences tends towards the metaphorical-analogical due to the fact that the composer is seeking to model sound-musical events that possess a similarity with some phenomena of nature that are mainly dealt with by physicists: i.e., phenomena that are linked to statistical physics (e.g., the collision of millions of particles in a gas cloud).[8] Let us note what Xenakis says:

> But other paths also led to the same stochastic crossroads [...] natural events such as the collision of hail or rain with hard surfaces, or the song of cicadas in a summer field. These sonic events are made out of thousands of isolated sounds; this multitude of sounds, seen as a totality, is a new sonic event. This mass event is articulated and forms a plastic mold of time, which itself follows aleatory and stochastic laws. If one then wishes to form a large mass of point-notes, such as string *pizzicati*, one must know these mathematical laws [...] It is an event [sound masses] of great power and beauty in its ferocity.[9]

Elsewhere, he also points out:

> The first step was the control of mass events and the recognition of laws which govern nature. Then I looked for the analogy of these natural phenomena in music [...] I followed Maxwell's approach step by step: what he did with the molecules I did with the sounds. Why not? I made the same simple initial hypotheses with intervals, durations and intensity; I found the formulas that determine them. Then two questions arose: is it possible to make music with fewer elements (i.e. fewer than a "mass") and yet with the same method, that is, stochastically? And: do I have the right to make computations with elements which are not physical by nature but are linked to our senses? I was seeking to

5 Wigner, [1960] 2004.
6 Beran, 2004; Araya, 2018, 2020a, 2020b.
7 Zaplinty and Xenakis, 1975.
8 Solomos, 2004; Duhautpas, Meric, and Solomos, 2012.
9 Xenakis, 1971, p. 9.

> justify what I was doing—after all, I was the first to embark on this path [...] That's my contribution to the development of music: I use ideas in composing that are completely alien to music.[10]

The above quotations corroborate, to some extent, the hypothesis that under Xenakis's music lies a metaphor-analogy with certain phenomena of nature that are studied and modeled by physicists (mostly statistical physics) or by some applied mathematicians. Therefore, from this point of view I consider that the most notorious of the Xenakian connections between music and the exact sciences is the cognitive mechanism linked to metaphor and analogy. However, as I will explain below, there are some obscure points in this connection.

The Metaphor-Analogy of Xenakis

Now, I will try to show (although I am not a logician or a philosopher, nor do I have great knowledge in cognition or computation) how Xenakis deployed his metaphor-analogy between the exact sciences and music. I will carry out this task in a sequential way, although I know that this entails certain risks because the cognitive mechanisms linked to creativity do not work linearly. The following methodology will be applied:

- First, I will outline a brief definition of metaphor and analogy.
- Then I will take as a reference a specific set of theoretical perspectives in relation to metaphor and analogy that will serve to support my hypothesis.

Brief Definition of Metaphor and Analogy

Almost all the authors and texts consulted agree that both metaphor and analogy are cognitive mechanisms, proper to human beings, that consist of explaining or understanding something from concepts and ideas that are foreign to that original something.[11] Consequently, what we have is a connection (mapping) of domains that may be more or less close or very distant from each other: the domain of the origin is the source-domain, while the domain with which the source-domain is connected is the target-domain. The functions and purposes of metaphor and analogy are multiple and are linked to various areas or disciplines (law, philosophy, pedagogy, artificial intelligence, etc.). However, the metaphorical and the analogical seem to play a very decisive role in the creative field (in the exact sciences, the arts, and in all the disciplines I have just mentioned), hence my interest in delving deeper into this topic.[12]

10 Varga, 1996, p. 77–9.

11 Lakoff and Johnson, [1980] 2003; Lakoff, 1993; Lakoff and Núñez, 2000; Hofstadter, 1995; Holyoak and Thagard, 1995; Walton, 2006; Walton, Reed, and Macagno, 2008; Bartha 2010, 2022; Gelfert, 2016; Walton and Hyra, 2018; Visokolskis and Carrión, 2018; Olguín and Tavernini, 2018; Trench and Minervino, 2020.

12 Veale, Gervás, and Pease, 2006.

First Perspective: Aspect Schema (Lakoff and Núñez)

From the linguistic perspective of George Lakoff (b. 1941), the metaphor, which connects or maps two areas or aspects of reality with different degrees of remoteness or closeness to each other, is based on a concrete, physical experience or sensation of the person.[13] Thus, the metaphor and the elaboration of the concepts derived from it emerge from a series of experiences (which we could call "everyday"), rooted in the bodily and the sensory; this process or mechanism presents a specific structure called an aspect schema.[14]

This is not a minor fact if we relate it to Xenakis's music: on more than one occasion, the composer expressed that his creative insight (the one linked to physics and mathematics) was influenced by experiences and impressions that were part of his daily life and that seem to have strongly marked him:

- In his adolescence, the buzzing of clouds of cicadas or mosquitoes that he heard on his excursions to the countryside.[15]
- In his youth, at the time of the Nazi occupation of Greece, the following stand out: a) the shouts and chants of the political demonstrations in which he participated, and b) the firing of British tanks and machine guns into those demonstrations.[16]
- In his years of resistance and struggle, the wound he suffered from a bomb that exploded near his face left him with important visual and auditory consequences: his hearing tended more to the inharmonic spectrum than to the harmonic.[17]

About these events that Xenakis experienced firsthand, the following should be noted: 1) they are phenomena made up of multiple (thousands or millions) components or elements; that is, they are collective or mass phenomena, which refers us back to the sound masses of *Metastasis* and *Pithoprakta*; 2) the behavior of these masses tends to be chaotic or disordered (something that is also emulated in these two works); and 3) in both pieces there is a tendency towards the inharmonic spectrum (noise).

Therefore, it seems that Lakoff and Rafael Núñez's perspective could be plausible. But, moreover, this detracts from the idea of abstraction that Xenakis and some

13 Lakoff and Johnson, [1980] 1998; Lakoff, 1993; Lakoff and Núñez, 2000; Bartha, 2022.
14 Bartha, 2010, p. ix; Lakoff and Núñez, 2000, p. 34–7.
15 Xenakis, 1971, and Andrew Toovey, "Iannis Xenakis (1 of 2) Filmed Interview in English with German subtitles" (28 Oct 2010), *YouTube*, https://www.youtube.com/watch?v=j4nj2nklbts&ab_channel=AndrewToovey
16 Varga, 1996, p. 54; Andrew Toovey, "Iannis Xenakis (1 of 2) Filmed Interview in English with German subtitles" (28 Oct 2010), *YouTube*, https://www.youtube.com/watch?v=j4nj2nklbts&ab_channel=AndrewToovey
17 Varga, 1996, p. 48; Suicrea unam, "Julio Estrada Y…", *Facebook*, https://www.facebook.com/SUICREA.UNAM/videos/355215483264868

musicologists have given to his creative work.[18] So, with the Lakoffian approach, we see that the creative imagination, whether or not it then involves a hyper-abstract cognitive work, cannot be detached from the concrete: it is first necessary to be grounded in the material-daily to then go towards regions where the intangible-abstract is what predominates. In this sense, it seems that the one (the material-daily) without the other (the intangible-abstract) is not a viable option to understand the creative act.[19]

Second Perspective: Creative Insights (Visokolskis and Carrión)

The work of the researchers/philosophers Sandra Visokolskis and Gonzalo Carrión tries to understand how the creative factor occurs in subjects through mathematical diagrams. However, these philosophers offer a referential framework to explain some issues that are linked to Xenakis's creative-musical work. It should be noted that I will not make a strict interpretation of the proposal of these two specialists; I will be forced to make some adaptations.[20]

The first interesting aspect of the approach of these philosophers lies in their definition of creative work:

> Thus, insight or ingenuity is the demonstrative ability to find the right middle term [...] The key to the ingenious act lies in connecting two extreme terms to each other through a found middle term, thus forming a mathematical proportion. The curious thing about this finding is the unexpectedness of such a connection, given that, in principle, the extreme terms are radically different from each other and it would be difficult to link them, unless an idea obtained in a perspicuous way emerges. Moreover, instead of a single middle term C, there could be a finite number *n* of them greater than one, establishing a continuous proportion: A: C1 :: C1: C2 :: ... :: C*n*: B, with natural *n*.[21]

From the above quotation, it is clear that a novel (or ingenious) creative act requires the connection of two terms (A and B) distant from each other; however, this union or connection must find an/other term/s (C, C1, C2...C*n*) in between that are the ones that make A and B connect. Beyond this, we must note two things:

18 Varga, 1996; Solomos, 2004.

19 Estrada, 1990; Vigotsky, 2007; Araya, 2020a.

20 In the development of this segment, I will not resort to the use of a technical language linked to logic (something that Visokolskis and Carrión do contemplate); all my appreciations or deductions will be circumscribed to an intuitive and, probably, equivocal procedure. In any case, I consider that, beyond this shortcoming, the general idea of what I want to express can be grasped.

21 Visokolskis and Carrión, 2020, p. 712 [*Por tanto, la perspicacia o ingenio es la capacidad demostrativa de encontrar el término medio adecuado* […] *La clave del acto ingenioso reside en conectar dos términos extremos entre sí a través de un término medio hallado, formando así una proporción matemática. Lo curioso de este hallazgo es lo inesperado de tal conexión, dado que, en principio, los términos extremos son radicalmente diferentes entre sí y sería difícil vincularlos, a menos que surja una idea obtenida de manera perspicua. Más aun, en lugar de un solo término medio C, podría haber una cantidad finita n de ellos mayor que uno, estableciendo una proporción continua: A: C1 :: C1: C2 :: ... :: Cn: B, con n natural*].

- The mathematical expression outlined by Visokolskis and Carrión contains an idea of proportionality that, for the purposes of this paper, is not very relevant (we will see why shortly).
- The linking of terms refers to metaphor or analogy; that is, connecting A and B implies establishing a cognitive mechanism linked to the metaphorical or the analogical.

Closely related with the preceding concepts, these two researchers add something equally important: for this metaphorical-analogical connection to take place, that is, for the creative insight to be realized and ingenious, there must be a change of perspective (P), meaning a change from P (whose properties are a1, a2, ..., a*n*) to P′ (whose properties are b1, b2, ..., b*n*).[22] Hence, for A [C, C1, C2, ..., C*n*] B to be realized, it is essential that there be a different view or appreciation in the metaphor-analogy mapping (P → P′).

Thus, keeping in mind the point of view of these philosophers, I will try to trace, not without limitations and with some deviations or inconsistencies, the creative-cognitive-musical mechanism of Xenakis. In this direction, it is evident that the Xenakian connection between A and B refers to the link between the exact sciences (A) and music (B). But what elements (C or C1, C2, ..., C*n*) are there in the medium that allow A and B to be linked? I propose the following:

- C1 would be linked to everyday experiences of multiple events (popular demonstrations and hearing clouds of insects).
- C2 would imply that these daily experiences are now perceived as sound phenomena independent of their immediate experiential context.
- C3 would be the moment when Xenakis becomes aware that these sound phenomena (masses) have a behavior tending to "disorder" or "chaos."
- C4 means that the composer recognizes that such phenomena are susceptible to be understood and modeled under a specific mathematical language (stochastic).
- C5 involves the desire (on the part of Xenakis) to transfer all the above-mentioned to the realm of music.
- C6 corresponds to the decision to choose the pertinent musical parameters and the appropriate instrumental organics to achieve the sound masses.
- C7 refers to the conciliation of the graphics with the mathematical calculations (use of certain formulas or equations) for the creation of the musical work; that is, it seeks to concretize (model) the idea of the sonorous mass by resorting to formulas or equations related to stochastics (in Xenakis's terms).

22 As Visokolskis and Carrión explain, the properties of P′ (which are b1, b2, ..., b*n*) in P were something peripheral; likewise, in P′ they cease to be irrelevant and, because of this, the cognitive leap is made.

Xenakis hinted at the path that I propose in chapter 1 of *Formalized Music* called *Free Stochastic Music*.[23] In any case, the operation A [C, C1, C2, ..., C7] B equally shows the change of perspective (the cognitive leap P → P′) in the observance of the problem, that is, in the construction of the metaphor-analogy (on Xenakis's side), which implies that perceiving or intuiting that part of the mathematical scaffolding linked to stochastics is susceptible of being applied to music. Thus, because of this, a different panorama is obtained (P′) and the originality and uniqueness of Xenakis's work is understood (although I only allude to *Metastasis* and *Pithoprakta*).

Finally, and it cannot be overlooked, the model provided by Visokolskis and Carrión, as far as the topic I address in this paper is concerned, is not completely satisfactory (beyond its usefulness and value in providing a framework to develop and tackle the problem of musical creativity): the introduction of the terms C, C1, C2, etc., do not always work in a balanced, proportionate way (with a predominance of terms in equal proportions and without maintaining a complex interrelation between them; between C1, C2, C3, etc. there are non-linear relations, which means that the creative process is unstable and not at all immediate). Moreover, as the terms progress, it seems that sub-analogies emerge or are generated at different spatio-temporal scales.[24]

Third Perspective: Degrees of Positivity/negativity and Plausibility in Xenakis's Analogy (Bartha)

The work of Paul Bartha is truly comprehensive and complex. He presents a sort of summary of the many ways of approaching analogy. Naturally, in this paper I will not take into account all the possibilities that this philosopher offers. However, taking as a reference some of his contributions, always adapting and modifying them in some way, I will propose a perspective that can help us better understand the metaphor-analogy carried out by Xenakis. So, let us look at Bartha's interpretation of the analogy:

> *S* and *T* are the source and target domains, respectively. A domain is a set of objects, properties, relations, and functions, together with a set of accepted statements about those objects, properties, relations, and functions. More formally, a domain consists of a set of objects and an interpreted theory about them. The language of the theory has symbols for the objects, properties, relations, and functions to which the theory refers. I shall adopt the convention of using unstarred symbols (a, P, R, f) for items in the source domain and starred symbols (a*, P*, R*, f*) for items in the target domain. An analogy between S and T is a mapping between objects, properties, relations, and functions in *S* and those in *T*.[25]

23 Xenakis, 1971.

24 Here there is an indirect reference to the Cognitive Neuro-Dynamics of Perlovsky and Kozma (2007a) that considers the brain as a complex dynamic system in perpetual motion. However, this movement is always at the edge of stability. For this reason, the mathematical modeling of the mental processes occurring in the brain, from the point of view of the Cognitive Neuro-Dynamics, resorts to nonlinear chaotic dynamics and fuzzy logic.

25 Bartha, 2010, p. 13.

Here, I attempt to link Bartha's conclusions with Xenakis's creative procedure:

Source-domain (statistical physics) – *S*	Target-domain (stochastic music) – *T*
Objects (*a*): Models or mathematical formalisms represent global or collective natural phenomena.	Objects (*a**): Notational models or formalisms represent global or collective sound phenomena (sound masses).
Properties (P): Statistical physics studies the properties of systems made up of an immense number of elements.[26]	Properties (P*): Stochastic music involves the creation of works whose main characteristic lies in the fact that it is constituted of an immense number of sound events (example: pitches = notes).[27]
Relationships (R): Seeks to understand the relationship between the microscopic (the properties of the constituent elements of the system; for example, molecules) and the macroscopic (collective properties of the system).[28]	Relationships (R*): Relates the microscopic (the properties of the constituent elements of the system; for example, pitches or notes) and the macroscopic (collective properties of the system; example: resulting texture = sound mass).[29]
Functions (*f*): Generates the necessary tools, from the point of view of Prigogine, to build an image of nature in which concepts such as: instability (chaos) → probability → irreversibility are incorporated; thereby tackling the problem of complexity in its various facets.[30]	Functions (*f**): Uses concepts and tools from statistical physics to compose musical works with a radically different creative profile.

Table 11.1 Analogical correspondence between exact sciences and music in the creative work of Iannis Xenakis, taking into account Paul Bartha's study of analogy.

Thus, for Bartha, analogy is consolidated when there is a mapping between the objects, properties, relations, and functions of the source-domain and the objects, properties, relations, and functions of the target-domain.[31] Unfortunately, he does not specify what he means by objects, properties, relations, and functions. For this reason, the

26 Prigogine, 1990, 2009; Reif, 1993.
27 Xenakis, 1971.
28 Prigogine, 1990, 2009; Reif, 1993.
29 Xenakis, 1971.
30 Prigogine, 2009, p. 95
31 Bartha, 2010.

mapping I have outlined above was made arbitrarily. Now, bearing this in mind, I will attempt to determine, however rudimentarily, the degree of positivity or negativity of the analogy. Also, and based on the degree of positivity or negativity I just mentioned, I will attempt to determine the degree of plausibility of such a metaphor-analogy. In any case, the result of the former (degree of positivity or negativity) as well as the latter (degree of plausibility), will depend on the mapping or correspondence between a, P, R, f and a^*, P*, R*, f^*:

$a \leftrightarrow a^* = +$; one of the main objects in both domains refers to the use of models to represent and, redundantly, model the phenomena they are interested in; here there is a strong and positive reciprocity.

P $\leftrightarrow$ P* = $\pm$; here we observe a partial correspondence between the terms: while P studies and knows the properties of systems made up of a large number of elements or components, P* intends to use this knowledge for creative purposes; that is, there are different cognitive functions: P = knowing / P* = creating. Consequently, the reciprocity is more or less strong and positive.

R $\leftrightarrow$ R* = +; the relationships within each domain have the same purpose: to understand how the microscopic is linked to the macroscopic, therefore, reciprocity remains strong and positive.

$f \leftrightarrow f^* = \pm$; the functions that the tools have in each domain are quite different: f tries to generate mathematical tools (statistical mechanics) to construct a different image of nature and thus obtain a greater degree of certainty in knowledge; f^* only applies those mathematical tools, although it does so for creative purposes; again, these are different cognitive functions. Because of this, it follows that there is a more or less strong and positive reciprocity between f and f^*.

From the above it follows that:

$a \leftrightarrow a^* = +$ (strong and positive reciprocity).

P $\leftrightarrow$ P* = $\pm$ (more or less strong and positive reciprocity).

R $\leftrightarrow$ R* = + (strong and positive reciprocity).

$f \leftrightarrow f^* = \pm$ (more or less strong and positive reciprocity).

Thus, one has two strong and positive reciprocities and two more or less strong and positive reciprocities; therefore, the degree of plausibility of Xenakis's metaphor-analogy is optimal.[32] Likewise, the procedure I used to determine the degree of

32 Note that I am not resorting to formalism or to the technical definition that Bartha (2010; 2022) deploys in his research on the concept of plausibility; for him there are two types or classes of plausibility: one in terms of degrees or gradations, and the other in categorical terms. The one I developed above could

plausibility (which could be translated into the degree of strength and reciprocity between the objects, properties, relations, and functions of each domain) reminds us of the analogy of attribution proposed by the Mexican philosopher Mauricio Beuchot (b. 1950): the plausibility or strength of the analogy, which, as I already explained, has to do with the type of correspondence or reciprocity between the terms of each domain, gradually degrades, beyond a certain proportional limit, the analogy is out of context and cannot be sustained.[33]

Perspective Four: Similarities, Structure, and Purpose in analogies (Holyoak and Thagard)

The work of Keith Holyoak and Paul Thagard is often referred to as multi-constraint theory and is developed within the area of artificial intelligence and what Bartha calls structuralist approaches.[34] Again, I will make a nearly free use of their perspective, adapted to my interests.

Holyoak and Thagard explain that, in almost any analogical reasoning, there are three basic features or conditions (constraints):

- Similarity between the elements of each domain.
- The need to find structural parallels between the domains. In any case, the structural correspondence must be one-to-one between the different elements of each domain (isomorphism).
- Purposes: it is the intentions and objectives of the agents that lead one to consider or evaluate the possible analogical correspondence.

Thus, these three components (similarity, structure, and purpose/s) are what determine (in a flexible way) the establishment of the analogy/ies. So, it follows that analogy is obtained because of people's ability to find structural patterns underlying both the source-domain and the target-domain: "On the surface, the elements are very different, but at the base [underlying] the relationship of the elements finds very similar structural patterns."[35]

Of course, this theory states, contrary to the position of Lakoff and Núñez, that analogy responds to an abstract cognitive capacity.[36] Beyond this particularity, I will try to apply Holyoak and Thagard's principles in the analysis of the Xenakian metaphor-analogy.

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be said to attempt to approach the former.

33 See Mauricio Beuchot in Rafael Frances, "Curso sobre el método analéctico crítico 03 17/02/16. Dr. Mauricio Beuchot" (6 May 2016), *YouTube*, https://www.youtube.com/watch?v=rXSOim6WHcw; Araya, 2020a.

34 Holyoak and Thagard, 1995; Bartha, 2010.

35 Holyoak and Thagard, 1995, p. 19.

36 Lakoff and Núñez, 2000.

	Source-domain: Exact Sciences (statistical physics)	Target-domain: Stochastic Music (Xenakis)
Similarity between elements of the domains:	a) Phenomenon/a it deals with: statistical physics focuses on phenomena consisting of thousands or millions of elements (example: collision of particles in a gas cloud). b) Agent/s: it is the scientist who studies and knows these natural statistical phenomena. c) Mathematics: to know and model those phenomena susceptible of being expressed in statistical terms, the scientist uses the construction of mathematical models (I referred to this in the third perspective).	a) Phenomenon it deals with: Xenakis's stochastic music recreates a phenomenon made up of hundreds or thousands of sound events (example: sound masses made up of, redundantly, multiple sound events). b) Agent/s: it is the composer who perceives and creates these musical statistical phenomena (sound masses). c) Notation: in order to reason, model or, if desired, compose the phenomenon in question (with qualities susceptible of being expressed in statistical terms), the composer uses the construction/ configuration of notational formalisms (I referred to this in the third perspective).
Structural parallels (isomorphisms):	Clearly, the similarity between the elements of each domain shows us the structural parallel between, redundantly, each domain.	The same (as cell to the left).
Purposes of agents:	The agent who has purposes in the scientific domain is the scientist (a physicist or an applied mathematician). Basically, his purpose is to know and understand the phenomenon.	The agent who possesses purposes in the field of music is the composer.[37] Certainly, its main purpose is to perceive and, from there, to create music.

Table 11.2 Analogical correspondence between exact sciences and music in the creative work of Iannis Xenakis, taking into account the study of Keith Holyoak and Paul Thagard in relation to analogy.

37 The chapter seeks to understand the musical cognitive-creative process of Xenakis from its relationship with the exact sciences. Consequently, my intention is to understand the composer's perspective which, in this case, refers to Xenakis. Therefore, and beyond the fact that other important actors (performers, audience, etc.) are involved in the field of music, when I speak of purposes (in the context of Holyoak and Thagard's research), I am unequivocally alluding to the possible purposes that Xenakis may have had at the time of making his music. Of course, one of Xenakis's most prominent purposes, I believe, at least in this case, was to generate works that show new ways of structuring and perceiving music. Therefore, and in order to achieve this goal, Xenakis established a

To summarize the idea discussed in the table above, please refer to the following chart:

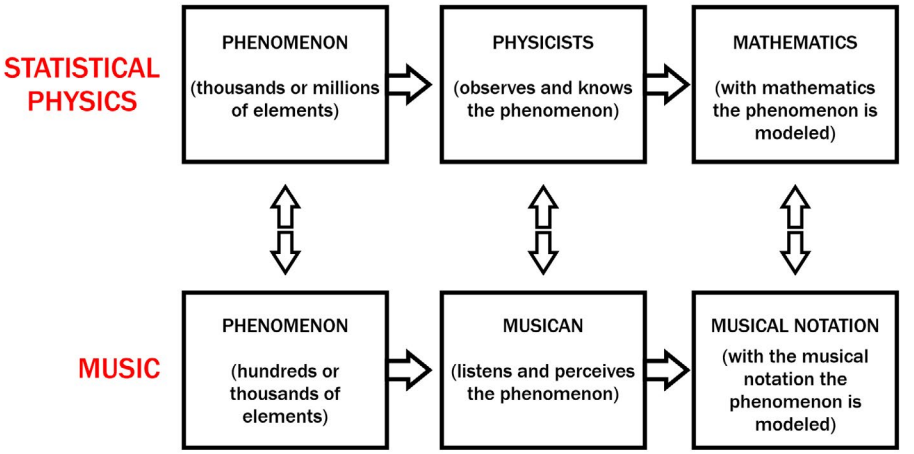

Fig. 11.1 Connection and relationship of the domains according to Holyoak and Thagard. Figure created by author (2022).

The detection of the three basic conditions of Holyoak and Thagard does not seem to be so straightforward and obvious. Why? For the simple reason that Xenakis does not establish a resemblance with statistical physics; on the contrary, the similarity is with certain natural phenomena studied by statistical physics. Then, and as Xenakis himself explained in different interviews, what he did was to take the object of study or knowledge (the phenomenon itself) of statistical physics as a reference and, based on this, he performed two operations: 1) he noticed that it was possible to connect the natural phenomenon with the musical one: the former (let us suppose it is a gas cloud, the beating of raindrops on a sheet metal roof or the singing of cicadas) was transferred to the latter (the sound masses made up of hundreds or thousands of notes of different durations); 2) he determined that the musical parameters (punctual sounds and sets of discontinuous -granulated- and continuous -*glissandi*- sounds) and their qualities (density, durations, registers, velocities, etc.) could be modeled mathematically with the tools of statistical mechanics (probabilities).[38]

The proposal I have developed above shows that the Xenakian metaphor-analogy is quite diffuse. This is because each domain involves the deployment (and acquisition), by the agents, of different abilities and cognitive mechanisms: the physicist observes the phenomenon and models it with mathematical tools and, finally, knows it; the musician (composer) listens to the phenomenon and models it with the notation

fruitful dialogue with the exact sciences (statistical physics). However, as will be seen in the following lines (within the main corpus of the text), this dialogue was neither direct nor simple.

38 Varga, 1996; The object or phenomenon of knowledge of statistical physics refers to events made up of thousands or millions of elements (Xenakis, 1971; Prigogine, 1990); Xenakis, 1971, p. 12–16.

system and, more than knowing it in an epistemological sense, seeks to create or re-create it. In any case, and beyond these appreciations, one could also think that Xenakis has achieved, if you will, a sort of mixture or fusion of the functions and cognitive mechanisms I have just pointed out.[39]

But, regardless of this: is the metaphor-analogy that Xenakis proposes totally convincing? The answer is no. It can only be partially trusted. The reason for this distrust is that, as I said, the metaphor-analogy is given with the phenomenon that physicists deal with. However, this does not mean that statistical physics and stochastic music have a clear and definite structural isomorphism: Xenakis uses or applies statistical mechanics (mathematics) to model or shape the sound, but the metaphorical-analogical correspondence is given with the phenomenon and not with the mathematics that analyzes the phenomenon. So, from this point of view, there would be no connection (or a very remote connection) between the exact sciences (statistical physics) and music.[40]

Final Considerations

A fact that is not minor, and which should be taken as a warning, is that the study of metaphor and analogy of almost all the authors or specialists to whom I have had recourse is directed towards the philosophical (informal logic or argumentation theory) or scientific (artificial intelligence) fields. This means that such theoretical perspectives are not always helpful to me: the subject matter I address in this text is centered on the creative-musical (within the artistic field, although music does not always fit this field),[41] and not on the philosophical or the scientific. Hence, perhaps this is the reason why such theories around the metaphorical or the analogical do not quite fit with my inquiry regarding the exact sciences-music link in the work of Xenakis. In any case, and beyond this circumstance, I consider that there are two elements in common between music and the exact sciences that function as a substratum or an ultimate foundation, and that, nevertheless, are the ones which allow the Xenakian metaphor-analogy to be plausible: I am referring to the notions of measurement (the use of a notation system to reason and then model the phenomena) and of structure (with the notation system it is possible to visualize and manipulate phenomena, although, likewise, it is also possible to generate-creatively-diverse patterns, configurations, ordering criteria, or

39 I said that the physicist observes/knows and the musician listens/perceives: this seems excessively restrictive since the act of knowing or perceiving contemplates many and very complex sides. But, regardless of this apparent restriction, what I mean to imply is that in both cases there are some cognitive mechanisms that may be more predominant than others due to the specific disciplinary field to which they belong.

40 The discussion around this problem is not exhaustive here, since mathematical models are also understood as metaphors or analogies of reality (Barrea, 2021). If we believe this to be so, Xenakis's metaphor-analogy would be given, then, from three consecutive steps: natural phenomenon → mathematical tool to model the phenomenon → music (sound mass).

41 Goehr, 2017.

structures). In this sense, I will try to give some degree of plausibility to this way of understanding things by means of the following reasoning associated with analogy:[42]

- *a* (exact sciences: physics and mathematics) have the characteristics *f1* (a notation system for reasoning and then modeling phenomena), *f2* (gravitation of the idea of structure), ..., *fn*.
- *b* (music) has the characteristics *f1* (a notation system for reasoning and then modeling sound-musical phenomena), *f2* (gravitation of the idea of structure), ..., *fn*.
- *a* and *b* should be treated or classified [at least in a preliminary instance] in the same sense with respect to *f1*, *f2*, ..., *fn*.

So, this reasoning or "logical formalism" attempts to show that both the concept of structure and the use of a notation system (measurement) are essential components for music and the exact sciences; this statement belongs to David Bohm (1917–92), who presaged it in this way:

> The consideration of the joint work of order and measure in ever wider and more complex contexts leads us to the notion of structure [...] The classes of order and measure and more complex contexts leads us to the notion of structure [...] The kinds of structures that can evolve, grow or be structures that can evolve, grow, or be built are obviously limited by the order and measure that underlie it. A new order and measure will make it possible to consider new kinds of structures. We can take a simple example from music. Here the structures we can work with depend on the order of the notes and certain measures (scale, rhythm, tempo, etc.). Evidently, new orders and measures will make it possible to create new structures in music.[43]

Bohm's quotation exposes, in my opinion, the reasons and the platform on which Xenakis's metaphor-analogy could be concretized, a matter that resulted in a musical revolution. In this sense, it must be understood that, although the metaphorical-analogical is not new in the field of music, the type of metaphor-analogy that this composer deployed is.

Now, if the interference and predominance of the metaphorical-analogical in the musical field are characteristic and undeniable, this means that the one (metaphor) and the other (analogy) must be understood as particular and relevant cognitive devices or resources to explain the creative processes in music. Also, as I explain above, metaphor

42 Walton, Reed, and Macagno, 2008, p. 57.

43 Bohm, 2002, p. 173–4 [*La consideración del trabajo conjunto del orden y la medida en contextos cada vez más amplios y más complejos nos lleva a la noción de estructura* [...] *Las clases de estructuras que pueden evolucionar, crecer o ser construidas están limitadas evidentemente por el orden y la medida que la subyacen. Un nuevo orden y medida harán posible el considerar nuevas clases de estructuras. Podemos tomar un ejemplo sencillo de la música. Aquí las estructuras con las que podemos trabajar dependen del orden de las notas y de ciertas medidas* (*escala, ritmo, tiempo, etc.*). *Evidentemente, órdenes y medidas nuevos harán posible la creación de nuevas estructuras en la música*].

and analogy play a prominent role in other activities of human endeavor.[44] In order to clarify and better contextualize this approach it will be convenient to take into account the following: in his *Analytic of the Beautiful*, Immanuel Kant (1724–1804) established a clear division between the exact sciences and art.[45] However, his separation proposed something more than a simple partition between fields; he was actually determining the cognitive mechanism that would be incumbent on each area: exact sciences/scientist = cognitive work linked to an analytical and linear process; art/artist = genius, whose cognitive-creative procedure is unknown.[46] From this, Kant concluded: exact sciences/scientific = there is learning and knowledge; art/artist = genius/there is no learning or knowledge.[47] Thus, through the analytical and linear procedure, the German philosopher believed that it was possible to trace and determine the cognitive mechanism of the scientist and the exact sciences. However, when facing the issue of creativity in the artistic field, he was unable to explain precisely how it worked; therefore, he invented the figure of the genius.[48]

But then, what is the cognitive mechanism that the artist (musician in this case) deploys? One of the possibilities, as I proposed at the beginning of this paper, is linked to the metaphorical and the analogical. Furthermore, a pioneer who made important contributions relating metaphor and analogy with music was Julio Estrada (b. 1943).[49] What does this creator-researcher propose? Broadly speaking:

- A listening (perception) and an imagination tied to tradition will tend to generate a more conservative creative-cognitive procedure (reproduction of old musical structures).
- A listening (perception) and an imagination linked to the metaphorical-analogical will tend to generate a more original creative-cognitive procedure (construction of different musical structures).

The Estradian approach is fundamental because it recognizes the impact that the

44 Veale, Gervás and Pease, 2006; Visokolskis and Carrión, 2020; Gelfert, 2016; Olguín and Tavernini, 2018.

45 Kant, 2006, p. 216–18.

46 The analytical and linear procedure implies that a problem, in reference to knowledge, is first decomposed into its essential parts; then those parts will be recombined and thus the complete solution of the problem will be obtained. In short, this means that the whole is nothing more than the sum of its parts. In other words, through a series of successive and orderly steps (analysis), the final result (the whole) is reached and obtained. This way of understanding and approaching things has its origin in mathematics and in Descartes's (1596–1650) method, but it was also used in Newton's (1643–1727) physics. In any case, and beyond its effectiveness, the analytical and linear method was questioned by thermodynamics and nonlinear and chaotic dynamics in the 20th century (Prigogine and Stengers, 1990; Strogatz, 1994; Reale and Antisieri, 1995; García Morente, 2013).

47 Although I am simplifying the separation proposed by Kant, in essence, this is how it happened.

48 Of course, at this point no one can think that things work this way, neither for science nor for art, especially because of the latest advances and contributions of neuroscience and artificial intelligence (Perlovsky, 2006, 2007; Perlovsky and Kozma, 2007; Perlovsky and Illin, 2012; Araya, 2022a, 2022b).

49 Estrada, 1990. As far as I know, Xenakis also alluded to the metaphorical and the analogical (Glissant, 1986); however, his theoretical investigations do not seem to have delved into this topic.

metaphorical and the analogical have on the cognitive-creative factor: both give rise to a more personal creative experience, that is, an experience linked to one's own imagination; and also leads to a process of reconceptualization and resignification of musical structures, something that, as we have already observed, seems to have been the main attribute of Xenakis's creative work.[50]

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12. Activating Sound Phenomena in the Music of Iannis Xenakis

Mauricio García de la Torre[1]

> His approach to nature is extraordinary [...] For him, natural phenomena are the ultimate expression of primary energies. Hailstorms, hurricanes, storms, sandstorms, do not have a specific meaning for him, they are the manifestation of energy.
>
> Maurice Fleuret[2]

Orbiting Xenakis

This article reflects upon the musical contribution of Iannis Xenakis from a particular perspective which is different than that of the typical research about this composer: focusing on the role of acoustic energy in his artistic endeavors. Much of Xenakis's music invokes an overwhelming physicality, a by-product of powerful designs originating from his creative strategies and from his conception of original ideas in each project. Through a descriptive analysis anchored in my own perception, and guided by the references in *Xenakis: His Life in Music* by James Harley, this study associates the phenomena of physical energy with some iconic passages of Xenakis's works.[3]

Certain studies in perception drew my interest to inquire about physical energy and its musical manifestation. First came the notion from psychoacoustics known as "activating sound," one of the four mechanisms that enable an emotional response to music. For Hauke Egermann, this mechanism is the neurophysiological pathway of musical perception that deals with sound reception as physical energy.[4] This approach studies the influence that musical events have on the sympathetic system, and how they generate tension or orientation towards them, as well as subjective and

1 This article also appears in Spanish García de la Torre, 2022. Reprinted by permission in English translation by the author.

2 Commentary by Maurice Fleuret in Kidel, 1990; recording available at https://youtu.be/2p_uhmOIsnQ at Anthoney Hart, "Something Rich and Strange: The Life and Music of Iannis Xenakis" (14 February 2022), *YouTube*, https://www.youtube.com/watch?v=2p_uhmOIsnQ (c. 37′07″).

3 Harley, 2004.

4 See Egerman's TEDxTalk, recording at TEDx Talks, "Emotional Responses to Music | Hauke Egermann | TEDxGhent" (2 September 2014), *YouTube*, https://youtu.be/kzFgoaZ9-VQ

 https://doi.org/10.11647/OBP.0390.14

even physiological arousals. Patrik Juslin and Daniel Västfjäll consider this kind of processing a reflex response by the brain stem:

> It is a process whereby an emotion is induced by music because one or more fundamental acoustical characteristics of the music are taken by the brain stem to signal a potentially important and urgent event. All other things being equal, sounds that are sudden, loud, dissonant, or feature fast temporal patterns induce arousal or feelings of unpleasantness in listeners [...] Such responses reflect the impact of auditory sensations—music as sound in the most basic sense.[5]

The embodied cognition approach presents affinities with such studies. Leman believes that musical communication is rooted in the relationship between musical experience (mind) and sound energy (matter):

> In this mind/matter relationship, the human body can be seen as a biologically designed mediator that transfers physical energy up to a level of action-oriented meanings, to a mental level in which experiences, values, and intentions form the basic components of music signification. The reverse process is also possible: that the human body transfers an idea, or mental representation, into a material or energetic form.[6]

In light of these references, and without intending to study the emotional effects of Xenakis's music, this chapter reviews the subject of physical energy to ponder this personal take on the composer, instead of discussing more usual topics such as the mathematical applications in his music, research that others have already conducted to a great extent. This approach constitutes a contrast from studies that portray Xenakis as a structuralist, hyper-rational, or scientific kind of artist, a view perhaps promoted in life by the composer himself if we consider the ways he sought to account for his creative procedures.

Metaphysical Approach: Potency

I recognize an outstanding quality while listening to the music of Xenakis: the musical experience is characterized by an open physicality. Works such as *Persephassa* (1969), *Jonchaies* (1977), or *Mists* (1980) are assertive, frontal, powerful; it is music that strongly impacts perception, sometimes overwhelmingly. Xenakis's music manifests itself in lived experience as potency. According to Baruch Spinoza (1632–77), "potency" (*potentia*) refers to the active essence by which a thing produces the effects inherent to its nature, that is, the capacity of preserving its own being.[7] This definition has three aspects of note: (1) the notion of active essence, (2) the idea that a musical work is capable of producing the effects inherent to its nature, and (3) the claim that the work's "own being" is preserved in the context of a creative act. Following the path of phenomenology, an active essence is a permanent and invariable constant of an

5 Juslin and Västfjäll, 2008, p. 564.
6 Leman, 2007, p. XIII.
7 Spinoza, 2007, p. 96.

object's structure, event, or process, that is updated as phenomena in each appearance in consciousness.[8] For this reason, musical experiences can be renewed in similar intensity and with a similar effect on mood; regardless of whether the same work has been heard dozens of times, music is updated in consciousness and is capable of moving the listener again and again, even if the piece is highly familiar. The second part of the definition refers to the fact that music is capable of producing the effects inherent to its nature. This relates to the composer's ability to translate perceptions, ideas, memories, emotions, and other facts into sound, giving rise and meaning to the creative process; thus, the creative drive produces inseparable impressions of its own features and qualities, in metaphorical terms, "its own nature."[9] Finally, the definition mentions one "being" that manifests itself in the work of art, not as a hidden or ethereal entity, or a product of the imagination, but as the ultimate and true expression of the artist in his own work or, taking our composer as an example, the way in which Xenakis makes his presence felt as an individual in his own music. I am thinking here of Eduardo Nicol's (1907–90) theory of human expression, that considers this "being" always as a "creative being," who moves with a certain direction and intensity to manifest and make himself present through his acts.[10] What better compliment can be paid to a composer like Xenakis than to recognize that his artistic being is revealed as potency and that his music produces the effects inherent in its nature?

However, the idea that certain music manifests itself in experience as potency has no shortage of challenges. Perhaps the first issue is establishing valid criteria with which to distinguish the necessary conditions for a piece of music to be considered powerful. We know that musical potency is not exclusive to Xenakis; works by other great composers share this extraordinary virtue. Musical potency is also not explained by the factors that articulate a large part of traditional musicological research: historical period, style, and musical system. It is clear that not all the works of the same composer emanate this quality. Recognizing the above, and from a philosophical scheme nourished by Spinoza's idea, I consider that musical potency depends on a basic condition: the ability to constitute meaning.

Construction of meaning is a classic subject in philosophy of music. It is the process by which people discover, in their interaction with music, the purpose of the phenomenon they are attending to, in order to achieve a certain degree of affinity or understanding. Leonard B. Meyer's (1918–2007) theory of musical perception argues that some

8 Edmund Husserl's (1859–1938) phenomenology can be considered as a philosophy of essences whose basic principle consists in detecting, without pre-conceptions, those stable structures that prevail in each manifestation of the experience of a phenomenon, with the purpose of carrying out a descriptive study that starts from intuition as a path to knowledge. See García de la Torre, 2018, p. 81.

9 For a broader exposition of the psycho-physical operations involved in the musical creation process see ibid., p. 134. The concept of drive refers to Freudian psychoanalytic theory. However, its use here, as a creative impulse, is more moderate. I think of the psychic impulse or intuitive tendency originated in an internal excitation—perceived as a state of tension—which is directed towards satisfying a creative need.

10 Nicol, 1957, p. 121.

epistemological positions that have explained the construction of musical meaning, such as absolutism, meaning built upon the structural relationships that a work establishes, and referentialism, meaning built upon allusion to concepts, actions, and emotional states, are not mutually exclusive.[11] Meyer believes that these positions can coexist in music perception; affective meaning can be configured from understanding the music's referential content, and, in addition, people can enrich their listening experience from intellectual and abstract comprehension of structures.[12] Based on Meyer, potency of music is attainable if 1) the work is capable of expressing immediate meaning and 2) if perception manages to adapt its processes without too much conflict while attending to musical events. Having to assimilate overly sophisticated codes, dependent on hyper-stylized and unbinding forms, loaded with complex symbols to decipher, reduces the probability of reaching a powerful experience. Any condition preventing the general meaning of music from being found in a limited number of auditions truncates the possibility of potency. The acquisition of meaning is facilitated if musical events emulate the iconic behavior of phenomena in the physical world, events related to factors such as movement: ascending-descending, accelerating-decelerating; space: events located in reference to something else, in front, in the back, from inside or from outside; or even tension: objects related or non-related, forming subtle or decisive oppositions between components. Given their perceptual forcefulness, anchored in the findings on sound activation already discussed, I argue that these types of phenomena embody musical potency.

Physical Approach: Energy

Discussing the ways in which Xenakis's music manifests physicality calls for clarification of the concept of energy, a notion from which several slightly separate meanings emanate. Without denying the importance of the daily and spiritual sense of the word, and especially since we deal with the figure of Xenakis, this article will focus on the scientific sense: physical energy.[13]

The cosmological vision of Heraclitus (540–480 BCE) pointed to the existence of something that drives the activity of nature: a "fire" which has a continuous flow or movement, structured by antagonisms and tensions. According to Werner Heisenberg (1901–76), this may have been the first indirect reference to energy in Western history.[14] Later, Aristotle proposed the concept of "energeia" (ἐνέργεια), which "implies act, actuality, insofar as it is opposed to possibility, in his explanation of change or movement in nature, is incumbent [...] on the prime principle or prime movement of all beings."[15] The definition of energy has been a classic problem for modern science

11 Meyer, 1956.
12 Ibid., p. 1–3.
13 For a detailed review of the most recurring properties of physical energy, see Jaffe and Taylor, 2018.
14 Heisenberg, 1958, p. 63.
15 "Energeia," *Encyclopedia Herder*, https://encyclopaedia.herdereditorial.com/wiki/Energ%C3%ADa

because the concept is described in the specialized literature more for what it *does* or *causes* and less for what it actually *is*:

> Energy is not easy to define [...] we observe that in any physical system free from outside influences, energy does not change with time. This fact is referred to as conservation of energy, and this is energy's most fundamental attribute.[16]

For researchers, energy is not a substance with causal agency, but the abstract measure of a property possessed by an object.[17] In *Energy, The Subtle Concept* (2015), Jennifer Coopersmith reflects upon the complexity of a simple definition: "Energy is [...] the ceaseless jiggling motion, the endless straining at the leash, even in apparently empty space, the rest mass and the radiation, the curvature of spacetime, the foreground activity, the background hum, the *sine qua non*."[18]

Acoustic Energy: Transmission and Reception

Considerable scientific agreement is found in the field of acoustics and psychoacoustics on the mechanisms of origin, transmission, and reception of sound.

> Sound waves in fluids involve local changes (generally small) in the pressure, density and temperature of the media, together with motion of the fluid elements. Fluid elements in motion have speed, and therefore possess kinetic energy. [...] In regions where the density increases above its equilibrium value, the pressure also increases; consequently, energy is stored in these regions, just as it is in a compressed spring. This form of energy is termed potential energy.[19]

Potential and kinetic energy created by the sound source are transported as a disturbance by the fluid medium, i.e. air, towards the human auditory apparatus. The tympanic membrane converts external acoustic pressure variations into mechanical vibrations that are transmitted to the oval window of the cochlea, which is responsible for converting mechanical vibrations into nerve discharges.[20] Thus, energy, as a fundamental element that animates sound, is present from the emanation and transmission mechanisms in different environmental conditions, as well as in the consequent bio-mechanical processing of hearing.

Acoustic theory holds that sound has four basic components: frequency, amplitude, timbre, and duration. Frequency, the rate of periodic movement of compressions and refractions of a sound wave, is expressed in pitch. In terms of energy, a higher frequency implies a faster vibration; hence a high-pitched sound contains more kinetic energy than a low tone. Amplitude is manifested as the distance from the rest point of the sound wave

16 Jaffe and Taylor, 2018, p. 3.
17 Feynman, 1966, p. 34.
18 Coopersmith, 2015, p. 362.
19 Fahy, 2002, p. 1.
20 For a detailed description of this process see Howard and Angus, 2017, p. 72–4.

to the moments of compression and maximum refraction. In simple terms, amplitude is perceived as the intensity of the sound.[21] An increase in sound pressure is perceived explicitly as acoustic energy, that is, as an increase in perceived intensity. The relative densities of the compression and refraction points are further apart in loud sounds and narrower in silent ones. This difference has a direct correlation with the energy applied in the attack that excites the sound source. Harmonic content is a constituent factor of timbre, the attribute of auditory sensation that enables the hearer to judge the difference between two sounds with the same pitch and intensity.[22] It also registers the spread of the available energy across the range of frequencies that are present. Timbre description depends on inter-sensory associations that have subjective ingredients, which lead us to qualify a sound as bright, smooth, or rough, adjectives related to the degree of complexity between its harmonic components. Energy is expressed in timbre primarily as perceived tension. Finally, duration is the temporal measure of sound; however, of all of the components of acoustic theory, duration is the element whose relationship with energy seems less significant. In any case, duration implies the presence of sound or silence, and the former enables all energy expressions described above.

Music and Energy in Perception

The manifestation of acoustic energy in musical perception seems to have multiple origins and involve several factors. However, any project intended to trace the energetic *qualias* of music must consider the aforementioned acoustic components as a starting point.[23] From this essential point of departure, the theory of macrotimbre by Julio Estrada (b. 1943) highlighted elements linked to the creation and execution of sound, such as pulse, attack, pressure, vibration, noise, space, and chaos.[24] Each element of Estrada's macrotimbre can be considered an independent magnitude with degrees of energy forming a conglomerate of audible factors which in a compositional process can be graphically expressed in trajectories of a system of Cartesian axes in two or more dimensions.[25]

21 The energy of the sound wave is a measure of the amount of sound present. However, in general, we are more interested in the proportion of energy transferred than in the total energy transferred. So we are interested in the amount of energy transferred per unit of time, the number of joules per second (watts). But sound is a three-dimensional quantity, so we have to consider that the sound wave will occupy space. Therefore, it is necessary to characterize the proportion of energy transfer per area unit. This quantity is known as "sound intensity." In Howard and Angus, 2017, p. 20.

22 ANSI, 1960, in Howard and Angus, 2017, p. 238.

23 The notion of *qualia* is used here in reference to the sensory data of perception. The idea of energetic *qualias* of the musical supposes the search for and identification of perceptual data that make audible some qualities of energy in acoustic terms.

24 For Estrada, the macrotimbre is the synthesis of the physical-perceptive fusion of the musical matter in which the treatment of rhythm and sound is generalized starting from a homogenization of their respective components, a set that allows showing a chrono-acoustic integration of musical matter. Estrada, 1994, p. 116.

25 Estrada writes, "With the UPIC, time becomes the x coordinate while the y coordinate represents the energy level of the pitch frequencies, envelopes, or waveforms [...] This energy, whether physical or even abstract, represents information as important as that of the specific component assigned to a

Another layer within the quest for perceived acoustic energy is added by considering rhythmic-metric design and harmonic strategies. Here, the axial organization of music comes into play. If the presence of sound is equivalent to a form of acoustic energy, then rhythm, the organization of durations of sound and silence, is a way of structuring energy signals in time. In a rhythmic-metric organization of music, factors such as degree of regularity, metric affinity, and speed of the unit of time constitute a particular modality of energetic-musical events. On the other hand, affinity or disparity of simultaneous sounds and their respective harmonic properties determine the resulting level of tension. The organization of harmonic space is a determining quality of musical energy. Intervallic, chordal, and scalar relationships have produced the principles of harmonic tension in music. Although the traditional dominance of pitch has diminished in the music of composers of the last century, it is clear that it continues to be a factor in musical composition of our day. Western musical systems have been built for centuries on intervallic, chordal, and scalar relationships to define the principles of harmonic tension. Although the traditional dominance of pitch has diminished in the music of composers of the last century, it is clear that it continues to be a factor in musical composition of our day.

For this study, the listener's relationship with the sound source in terms of location and distance, i.e., the aspect of physical space, is of primary interest when considering perceived acoustic energy. The spatialization strategies of multi-instrumental, electroacoustic, or electronic works consider the localization between the source and the public as an essential element for design. As such, composers of the last seventy years have found creative ways to explore space as an independent element in music. A piece exploring this approach can suggest distance, depth, laterality, orientation, and movement, all of which are achieved more easily than in conventional concert arrangements.

Texture is another stage of perception of musical energy. The concept has several meanings, often referring to the correlation between events of a piece, aspects such as density of objects, distance between objects, type of interaction established, rhythmic and harmonic affinity, and timbre correspondence. Among these meanings, degrees of density in time units are definitive in the perception of wide-ranged, global activity. Thus, the textural interactions allow perception to establish hierarchies, that allow the description of musical behavior; this, of course, is applicable to solo pieces as well as orchestral masses, or music made with media that support multiple layers of sounds.

All the factors discussed above make it possible to classify musical manifestations in terms of perceived energy. It is clear that creating music implies the organization of these elements according to strategies and resolutions, whether intuitive or deliberate. In *Art, Energy and the Brain*, Robert Pepperell claimed to recognize the essential role of energy in the aesthetic experience of Art and reviews the ways in which this type of

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macrotimbre. For musical thought, drawing becomes a dynamic alternative that extends the methods of assigning macrotimbric data. For example, a vector with the same amount of energy as another—at the level of the ambitus of each component—can always express itself with an equivalent value." Estrada, 2020, p. 317–23.

organization occurs. Pepperell refers to John Dewey (1859–1952), who considers artistic products and their lived experience as manifestations of "organized energy," based on a series of antagonisms such as rhythm and variation, beginning and end, or movement and rest. According to Dewey this organization is "vital, physiological and functional."[26]

Acoustic Energy Organization from a Gestalt Perspective

The way energy is organized, rather than its mere presence or pure measure, became an important subject for the aesthetics of the Gestalt school. Its adherents endorsed a general principle of perceptual organization in which aesthetic preference is directed toward the simplest and most efficient arrangement of elements.[27] Rudolph Arnheim (1904–2007), an art theorist with a background in Gestalt psychology, attempted to understand the function of visual art as the action of "exquisitely balanced perceptual forces." These are dynamic properties of shapes and patterns, energetically driven and suspended in relationships of mutual tension, reminiscent of the principles claimed by Dewey.[28]

Art perception—in this case, music perception—depends on the combination of energetic *qualias* as a Gestalt construction. The highest hierarchy of this Gestalt can be found in two fundamental aspects in the tracking of energy: perceived movement and perceived tension. Motion can be considered in its most general sense as change, whether in terms of an object's position, direction, continuity, regularity, activity, intensity, velocity, and acceleration relative to an observer or, in this case, the listener. On the other hand, tension can be considered as conflict between forces due to their relative position or configuration. Conflict between forces can occur in pitch, timbre, harmonic organization, contrapuntal and rhythmic-metric relationships, as well as in formal structures of music. The continuous updating of energy allows us to trace these instances, both at a macro-level of music, between contrasting sections, or in musical events at a micro-level, as interactions of cellular elements. In short, following Pepperell's idea, two primary factors facilitate the detection of musical energy in its kinetic and potential manifestations:

- Factors of change, in terms of movement, action, impulse, work, or excitement.
- Factors of conflict, in terms of tension, organization, structure, proportion, balance, and opposition.

The Gestalt structure formed by the energetic *qualias* of music is organized in a range of ascending layers of complexity. This could be represented by portraying the basic sound components in the lower levels up to the factors of change and conflict cited above (see Figure 12.1).

26 Dewey, 2008, p. 169.
27 Pepperell, 2018, p. 9.
28 Arnheim, 1969.

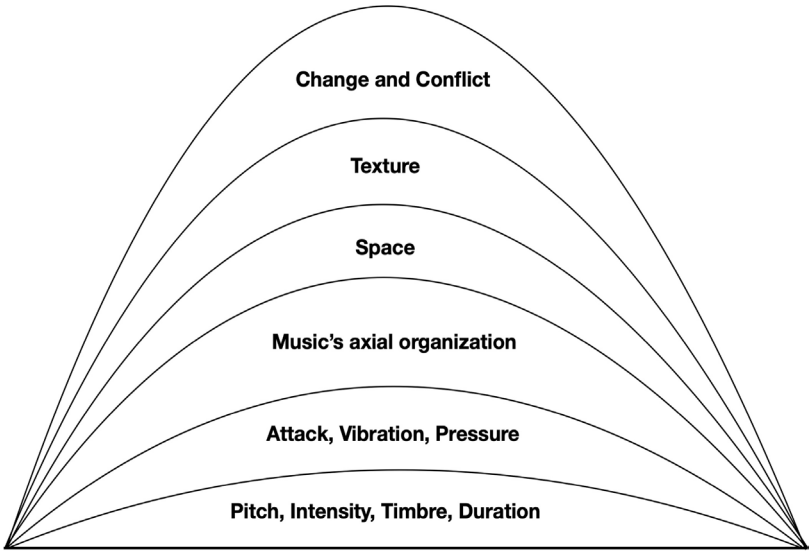

Fig. 12.1 Perceptual *qualias* of musical energy. Figure created by author.

Xenakis and Acoustic Energy

The primary sources of the work of Xenakis contain inconsistently scattered references to energy. This explains why the subject is not very visible in the research about the composer. Although researchers have not often noticed them, Xenakis mentioned energy many times in his writings and conferences. In *Formalized Music*, Xenakis, as someone well-versed in modern theories of physics, recognizes the importance of the principle of conservation of energy, following Einstein's findings:

> The principle of the conservation of energy in physics is remarkable. Energy is that which fills the universe in electromagnetic, kinetic, or material form by virtue of the equivalence matter-energy. It has become that which is "par excellence." Conservation implies that it does not vary by a single photon in the entire universe and that it has been thus throughout eternity.[29]

In the same text, in the chapter dedicated to time and space in music, Xenakis explains the origins of physical space, one of the topics that most occupied his reflections:

> As space is perceptible only across the infinity of chains of energy transformations, it could very well be nothing but an appearance of these chains. In fact, let us consider the movement of a photon. Movement means displacement. Now, could this displacement be considered an auto-genesis of the photon by itself at each step of its trajectory (continuous or quantized)? This continuous auto-creation of the photon, could it not, in fact, be space?[30]

29 Xenakis, 1992, p. 203.
30 Ibid., p. 257.

In *Conversations with Xenakis*, Bálint András Varga presented an interview with the composer in which a series of discussions about energy in the context of music appears.[31] Xenakis dedicated several lines to acoustic movement, achieved by designing the arrangement of the musicians and the use of non-traditional possibilities at concert venues. Works such as *Terretektorh* (1966) intended to explore kinetic energy in space. Varga explains:

> The most important thing is: if the musicians fill the space at their disposal we can exploit its kinetic properties. Instead of static music we can produce something mobile. Movement is an interesting means of expression, which can hardly be employed with traditional orchestras. Sometimes I have also used that limited possibility in an orchestra seated traditionally on the podium, making sound wander from right to left or from left to right. There's no depth, however, because the perspective of sound is insufficient. Genuine movement can come about only if the musicians surround the listener. We can therefore "tame" space.[32]

The energy radiation of the instruments was transcendental for Xenakis in the spatial design of his works; in this sense he was always careful to preserve the acoustic energy that emanates from the sound source in the context of a concert hall. The following comment is in reference to a performance of *Persephassa* (1969) at the Round House in London:

> The individual listeners don't hear a completely different kind of music, but they certainly do hear the same music from a different perspective. If the piece is good, it will be performed more than once, and it will thus be possible for everyone to hear it from different angles. This solution has another advantage as well: the physical proximity of the instruments makes their sonority much more alive than when you hear them at a distance, in which case the energy they radiate dwindles and components of the matter of sound are lost. If we are as near to the instruments as the conductor and the musicians then we find ourselves in the very middle of the sound.[33]

These references suggest that although Xenakis did not develop an explicit theory of musical energy, the subject was present in his thoughts. The primary source in which these phenomena seem to manifest most forcefully is, without a doubt, his music. In the following, I present generative aspects of some of his pieces from the perspective of energy. The focus will be on factors of change and conflict, as elements that facilitate the constitution of immediate meaning, which leads to a powerful listening experience.

Metastasis (1953–4): Initial Section, cc. 1–55

The first section of *Metastasis* famously features the unfolding of a single pitch into a cluster of forty-six pitches by means of string *glissandi*. The key to this process consists

31 Varga, 1996.
32 Ibid., p. 97.
33 Ibid., p. 98.

of the increase of energy in several features: density, intensity, harmonic tension, and activity of the continuous trajectories. The aim is to move from the simple texture of the opening to the harmonic complexity of the climax (mm. 55), which is emphasized by violent tremolos. Through careful design of dynamic processes, Xenakis achieved the transition from unity to mass, from immobility to change. The architectural origins of the piece are well-known, but from a listener perspective, the manipulation of these forces allows for a remarkable effect, never heard before: the imminent visualization of sound. The immediate meaning of this music and its expressive capacity could not be explained without the transformations of elements tending towards saturation, that is, the accumulation of acoustic energy.

Pithoprakta (1954–5): *mm. 52–9/mm. 60–104/mm. 105–8*

The construction of global sound entities is the compositional goal of *Pithoprakta*. I take mm. 52–108 as an example. The three textures that appear here depend on differentiated attacks and the internal activity of global events. The first texture (mm. 52–9) was conceived based on statistical models that were derived from one of Xenakis's most attractive sketches.[34] The strings form a cloud of *glissandi* with *pizzicati*, which, in its multiplicity, invokes a global behavior of a mass that widens, thins, or hollows out. A sense of unpredictability prevails, a kind of organized chaos. After a short pause, in mm. 60–104, a new texture of sustained sounds that cover the entire register appears; the sudden change towards the static and immobile is notorious. Furthermore, Xenakis emphasized the contrast by suggesting an ephemeral, metrical regularity with the pseudo-steady rhythm of the xylophone. A progressive stillness continues towards the awakening of internal activity when discontinuous trajectories of *pizzicati* and rapid attacks are heard on the percussion. A third texture opens from mm. 105 onwards, a typical passage with fast *glissandi* trajectories. The success of this contrasts lies in the handling of kinetic energy, manifested in the micro-interactions of each sound entity.

Terretektorh (1966)

Xenakis offered a radical conception of kinetic energy in *Terretektorh*. The exploration of space through the conception of sound movement and depth are key in the conception of the piece. The design of space calls for a circular arrangement of eighty-eight musicians around the conductor, with the public inserted between them. With this setup, Xenakis was able to build layers of complexity for the listener while keeping the harmonic-melodic environment static, in order to make way for percussion sounds

34 See blessing5150, "'Pithoprakta' by Iannis Xenakis" (2 Apr 2017), *Music 7703—Contemporary Compositional Practice*, https://music7703lsu.wordpress.com/2017/04/02/pithoprakta-by-iannis-xenakis/

like wooden blocks, whips, maracas, and whistles. Both directional and stochastic sound movement results through changes in intensity, register, density, timbre, and spatial localization.

Psappha (1976)

Psappha's compositional focus is the articulation of time through polyrhythmic patterns as independent layers in simultaneous interaction. The combination of timbres of percussion instruments, pitches, and attacks are the elements at play. Xenakis used a regular grid as a score to capture the rhythmic-metric organization. In general, three layers of percussion appear, each containing high, medium, and low pitches. The patterns presenting degrees of transformation lead the discourse progressively: accents, addition or subtraction of attacks, layers of rhythm, and timbre. *Psappha* has moments where a sense of transitory regularity seems to settle. Predictability is difficult to achieve due to the changes incorporated in each cycle. Some changes are due to systematic organization and others to intuitive manipulations of materials. Movement is manifested in terms of global behavior of passages in three forms: continuity, regularity and intensity of events, while changes in density are responsible for bringing tension. For example, there may be intense activity in a single layer (b. cc. 308–520), shared activity between layers (b. cc. 1410–1590), or horizontal saturation of activity in one or more simultaneous layers (b. cc. 2030–2170).

Mists (1980): First Two Sections

The first part of *Mists* opens with a series of scales displayed in continuous random walks.[35] A set of lines that overlap and intersperse gradually separate to find their individual culmination in the high register. Xenakis elaborated permutations of these arborescent events that are reminiscent of contrapuntal operations such as inversion or retrograde. Events with an upward trend are shown in different versions of density; sometimes they present high saturation while others spread out under probabilistic distributions. The second material, made up of stochastic clouds, marks a remarkable contrast, based on the opposition of densities, register, and intensities. The high register is explored as if the hands, as unpredictable springs, suddenly attack the piano with energetic impulses. Unlike the first material with a diagonal logic, the intermediate passage operates from a vertical beginning with non-simultaneous attacks poured into clusters.

The descriptions from this brief but representative collection of Xenakis's works have attempted to capture an overview of the dynamic transformations by which the composer articulates his music. On different structural scales, acoustic energy is manifested in each case as factors of difference and change, always in comparison

35 Squibbs, 2002, p. 91–108.

between the events that occurred—memory—and the present evolution—time—which establishes a complex system of cognitive interdependencies.

Final Considerations

From the perspective of physics there is enough evidence to affirm that music is a form of energy. However, traditional composition and even new forms of creation are usually considered as the organization of musical elements, and not as a process in which judgment and intuition regulate the energetic magnitudes of sounds in favor of meaningful constructions. The abstraction of this kind of musical phenomena, without considering the typical forms of compositional practice, seems adventurous, but Xenakis showed that is possible to take advantage of these resources. Within the framework of the complexity of his system designs, Xenakis treated the forces of the acoustic and musical fields with admirable freedom, managing to unleash his full power like few others. For this reason, and based on the Spinozian conception of *potentia*, I maintain that Xenakis was a creator of powerful listening experiences.

Much work remains to be done to elaborate the ideas of this article, especially since the subject of energy in musicology has been little addressed. For the moment, the proposal of a Gestalt formed by the energetic *qualias* of music is a first step towards greater instances; the exploration on the matter should lead towards further characterization and interaction of these qualities. The challenge of talking about energy in any discipline poses similar difficulties, such as its quantification, the qualities by which it manifests itself, monitoring its transformations, and the ways in which it is updated. It will be necessary to work on these paths to consolidate more research in this regard.

Anchored in his acute observation of nature and its phenomena, one of Xenakis's most extraordinary features is the regulation of energetic factors of change and conflict. Here lies the physicality of his music. By showing a particular interest in establishing criteria in the order-chaos polarity, Xenakis achieved structures of density of musical horizontality and verticality, building timbre categories to create contrast. He handled musical components as relational properties, constantly linked, whether as affinities, oppositions, or evolutions: as forces in interaction. From this perspective, the foundation for his aesthetics, in affinity with the Heraclitean vision, is to consider that what animates music is nothing else than energy.

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13. Spatial Movement of Sound Vectors

Ambrosio Salvador Rodríguez Lara

Introduction

In the field of physics, a vector is a quantity that has both magnitude and direction. In this chapter, I propose the concept and definition of what I shall call a "sound vector" in acoustic space, understood as the space of auditory phenomena within which we characterize sounds as high or low, simultaneous or sequential, and so on. I also explain that rhythmic-melodic movement meets this definition. In musical instruments such as the harp, the marimba, or the piano, when a melody is played, sound vectors are projected simultaneously over the acoustical space as well as over the physical space of the instrument. By using technological resources to synchronize several acoustic sources, not only is it possible to obtain a projection of sound impulses in wider spaces but also to model that projection on particular physical spaces, just as rhythmic-melodic sequences are modeled within the acoustic space. However, unlike the instruments mentioned above, in which each pitch is located only in one place, we find that, when using different sound sources, the possibilities of distribution regarding each sonorous aspect of the impulse—pitch, rhythm, dynamics, stress, timbre, etc.—get remarkably diversified. All this, in turn, leads to a great expressive flexibility. In this discussion, electroacoustic sources and means are excluded.

Sound vectors are classified in continuous and non-continuous displacement impulses. Some of my compositions, and those of other composers that show non-continuous displacement impulses, are presented as examples. In addition, I propose some compositional possibilities for this type of impulses. It is interesting to consider impulses with relatively fast speed over the physical space, like a *glissando* on the harp or the piano, and the impression that these produce of a near cancelation of both the physical and the acoustical spaces between the sources. Sound vectors are a resource of great expressiveness.

 https://doi.org/10.11647/OBP.0390.15

Definition of a Sound Vector

The definition that I propose for the term "sound vector" is the following: a sound impulse that moves in the audible frequency range—or acoustical space—with a determined speed and direction. Speed and direction are the two basic properties of a sound vector. We can define speed in this context as the number of events that occur within a certain duration. This definition allows for correspondence with the field of physics, where speed is a scalar magnitude and velocity is a vector, i.e., it has magnitude and direction in physical space.

In string instruments and keyboards, such as the piano, the harp, the marimba, or the vibraphone, sound impulses, through rhythmic-melodic movement, form simultaneously a trajectory in physical space that moves parallel to the rhythmic-melodic trajectory: a sound vector in acoustical space behaves as a sound vector in physical space, sharing the properties of speed and direction of the sound impulses. On the other hand, the continuous repetition of a sound event on these instruments does not move in the acoustic space or the physical space. Under such conditions, the sound event has a speed, but since it has no direction in the acoustical nor physical spaces, it is not considered a sound vector. Nevertheless, as explained below, textures can be organized so that repeated events do form sound vectors in physical space through the interaction of synchronized, fixed sources in a given space to produce sound impulses with speed and direction.

As emphasized above, I am referring exclusively to acoustic sources, so every electroacoustic source or means is excluded.

Classification of Sound Vectors

Sound vectors can be classified into two categories: continuous displacement sound vectors and non-continuous displacement sound vectors.

Continuous Displacement Sound Vectors

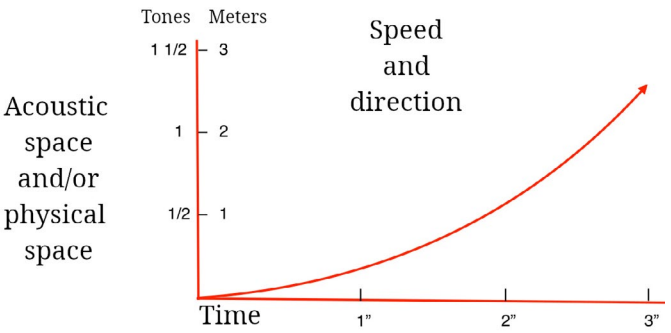

Fig. 13.1 Continuous displacement sound vectors are impulses that travel through all points in physical space, such as a *glissando*. Figure created by author (2022).

This kind of sound impulse comes from a source that can move continuously and travel through all points in a space, either physical or acoustical. A well-known example that encompasses both spaces simultaneously is the siren of an ambulance, which travels as a *glissando* through a certain extension of the acoustical space and moves continuously in physical space to a listening point and then away from it. When moving closer with a certain speed, the Doppler effect is produced: the values of frequency and intensity grow; the sound reaches a peak in frequency and intensity when the ambulance passes near the listener. After, when it moves away, the frequency and the intensity drop simultaneously.

Another example of a continuous displacement impulse in the acoustical space is a *glissando* in a string instrument like the violin, or in an air column like the trombone, or the human voice.

A different case of continuous displacement of sources in physical space, though much slower, can be observed in religious processions, marches, and military parades, even in funeral processions.

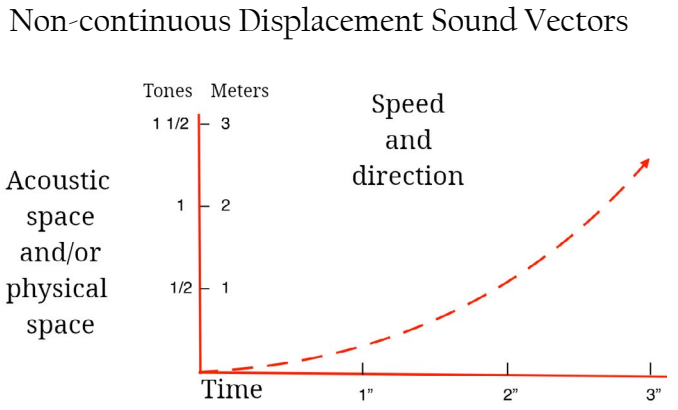

Fig. 13.2 Non-continuous displacement sound vectors. Impulses through fixed sources that divide the physical or acoustic space. Although the sources do not move, the synchronized impulses seem to travel through the physical or acoustic space with specific speed and direction. Figure created by author (2022).

Non-continuous displacement outlines a trajectory through fixed sources that divide the physical or acoustic spaces in a determined way. The sources do not move, but the synchronized impulses they produce with a determined speed give the impression of an impulse that is transmitted with a certain speed and direction, creating a sound vector.

Thus, any rhythmic-melodic sequence can be considered a sound vector in the acoustic space. These sequences are not perceived as isolated points, but as impulses with an identity, despite the constant fluctuation and the melodic leaps of some melodies—very wide, as in Anton Webern's (1883–1945) *Five Canons on Latin Texts*, Op. 16, or very small, as Julián Carrillo's (1875–1965) microtonal quarter-tone steps.

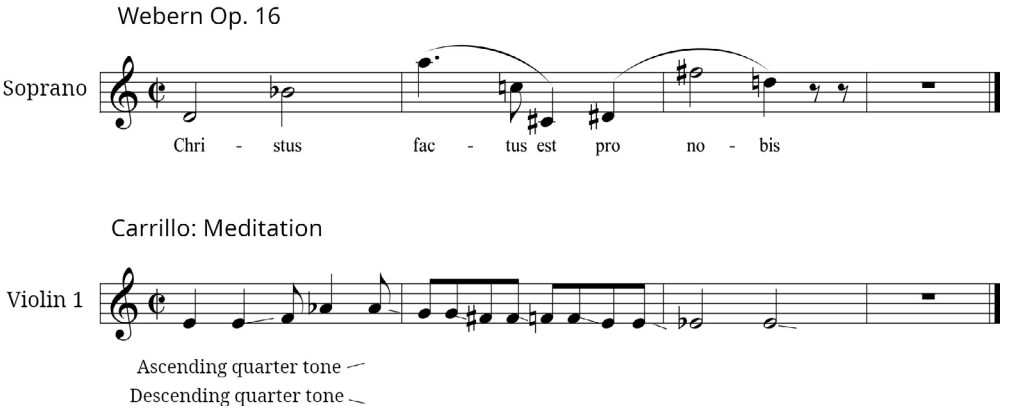

Fig. 13.3 Examples of extreme melodic trajectories: Anton Webern's *5 Canons*, Op. 16, No. I (1923–4), voice part, and *Meditación*, from Julián Carrillo's *2 Bosquejos pour quatuor en quart de ton* (1927), No. 1, violin I part in quarter tones (dates given are dates of composition).[1] Figure created by author (2022).

In his text *The Musical Timespace*, Erik Christensen refers to the acoustical space when he writes "Melody is the spatial shape of music."[2] But the spatial shape can also be organized in physical space through a particular spatial distribution of fixed sources and the synchronization of the impulses they produce. The perception of continuity of the impulse depends on factors such as the distance between sources, the transition velocity from one source to another—a very important aspect that I will discuss below, the duration of each impulse produced, its dynamics and timbre, and the location of the listener, among others. Both spatial shapes, i.e., the melodies, and the synchronized impulse, are transmitted between discrete points in acoustic and physical spaces.

One of the clearest interfaces that shows the connection between physical space and acoustic space is the keyboard in instruments like the piano or the harpsichord. This interface is a mechanism that assigns a different pitch to every key. The harp is another instrument that beautifully shows this special distribution and its correspondence in the acoustic space. These instruments produce non-continuous displacement sound vectors that are transmitted among fixed sources in the acoustical and physical spaces with given speed and direction, although the trajectory they form does not travel through each and every point of the acoustic or the physical space.

To perceive the sound vectors produced by the harp or the piano in physical space, one must be close enough to the instrument to distinguish separately each point of sound production. If one is far enough away, the sounding board acts as a diffuser, and it becomes more difficult to distinguish each sound production point. In the marimba, that has an individual resonator for each key, sound vectors in physical space can be perceived even if one is not very close.

1 Transcript of Webern, 1928, mm. 2–5 and of Carrillo, 1978, mm. 1–4.
2 Christensen, 1996, p. 98.

I find the *glissando* on the piano and the harp of special interest. It forms a sound vector in the physical and the acoustic spaces. Its great speed in the succession of sounds seems to cancel the distance between the strings, giving an impression of continuity in both spaces. Hence the name *glissando* (from French *glisser*, meaning slip or slide). What is really happening is that our ear cannot distinguish each separate event in time or in either space, and it groups everything as a sound mass with its own speed and direction. I will discuss this phenomenon below, where I analyze *Persephassa* (1969) by Iannis Xenakis.

I also find an analogy between sound vectors in space and light-series, dancing fountains, and lenticular paintings (Figure 13.4). In this case, paths formed by discontinuous elements can be perceived.

Fig. 13.4 *Maria*. Painting with lenticular effect by Lucía Andrade. © Lucía Andrade, reproduced with the artist's permission.

From now on, I will use the term "sound vectors" to refer to non-continuous displacement sound vectors, unless otherwise specified.

Sound Vectors in Original Compositions

In 1993, during a presentation of Conlon Nancarrow's (1912–97) studies by the kinetic sculptor and sound artist Trimpin (b. 1951), on a marimba keyboard, I could observe that the rhythmic-melodic impulses of Nancarrow's canons for player piano, adapted for a sculpturally spatialized rearrangement of the keys of the marimba by Trimpin, moved with several velocities through space, and it occurred to me that it was possible to synchronize similar events with other performers.[3] In 1998, I explored

3 This was at the *Conlon Nancarrow Exhibition* in the Palacio de Bellas Artes, in Mexico City from 23–7

these possibilities with the first version of my piece for thirteen trombones *Atecocoli* ("seashell" in Nahuatl, a prehispanic language of Mexico). It was carried out in the courtyard corridors of the National School of Music, UNAM—today's Music Faculty—during a homage to Nancarrow after his death. I chose thirteen trombones to recall thirteen seashells, whose sonority was typical of prehispanic cultures. At this time, I had no knowledge of the works *Orbits* (1979) for eighty trombones, organ, and sopranino voice by Henry Brant (1913–2008), or *Trombonhenge* (1980) for thirty trombones by Charles Hoag (1931–2018). Both compositions were designed to make use of the location of the trombones surrounding the audience. There are no sound vectors in these works because the group of musicians is not evenly distributed around the audience, and so do not produce the effect of continuous displacement of sound impulses.

In my opinion, this version of *Atecocoli* was a relative disaster given the difficulty of designing a score that allowed the performers to control the sound events. My purpose was not only to locate the performers in a specific space, but to map out sound trajectories with a certain speed and direction, which I now call sound vectors in physical space. For this I had to synchronize the sequence of events of each performer with great precision, which I solved with a *multi-tempi* MIDI sequence. To solve the problem of transmitting the audio signal with a pulse with a specific speed (that was independent of all the others) to each performer, being a considerable distance apart from the other performers, I needed very long cables to connect the MIDI modules with independent outputs for every channel, as shown in Figure 13.5.

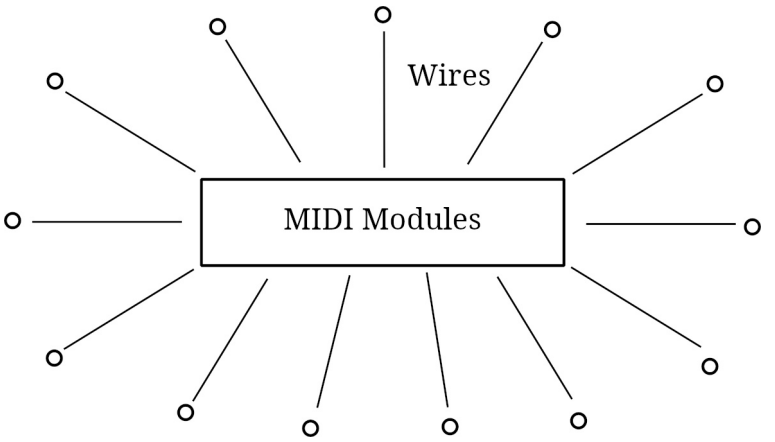

Fig. 13.5 Wiring from MIDI modules to thirteen points in a circle. Figure created by author (2022).

Another problem was to assemble, without a budget, thirteen trombone performers practically without any rehearsal. The participation was very enthusiastic, and the result showed me the potential of the system, although the desired result was not met.

March 1993. See ISCM, 1993.

As I already mentioned, making a useful score that allowed me to write clearly and with precision was one of the first problems I encountered. Figure 13.6 is a fragment of the score of this performance:

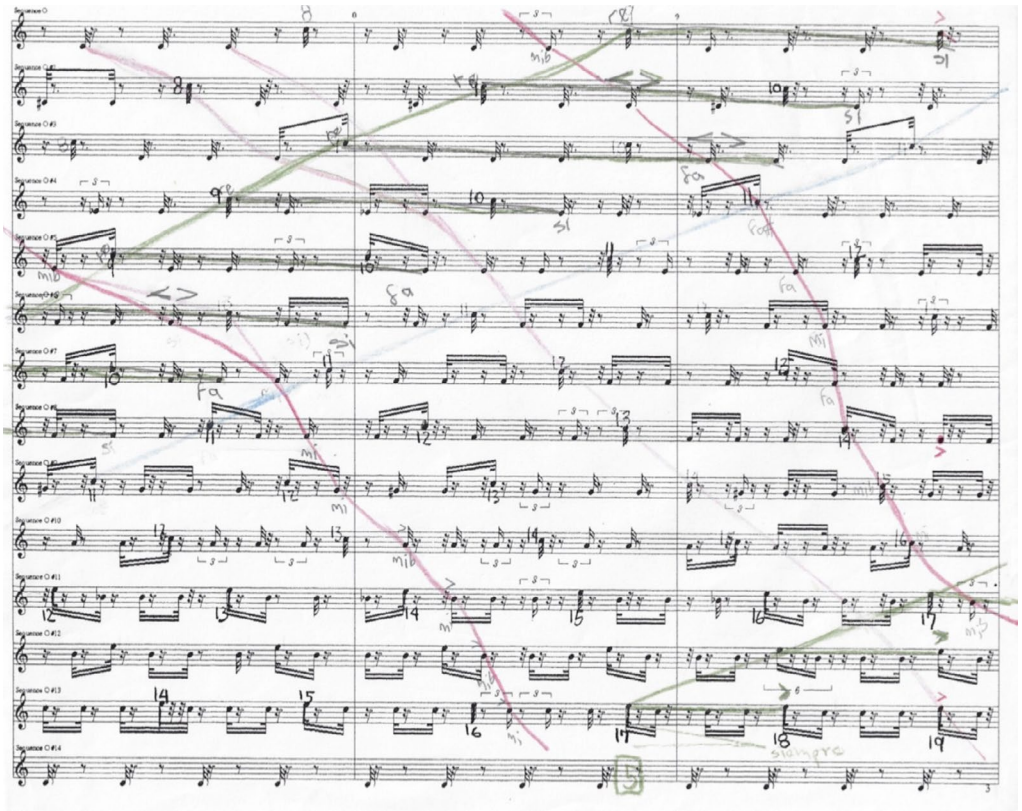

Fig. 13.6 Rodríguez Lara, guide notation for *Atecocoli 1998*.

This score is the conversion to notation of the MIDI events page. It was made in the Studio Vision sequencer. As can be observed, there is a lot of information concerning the pulses of each sequence—which is the graphic representation of the *multi-tempi*, but it hinders the visual organization of the score, even for something as elementary as writing the notes and duration of each event. I decided to trace with colored lines the trajectories chosen among all the pulses. This was a very rudimentary and inefficient technique, but it worked nonetheless and led me to the next step.

In the year 2000 I had the opportunity to explore the techniques required to achieve a score format that would allow for greater control of the notational elements: pitches, durations, dynamics, accentuation... practically every element of a "normal" score. With a series of strategies, I achieved a score format that graphically reflected the sequences of sound events in time. The first step in this process was the temporal organization of the sound events while this sequence of events is also planned as trajectories of displacement in space through the fixed sources.

For this new version, *Atecocoli 2000*, I could edit the sequence of events from Studio Vision to Finale, and in this score editor it was easier to remove all the elements that were not essential without losing the graphic placement of each event in the score.

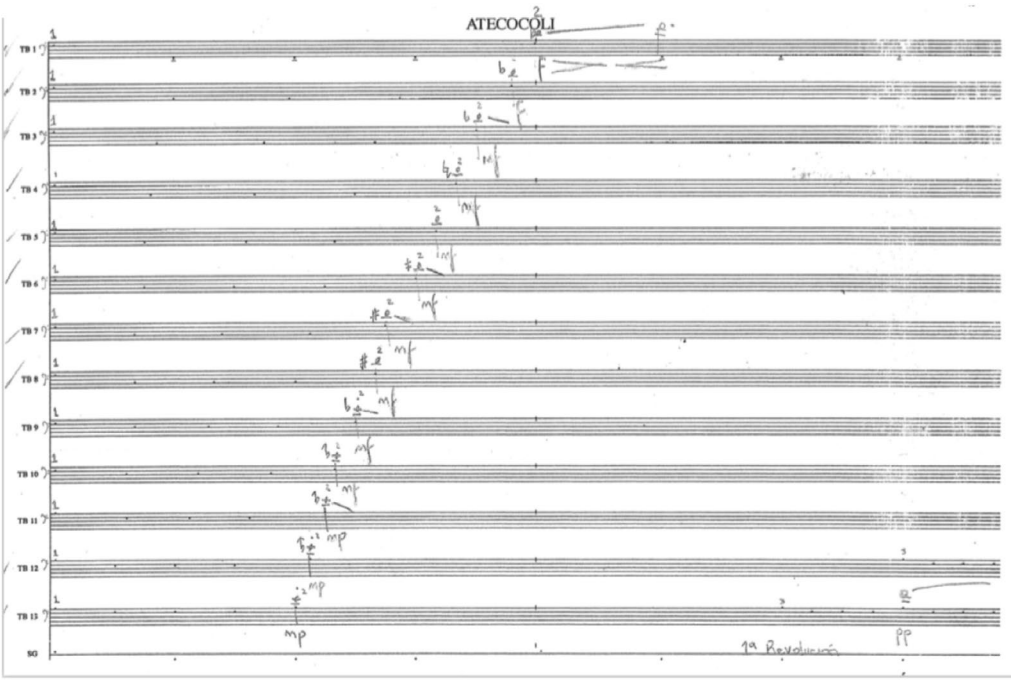

Fig. 13.7 Rodríguez Lara, score of *Atecocoli 2000*.

Techniques for Synchronizing Sound Vectors in Physical Space

For *Atecocoli 2000* I used three synchronization techniques which I explain below.

Multi-tempi

The *multi-tempi* that I had explored in *Atecocoli 1998* seemed to me like a relatively rigid grid to organize the pulses if followed for a certain time. I therefore used it only in small fragments, one of which is shown in Figure 13.8.

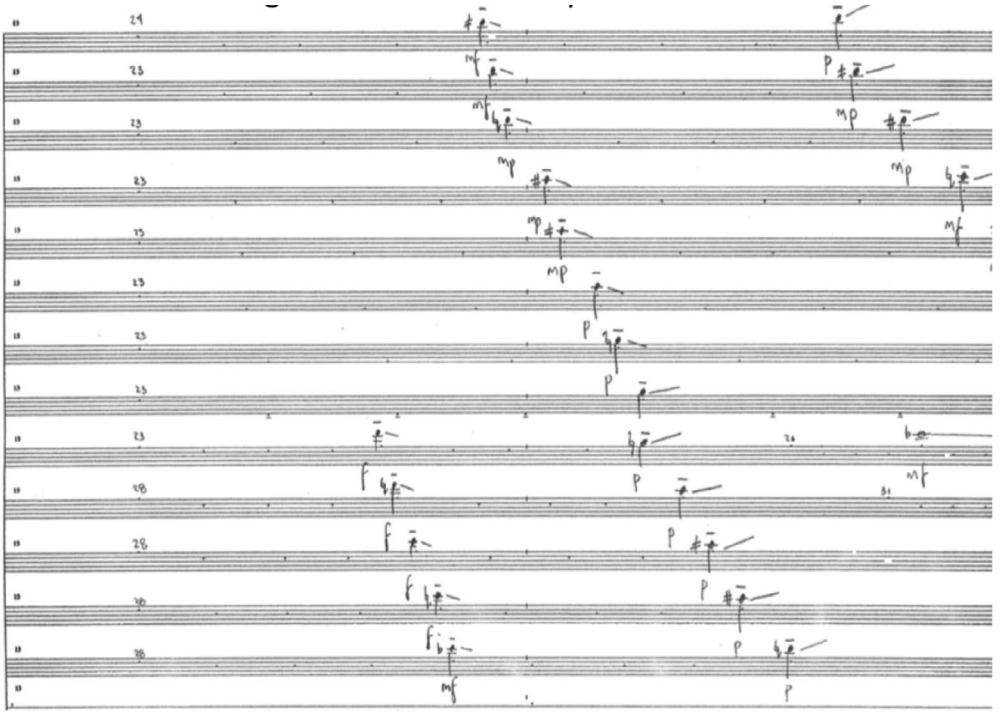

Fig. 13.8 Rodríguez Lara, *Atecocoli 1998*. Fragment in *multi-tempi*: each point of the score corresponds to a sound signal and is distributed independently on each channel. In total, there are thirteen simultaneous channels.

Anacruses

This is another very efficient synchronization technique. It consists of leaving each performer's track unpulsed until a four-pulse anacrusis indicates, both on the performer's *particella* and on the pulse recording, the time at which a particular event is to be played. This saves performers from having to count a sometimes-considerable number of silent beats before playing the next event, and allows greater flexibility in the placement of events not predetermined by a *multi-tempi* sequence:

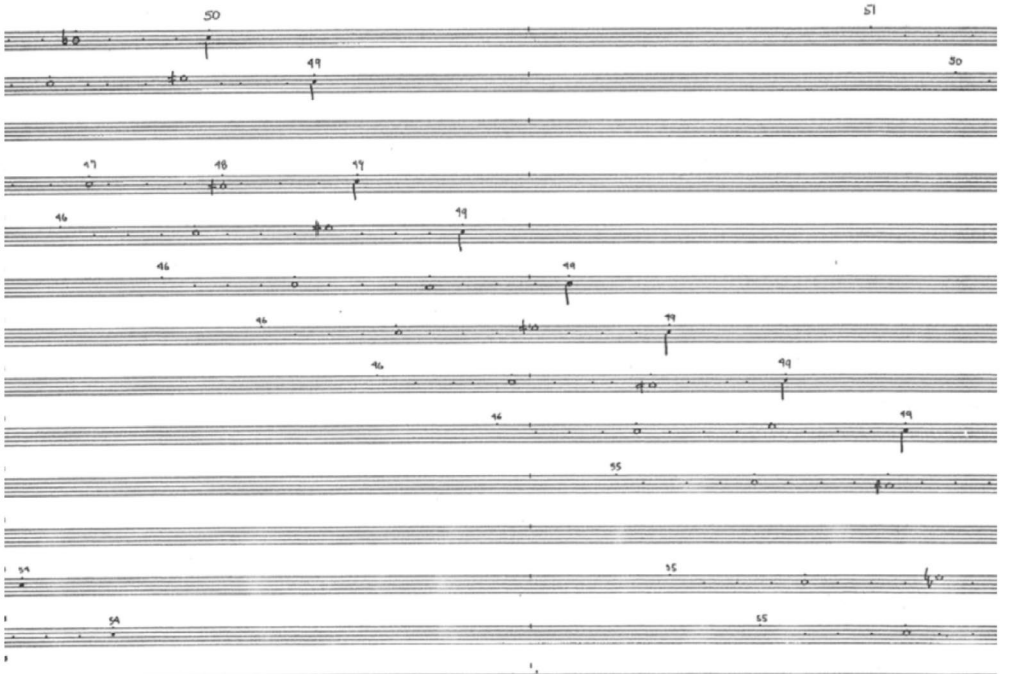

Fig. 13.9 Rodríguez Lara, *Atecocoli 2000*. Anacruses technique. Note that only when a performer is going to play a sound event, he or she prepares with a four-pulse anacrusis. There is silence from one anacrusis to the next.

Fine Phase Shift

Finally, another synchronization technique was the fine phase shifting of the same speed sequence. Towards the end of this version of *Atecocoli*, as a dense section, I used this technique. The offset shown is $1/13^{th}$ of a second:

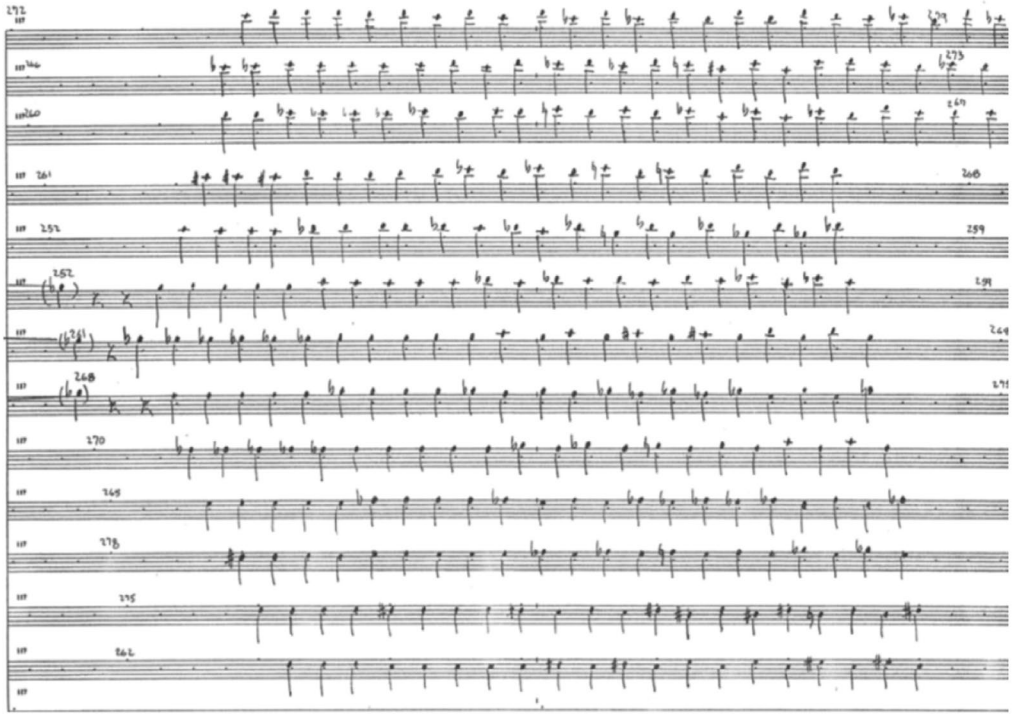

Fig. 13.10 Rodríguez Lara, *Atecocoli 2000*. Fine phase shift technique: a single constant speed sequence is shifted by 1/13th of a second.

Another piece composed in the same year and with similar techniques is *Saxteto* for saxophone sextet. The beginning is shown in Figure 13.11 below:

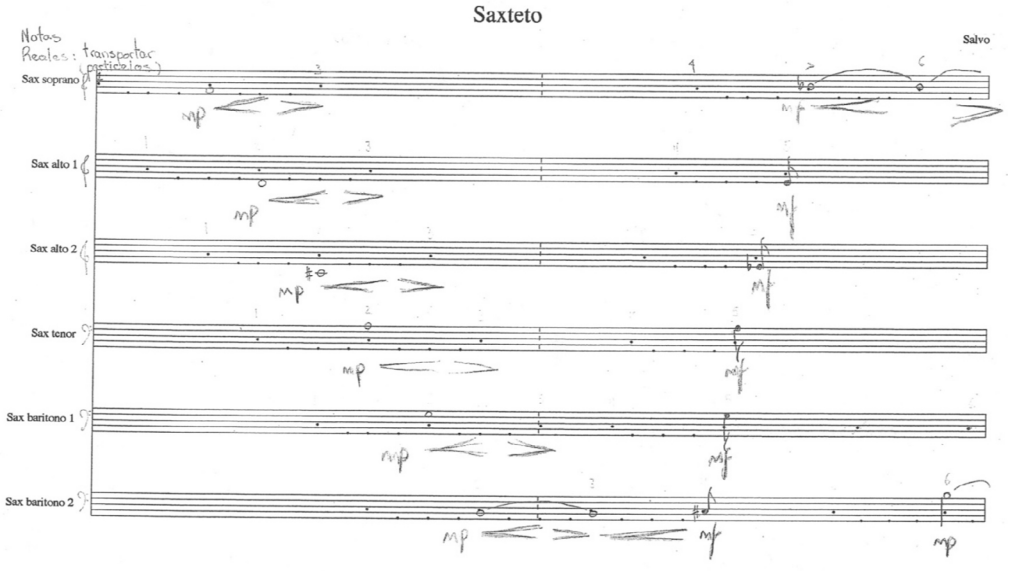

Fig. 13.11 Rodríguez Lara, *Saxteto* for saxophone sextet (fragment).

With these pieces, I was able to explore the behavior of more defined trajectories than in *Atecocoli 1998*. I believe the trajectory of sound vectors in physical space can be modeled by exploring their expressive possibilities more deeply towards a variety and a quality somewhat similar to the rhythmic-melodic and polyphonic elaboration carried out by composers of very different periods and styles, and interacting simultaneously with all the other factors of production of the sound event.

Other Compositional Possibilities with the Sound Vector Technique in Physical Space

Three possibilities that I find interesting to explore with this technique are the following: modeling of resonances, which reconstructs echoes of specific physical spaces; the atomization of texts, which is applicable to poetry texts or vocal sonorities; and the projection in physical space of sound vectors with the temporal proportions of harmonic sounds.

Modeling of Resonances

Using the technique of sound vectors in physical space, it is possible to configure, to a certain extent, the resonance patterns (behavior of the echoes) of a sound in a particular space from the articulation pattern of the sound and its decay time. This resonance is characteristic of certain locations, and can be projected into another space (container space) with its own resonance patterns reconstructed through the sound vectors in the physical space. The result of the interaction between the resonance of the reconstructed space and the resonance of the container space could be considered a virtual multi-space, as if the container space contained, at the same time, the acoustic characteristics of other spaces.

For now, I will only discuss the configuration of resonant echoes, which have a characteristic temporal pattern of articulation and a characteristic *decrescendo*. It is also possible to keep the echoes at a single point (with one source) or to shift the emission of the echoes, as if the echoes were "bouncing" in space or moving linearly in various directions. Echoes can be treated as sound vectors in physical space. It is even possible to model echoes in the opposite direction: anti-echoes whose resonance is presented in crescendo and ends with the "real" sound, although this is a very artificial contour.

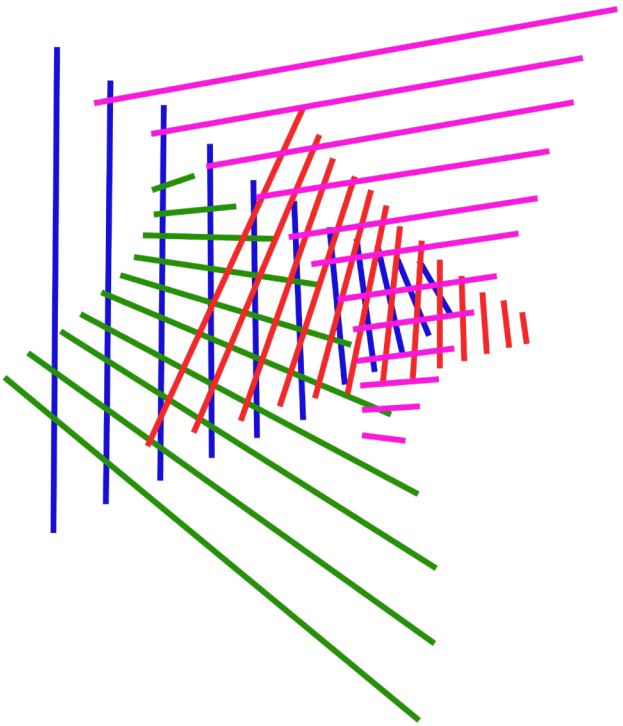

Fig. 13.12 Graphic representation of a virtual multi-space. Figure created by author (2022).

Atomization of Texts and Sound Poetry

In the genre of sound poetry, it is possible to project texts on a given space with the technique I call "atomization." This technique consists of assigning a word, a syllable, or even a letter of a word, whether vowel or consonant, to different sources-interpreters placed in different spots. In the sonority of the vowels, as in traditional music, it is possible to assign notes, durations, intensities, and some variations of the timbre. It is also possible to configure melismas as sound vectors in physical space.

In order to accomplish this, I classify the sonority of the usual consonants in Mexican Spanish by their articulation, their capacity to extend their duration, and their sonorous quality as follows: 1) short, explosive consonants that cannot extend their duration are [c (k, q)], [p], and [t]; 2) friction consonants, with air noise that can extend their duration are [f], [j (x)], and [s (z)]; and finally, 3) the consonants that can extend their duration are [b (w)], [d], [g], [l], [ll], [y], [m], [n], [ñ], and [r] (*frullato*). In consonants that can extend their duration there are a considerable number of timbre and color possibilities when varying the frequency.

Atomization is then the process of fragmentation of the sonority of a word or phoneme, according to these principles, and modeled as described above so as to enrich its expressive character.

Projection in Physical Space of Sound Vectors with Temporal Proportions of Harmonic Sounds

In his famous text *New Musical Resources*, [4] Henry Cowell (1897–1965) proposes the use of rhythmic values derived from the proportions of harmonic sounds, so that one can hear, as durations in time, values in the same proportions that present certain harmonics in the frequencies of the sound:

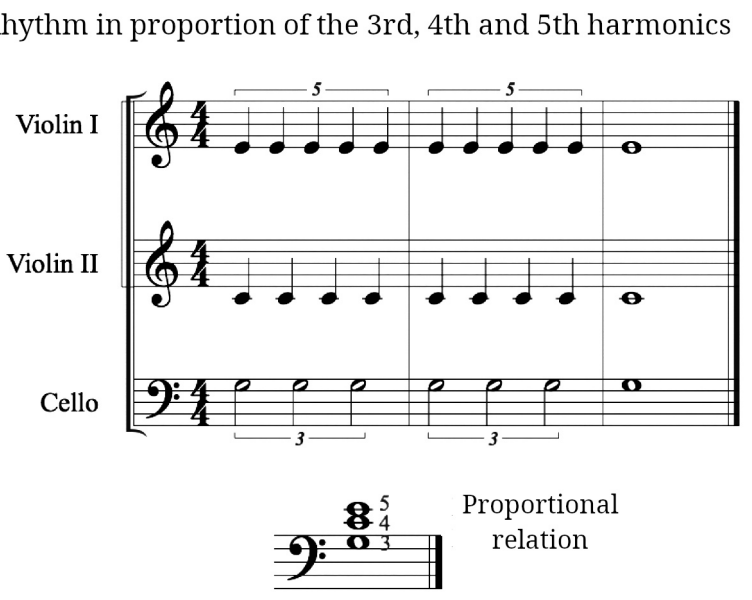

Fig. 13.13 Relationship based on Henry Cowell's proposal between rations of natural harmonics and rhythmic durations. Figure created by author (2022).

Harmonics are phenomena that occur naturally in the acoustic space, and they have a very precise proportional order. And, as Cowell proposed, using a projection of the proportions in the frequency of the harmonics onto the temporal durations of rhythmic-melodic sequences, sound vectors can also be projected onto physical space based on the same proportions:

4 Cowell, 1930, p. 52.

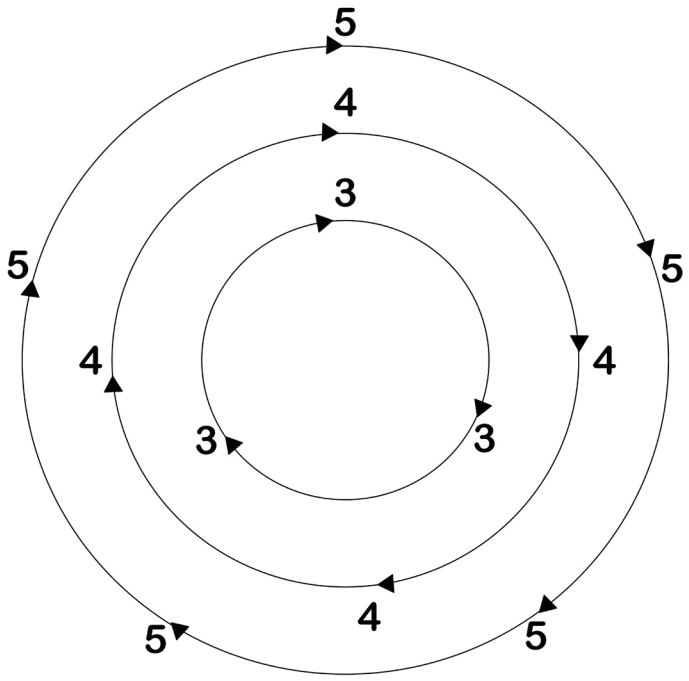

Fig. 13.14 Distribution of sound vectors in physical space: circular trajectories with the same proportion of the 3rd, 4th, and 5th harmonics. Figure created by author (2022).

Examples of sound vectors over wide physical spaces can be found among the following compositions, all from the second half of the twentieth century: Karlheinz Stockhausen's (1928–2007) *Gruppen* (1955–7); Xenakis's *Terretektorh* (1965–6), *Nomos Gamma* (1967–8), and *Persephassa* (1969); Julio Estrada's (b. 1943) *Canto Naciente* and *Eolo'oolin* (1981); Llorenç Barber's (b. 1948) *Vaniloquio Campanero* (1993); and *Saxteto* and *Atecocoli* (2000), aforementioned compositions of my own.

Displacement of Events between Time and Physical Space

Now we will explore the difference between speed considered as the number of events in time, and the speed of the displacement in physical space of an event, a difference that is more evident if that event is an articulated sound. Consider a short event that does not move in acoustic space and occurs every second, for example, a clap. Eight performers are placed in space in a defined path, either curved or straight. If an event is assigned to each performer consecutively, then a displacement in time equivalent to the movement in physical space is heard, as shown in Figure 13.15.

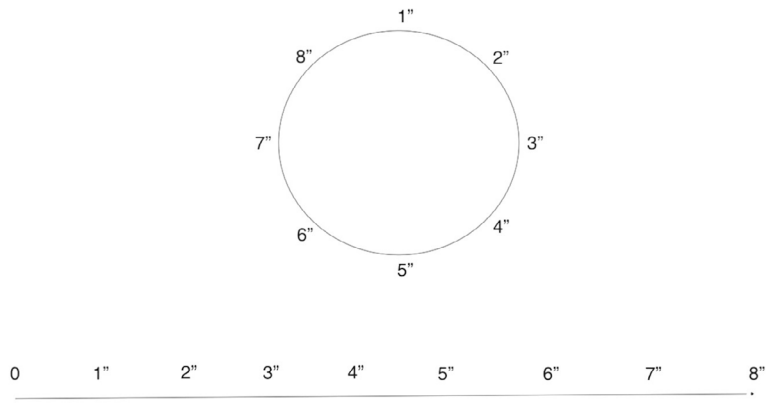

Fig. 13.15 Example of movement in time and in physical space. This event moves in different trajectories in physical space through time in a constant pulse of one second. Figure created by author (2022).

Now, we will think of a faster repetition of the event, such as a tremolo on a percussion instrument, and let us consider each stroke of the tremolo as an event. If a certain number of repetitions of the event are assigned to each performer, the speed with which the event moves in physical space will be slower that the speed regarded as the number of events per time unit. It is even possible to create a counterpoint between these factors: a sound event that presents an acceleration in time and a deceleration in physical space, or that maintains the speed of the event in time and accelerates its displacement in physical space, as we will see below in *Persephassa* by Xenakis. This is only one among many other possibilities of interaction.

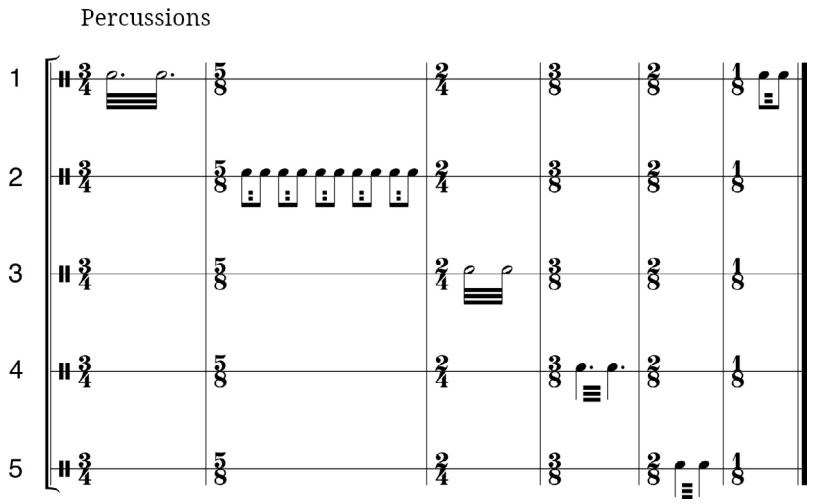

Fig. 13.16 Example of a tremolo moving in physical space accelerating between five performers. The duration of the notes of each performer is shortened and the spatial motion is accelerated, but the speed of the tremolo remains constant. Figure created by author (2022).

Persephassa

Xenakis's *Persephassa* for six percussionists placed at homogeneous distances around the audience (Figure 13.17) features several passages that, in my opinion, would fall into this category; especially the final section of the piece which features a series of tremolos distributed among the instruments of the six percussionists in order to give the impression of accelerating rotations.

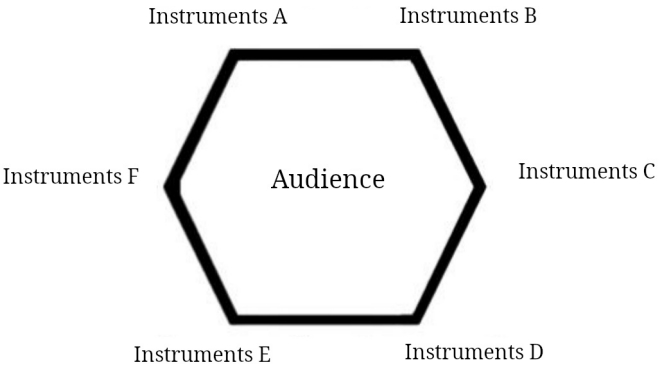

Fig. 13.17 Xenakis, *Persephassa* (1969): distribution of the performers around the audience.[5] Figure created by author (2022).

For this analysis, as I already mentioned, it is necessary to consider that one sound event is one stroke that is part of the tremolo and not each notated value that may contain a certain number of repetitions for its duration. If the notation gradually shortens the duration of the notes played in the tremolo, or if the pulse is accelerated, an acceleration of the rotational movement of the impulses will be perceived, but the speed of the tremolo will remain constant. In other words, each event (tremolo) occurs at a constant speed in time and with a high value extending over the duration of each note; these notes will gradually shorten their duration and thus move more quickly in physical space.

As Maria Anna Harley describes it:

> The climax of *Persephassa* (mm. 352–455) begins with a slowly rotating tremolo on the drums (four tom-toms and two snare drums) to which other timbrally distinct layers are gradually added, thus increasing the density of the texture [...]. The superimposed cycles of rotations are performed on metal simantras (from m. 354), cymbals (from m. 357), Thai gongs (from m. 361), wooden simantras (from m. 369), tam-tams (from m. 381), and woodblocks (from m. 395). The seven layers alternate in direction and differ in their starting points.[6]

Simantras are metal or wooden instruments, ancient in origin, but designed in reconstruction by Xenakis. Harley also writes:

5 Diagram based on Fig. 11 in Harley, 1994, p. 306.
6 Ibid, p. 307

> The seven layers of tremolos move 8 times faster at the end of their cycle of rotations than at the beginning, while the following solitary cycle of drum tremolos revolves 12 times faster than the same drums at the beginning. In *Terretektorh*, accelerations were constructed as segments of spirals; here, a large-scale temporal spiral is built from many individual 'circles' of increasing tempi.[7]

These cycles, which are distinguished by the timbre of each tremolo, are sound vectors: impulses with speed and direction, distributed in six zones of space. But again, the speed of each temporal event—each stroke of the tremolo—remains constant over time, while the displacement in physical space produced by the duration of the notes is shorter and shorter, and this is what causes an acceleration.

I also notice a very interesting effect on the physical space: due to the speed at which the notes move, it seems that there is less distance between the sources. In their spatial arrangement, the performers occupy what would correspond to a whole-tone scale in the acoustic space: six places dividing a circle of certain dimensions into homogenous distances. But the number of events per second gives the impression of greater proximity, as if there were a shorter space between them.

This phenomenon seems to me to be similar to a *glissando* on the piano or the harp (Figure 13.18). In this case, the impulse generated by pressing the keys, upwards or downwards, is so fast that the ear does not have time to process each sound produced individually and perceives a sound mass that moves with a certain speed and direction, as if the whole frequency field were being traversed in a continuous *glissando*. What actually happens is that it only travels through the white key scale or even the black key pentatonic scale with great speed. Again, the speed of succession of events gives the impression that the distance between sources, in acoustic and physical space, is shorter.

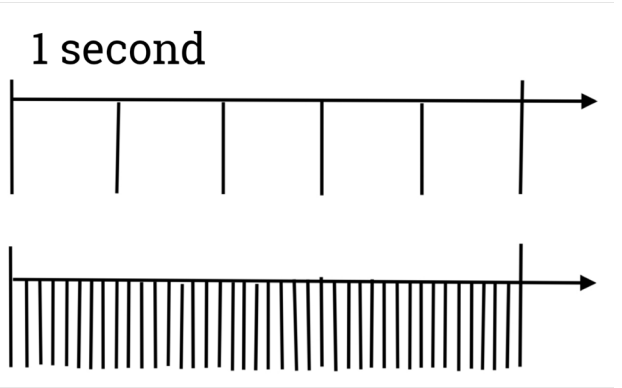

Fig. 13.18 Graphic representation of the effect of cancellation of the acoustic or physical space in a very fast presentation of events in one second. There is a tendency to perceive a certain continuity of the impulse. Figure created by author (2022).

7 Ibid., p. 307–8.

Another very remarkable example of this phenomenon can be found in the final section of Nancarrow's *Etude 21, Canon X* (1960), in which the transition of 110 events per second over the area of the strings of the player piano produces the impression of a turbulent, oscillatory cloud in physical space of the instrument. The intensity is increased by the number of attacks per second, and the sequence of pitches is also transformed into a timbre (in acoustic space). It is important to notice that in these cases, despite the speed, the Doppler effect does not occur because the sound sources themselves are not moving.

Conclusions

I consider rhythmic-melodic movement to be a sound vector in acoustic space, that is, a sound impulse with speed and direction. In acoustic instruments that are constructed with fixed sound producers, be they strings, wooden or metal keys, and ordered from the lowest to the highest pitch in a single direction, the rhythmic-melodic impulses will produce sound vectors in acoustic space and also in physical space, even if this space is reduced to the size of the instrument. With technological resources, it is possible to apply a similar projection of sound vectors, but over much larger and more varied physical spaces.

There are pieces by twentieth-century composers who have handled sound vectors in physical spaces of specific dimensions and conditions. Some of these vectors are carefully calculated, as in Stockhausen's, Xenakis's, and Estrada's works, and in my own works. Other vectors have a margin of limited uncertainty, as in Barber's works for city bell towers.

I consider the projection of sound vectors in a physical space as a certain extension of what occurs in the acoustic instruments here described. But, as Nancarrow achieved a control of very complex rhythmic events in his studies for player piano, many of them impossible for humans to execute directly, the techniques I propose allow for the management of temporal resources and their projection as sound vectors in physical space. These resources cannot be realized with other media, but they have a great expressive potential.

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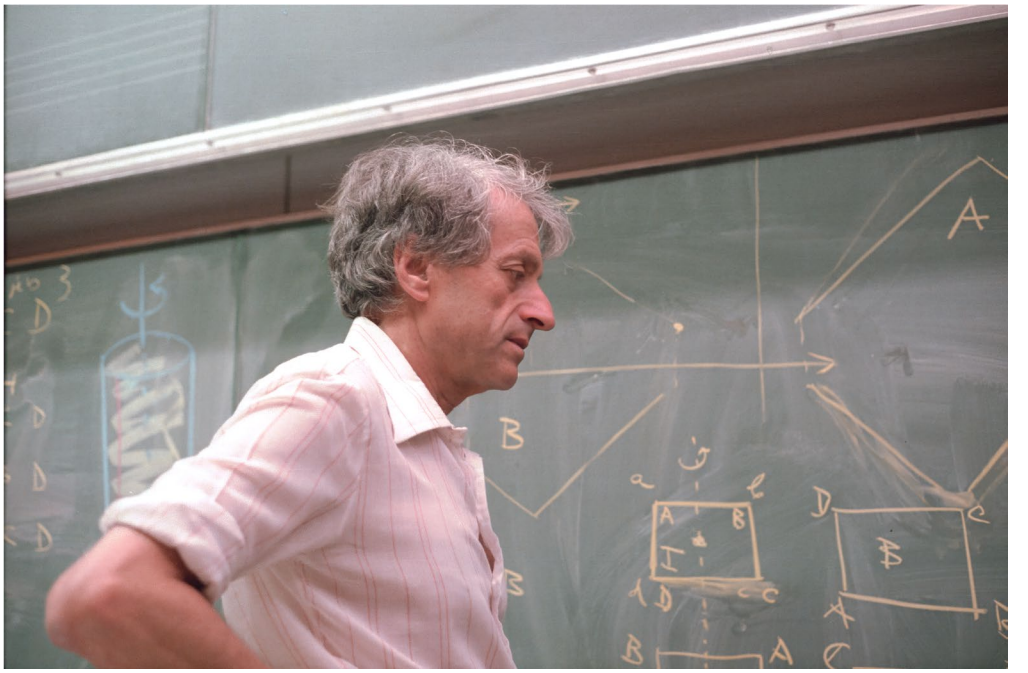
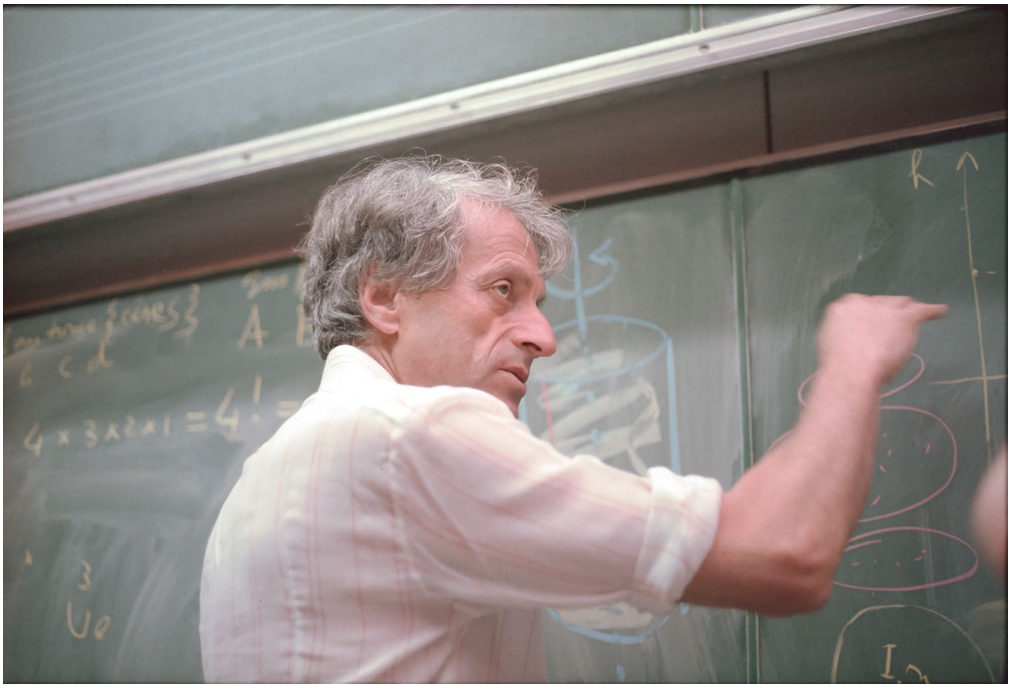
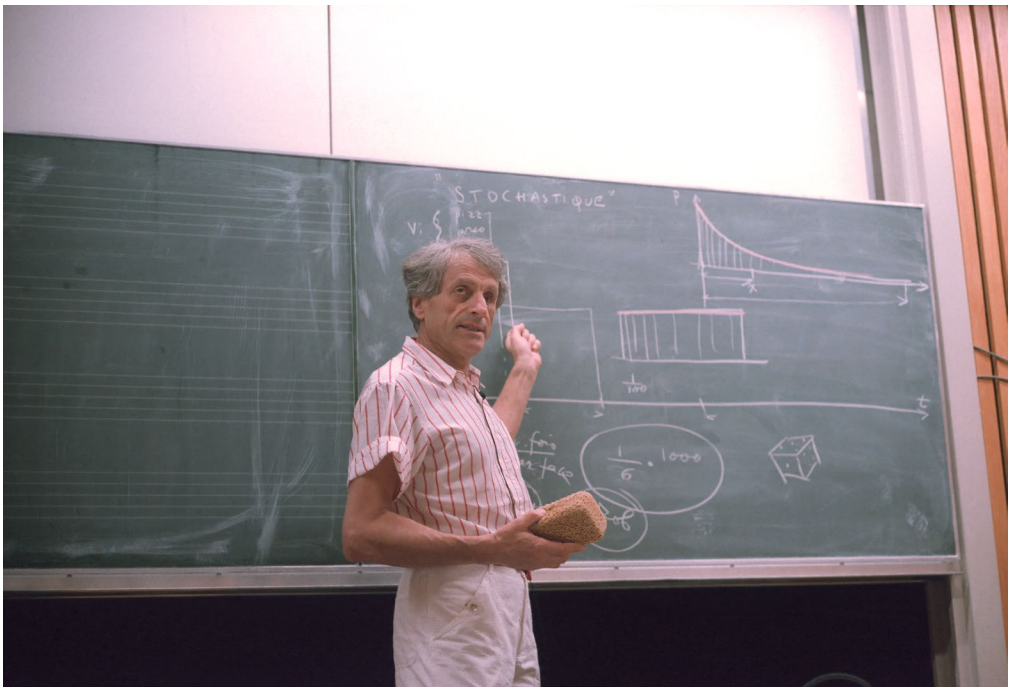
NEW PERSPECTIVES ON XENAKIS'S WORKS







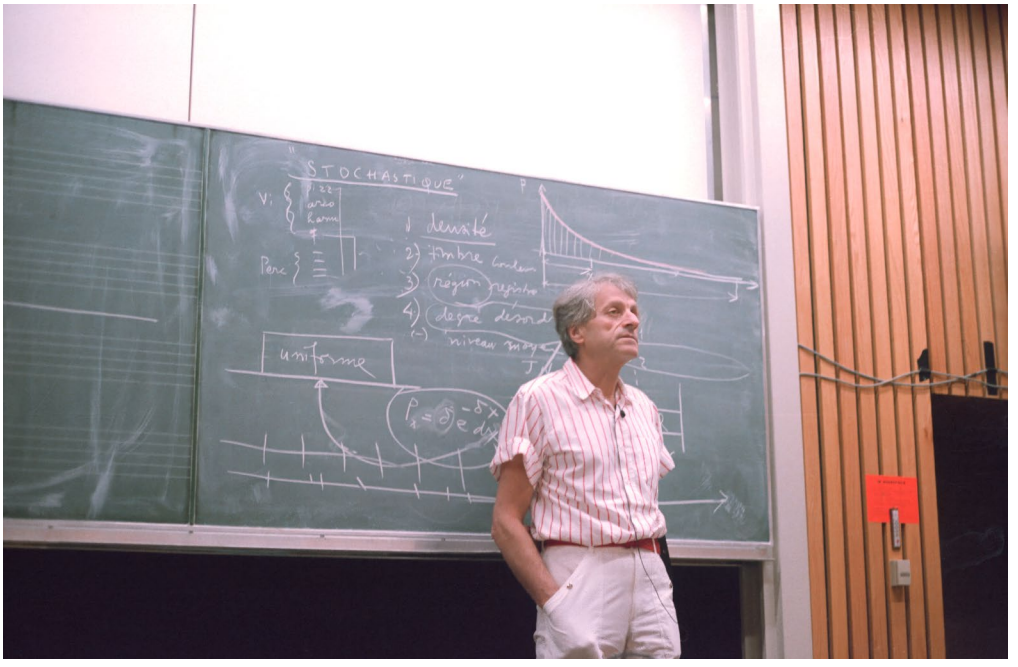


Plate 6 Iannis Xenakis, Centre Acanthes, 1985 Salzburg Mozarteum, during extended six-week course on his music, during the first European Music Year. Photos by Henning Lohner, courtesy of CIX Archives, Lohner collection.

14. The CIX Archives: Revalorizations and Hidden Treasures

Cyrille Delhaye

The work conducted on the conservation and valorization of the archives of the Centre Iannis Xenakis (CIX) since 2010 shows that the main collection includes all the archival documents of the association Les Ateliers UPIC (renamed the Centre de Création Musicale Iannis Xenakis (CCMIX) in 2000, before being renamed CIX in 2009).[1] This association, founded by Iannis Xenakis in 1985, aimed to promote the UPIC, a machine for aiding composition through drawing, invented in 1977 at Xenakis's research center, the Centre d'études de mathématique et automatique musicales (CEMAMu), through a whole series of pedagogical actions, composition workshops, and concerts throughout the world. Among the traces left by composers who came to Paris to compose on UPIC, a folder constituted by Iannis Xenakis for *Taurhiphanie* (1987) catches one's attention: it regroups compositional materials, UPIC pages, contextual archives, photographs of the first performance, etc. These documents highlight some aspects of the genesis of this polymorphic work, created in the Arles Arena (France) in 1987 for a real-time UPIC, percussion ensemble, horses, and bulls.

After presenting an update on the work in progress for the conservation and valorization of the CIX collections since 2010, we will dive into the depth of the collection by analyzing and contextualizing the traces left by Xenakis when composing *Taurhiphanie*.

What Is UPIC?

In the 1950s, Iannis Xenakis had the intuition to develop a machine that would allow him to free himself from the limitations of traditional musical notation, while simplifying the exploration of this new way of composing: in his mind, this instrument would facilitate, for example, the graphic and sonic transcription of the *glissandi* in his 1954 work *Metastasis*. But it was only in 1977 that the prototype of a machine

1 *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org

 https://doi.org/10.11647/OBP.0390.16

hybridizing drawing, sound synthesis, and music was born in his research center the CEMAMu: it was named UPIC (Unité Polyagogique Informatique du CEMAMu), a name that evokes the double vocation of this machine to be both for composition and for pedagogy. In its first version, the UPIC consisted of a large graphic table, a magnetic pen, and a sound signal calculation interface. It allowed the composer to conceive all the elements of a musical work visually, from the micro to the macro form, by hybridizing within a single system its formal conception, waveforms, and sound synthesis.

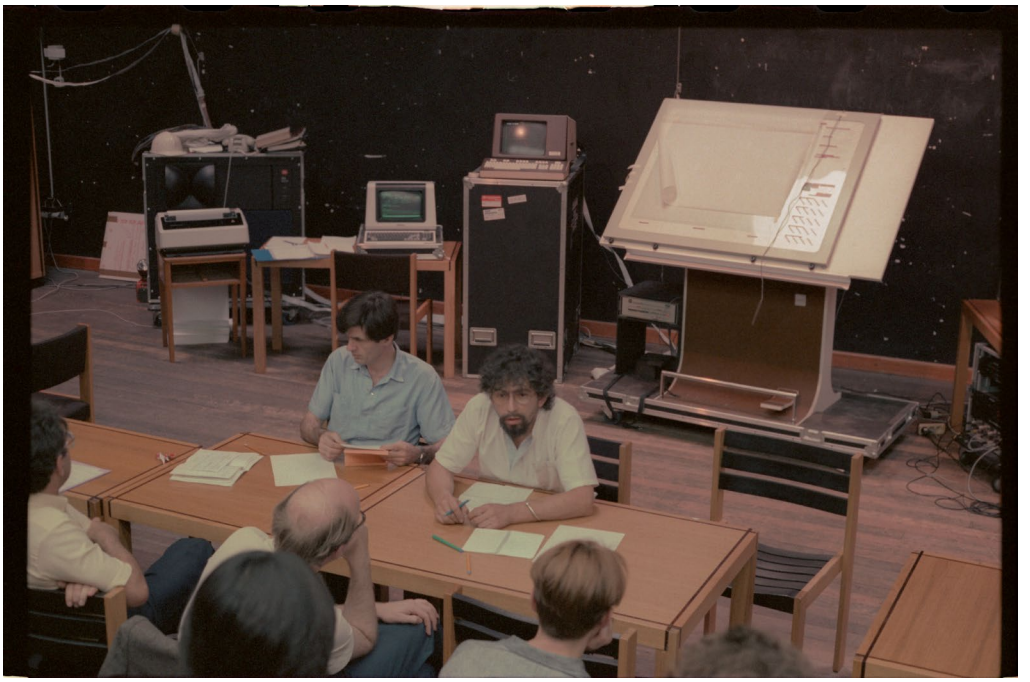


Fig. 14.1 Photo of a UPIC Workshop in Aix-en Provence, France (1985), with, at the desk in front of the UPIC set-up, composer Pierre Bernard (left) and director of Les Ateliers UPIC Alain Després (right). Photo by Henning Lohner. Archives of the Centre Iannis Xenakis, Lohner collection.

The archives of the Centre Iannis Xenakis reveal the traces left by circa 130 composers who worked at Les Ateliers UPIC/CCMIX between 1985 and 2009. For example, we find traces of work on the UPIC by François-Bernard Mâche (b. 1935), Luc Ferrari (1929–2005), La Monte Young (b. 1935), Brigitte Robindoré (b. 1962), Julio Estrada (b. 1943), Jean-Claude Risset (1938–2016), Roger Reynolds (b. 1934), Curtis Roads (b. 1951), Daniel Teruggi (b. 1952), and many others. In addition, the innumerable educational activities carried out in France and abroad by the association around UPIC are also reflected in this rich, unpublished, and very heterogeneous collection of documents.

The CIX Collections

The main collection of the CIX embraces more than twenty-five years of research and creation around UPIC. The fifty linear meters of archives deposited at the Service Commun de la Documentation of the Université de Rouen Normandie (University library) are composed of manuscripts, drawings, scores, tapes, records, DATs, books, press, correspondence, etc. It is a collection that is certainly small and specialized, but which synthesizes the general problems related to the management of contemporary music archives. From this point of view, this collection is particularly interesting to study, for the following reasons:

- Heterogeneity of data and multimedia supports: magnetic tape, DAT, QIC cartridges, burned CD, etc.
- Variety of printed materials: large posters, scientific and scholarly literature (including grey literature), equipment manuals, flip charts from summer sessions around UPIC, manuscripts, typescripts on onionskin paper, etc.
- Unpublished musical recordings, some anonymous.
- A very diverse collection of scores: manuscripts, copies, many resulting from the calls for composition competitions and workshops organized by the association, as well as several UPIC scores (on fax paper).
- Obsolete software used by composers.
- All the problems related to the rights of use of these materials.

Furthermore, this collection regularly benefits from bequests from collaborators, dedicatees, and other friends of Iannis Xenakis. Robert Dupuy (1945–2018), engineer and close collaborator of Xenakis, for example, entrusted three linear meters of his personal archives related to the first *Polytope of Cluny* (1971–72), the first event in Europe where lasers were introduced. These documents can now open the way to an authentically informed *reinterpretation* of this great "music and light work" initially presented in the medieval thermal baths in Paris (*les Thermes de Cluny*). Documents include the original source code, scores, photos, correspondence between Dupuy and Xenakis, and various suppliers, etc. This collection was recently processed by Daniel Teige, another founding member of the CIX, as part of a joint research residency between our university and the Hochschule für Kunst in Bremen. Teige will curate both a "hard copy" and a virtual exhibit from this extraordinary bequest in the near future.

New Archival Holdings[2]

Other new archives have been added to the initial collection and are waiting to be processed so they can all be utilized:

- Henning Lohner (b. 1961), a former student of Xenakis. This collection includes numerous photos of Xenakis in all sorts of situations (personal, in rehearsal, giving lectures throughout Europe), and with other composers such as John Cage (1912–92), Frank Zappa (1940–93), Pierre Boulez (1925–2016). It contains over a thousand photographs and six hours of film in all (see Figure 14.1 as well as throughout this volume, including the cover).
- Marie-Hélène Serra (b. 1960), a former collaborator of Xenakis at CEMAMu. This is an important collection estimated at about five linear meters, including boxes of working notes, articles, and documentation related to her years at CEMAMu, where she mainly worked on the GENDYN program (a dynamic stochastic approach to waveform synthesis).
- Bruno Rastoin (1954–2020), visual artist and scenographer, and collaborator with Xenakis on the *Diatope*, a work created in 1978 on the public square of the Centre Georges-Pompidou in Paris. Most of this collection has been digitized and cataloged. It consists of numerous photos of the *Diatope*—another polytope, like the *Polytope of Cluny* mentioned above—but one where Xenakis also designed the architecture. Its presentation in both Paris and Bonn, its construction and dismantling, and the light show itself are documented.

Actions for Revalorizing the Rastoin Collection

In 2022, as part of the Meta-Xenakis centenary events, a group of musicology students from the Université de Rouen Normandie (Master's Research cursus) immersed themselves in the CIX archives to create an exhibition that shows the genesis of the *Diatope* through photographs and unpublished documents at Bruno Rastoin's bequest.[3] The exhibition was inaugurated on 22 April 2022 at the Maison de l'Université (MDU, or campus student center) in Rouen, and a virtual rendering will soon be published on CIX's website.

2 This report on the current state of the archive is based on a paper given by the author with Sharon Kanach at the International Association of Music Libraries (IAML) congress in Prague in 2022. See Delhaye and Kanach, 2022.

3 "Video Presentation of the Exhibition: Xenakis's Diatope: A Visual Artist's Perspective by Bruno Rastoin" (2022), *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/items/show/4982

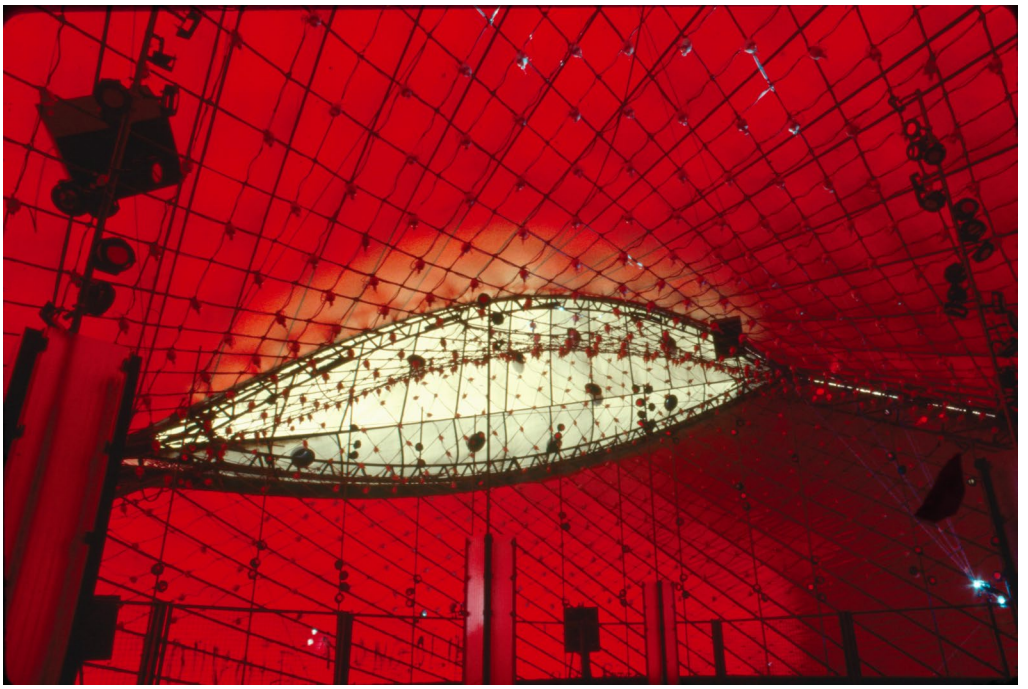


Fig. 14.2 Iannis Xenakis's *Diatope*, interior view. Photo by Bruno Rastoin (1978). Archives of the Centre Iannis Xenakis, Rastoin collection.

The CIX Website

Since 2012, the CIX has also launched a website using Omeka, a free and opensource content management system (CMS), which exposes a part of the fifty linear meters of its physical (and partially digitized) archives and their associated metadata in the Dublin Core format.[4] Even if Dublin Core does not have a fine granularity of data description, this set of metadata guarantees maximum interoperability from one system to another, and requires limited library and technical knowledge. In addition, Omeka allows the possibility of many custom fields in a second metadata set. Concerning the CIX archives, in the current state, the 3,500 records of the FileMaker inventory are in the CMS. Approximately 2,500 records are available in public mode; the general inventory of the CIX archives ("mother collection") is available as a downloadable PDF file.[5]

4 *Omeka*, https://omeka.org/

5 "Inventaire des archives," *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/inventaire_archives

KSYME and CIX

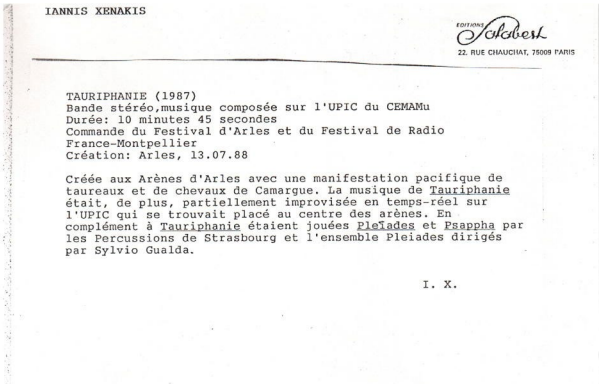
Since January 2015, CIX and KSYME/CRCM (Contemporary Music Research Center), housed at the Athens Conservatoire, have a project to create a joint library of their respective digitized archives in connection with Xenakis and/or UPIC. The KSYME/CRCM was founded in 1979 in Athens by Iannis Xenakis, John G. Papaioannou (1915–2000), and Stephanos Vassiliadis (1933–2004). The KSYME acquired a UPIC in 1986. The KSYME originally worked in the same way as the historical Ateliers UPIC/CCMIX did in Paris: running educational programs for children and the general public, and courses in music composition organized around the UPIC. In order to create this common digital library, an open archive repository (based on the OAI-PMH protocol) will be set up between our two Omeka instances: it will allow users to perform federated searches on the archival collections of both centers in a transparent way. CIX already uses the OAI-PMH protocol to disseminate archives to other research centers: the CIX archives were, for example, harvested by the Contemporary Music Portal from 2014 and more recently by Isidore, the federated search engine for Humanities data in France.[6] This work on a common digital library is in progress: KSYME has already started to digitize some of its archives and is exposing them on an Omeka instance.

Focus on *Taurhiphanie*

Let us now dive into the heart of the matter to discover the traces left by Xenakis himself around the genesis of a work: *Taurhiphanie*.

Taurhiphanie was first performed on 13 July 1987, in the Arles Arena following a commission from the Festival d'Arles and the Festival Radiophonique France-Montpellier. This work—composed by Xenakis on the UPIC—is written for a two-track stereo tape, lasting ten minutes and forty-five seconds. This work has the particularity of involving a group of bulls that influence the course of the show during its creation in the arena of Arles. According to this typescript from the CIX archives (Figure 14.3), the premiere of *Taurhiphanie* was programmed with two other works by Xenakis: *Pléïades* (1978) and *Psappha* (1975), performed by the Pleiades Ensemble directed by Sylvio Gualda (b. 1939).

6 *Isidore*, https://isidore.science/source/10670/2.ofsr4v



IANNIS XENAKIS

éditions Salabert
22, RUE CHAUCHAT, 75009 PARIS

TAURIPHANIE (1987)
Bande stéréo,musique composée sur l'UPIC du CEMAMu
Durée: 10 minutes 45 secondes
Commande du Festival d'Arles et du Festival de Radio France-Montpellier
Création: Arles, 13.07.88

Créée aux Arènes d'Arles avec une manifestation pacifique de taureaux et de chevaux de Camargue. La musique de Tauriphanie était, de plus, partiellement improvisée en temps-réel sur l'UPIC qui se trouvait placé au centre des arènes. En complément à Tauriphanie étaient jouées Pleïades et Psappha par les Percussions de Strasbourg et l'ensemble Pleiades dirigés par Sylvio Gualda.

I. X.

Fig. 14.3 Program note for *Taurhiphanie* by Iannis Xenakis (ca. 1987). Université de Rouen Normandie, CIX Archives, CIX 43, typescript.

As Xenakis pointed out to Bálint András Varga (1941–2019) in 1989, *Taurhiphanie* is a neologism he coined from tauros (bull), hippos (horse), and epiphany (apparition).[7] Ramón del Buey Cañas and Oswaldo Emiddio Vasquez Hadjilyra, in Chapter 8 of this volume, develop the foundations of these semantic associations and how they shed light on Xenakis's creative processes, particularly for *Taurhiphanie*. Also noteworthy is the work of Pierre Couprie, who in 2020 compiled an inventory of primary sources available for *Taurhiphanie* for the purpose of musical analysis.[8]

Taurhiphanie and "Live Elements"

As Maurice Fleuret (1932–90) pointed out, beginning with his *Polytope de Persépolis* (1971), Xenakis frequently introduced live elements in the conception of his *Polytopes*.[9] Furthermore, in an interview, Xenakis recalled the creation of *Taurhiphanie* by stating:

> *Taurhiphanie* was a summation of my dreams about the archaic Mediterranean past. The gods—Baal, Apis, the Minotaur, and Zeus, transforming himself into a bull to kidnap Europe, but who had grown up with the deafening percussion of the Corybantes, the divine and talking horses of Achilles [...] Of course, out of the two hundred bulls I had been hoping for, I only got 25! A symbol, and still speechless! But this modern day smallness was corrected by the few mares, who had come with their foals and two studs, whose beauty of undulations, fears, and erotic attractions were mixed, and who, all touched by grace, intermingled in an unequalled perfection of movement; and my music, with this animal participation, then became Nature. In addition to the "human" music of the percussionists, the animals, [there was] the music composed on the UPIC with the help of computers.[10]

7 Varga, 1996, p. 193.
8 Couprie, 2020, p. 437–57.
9 Fleuret, 1971.
10 Xenakis, 1988, p. 105 [*Cette Tauriphanie fut une synthèse de mes rêves quant au passé archaïque méditerranéen. Les dieux, Baal, Apis, le Minotaure, Zeus se transformant en taureau pour enlever Europe, mais qui avait grandi avec la percussion assourdissante des Corybantes, les chevaux divins et parlants d'Achille… Bien sûr, des*

Approximately one month before the premiere, Xenakis further revealed to Brigitte Massin (1927–2002) that the performance would finally unfold in four parts, with the third part for UPIC being framed by compositions for percussion. Xenakis specified to Massin that the arena would be fully equipped with sound reinforcement and that a tower would be erected in the center of the arena, on which a UPIC table would be installed. From this vantage point, Sylvio Gualda also would conduct the percussionists (the Pléïades Ensemble, and the Percussions de Strasbourg)[11] arranged in a circular formation in the front rows of the stands around the arena, while Iannis Xenakis would stand there to conduct, in real-time, *Taurhiphanie*, specially created for the occasion.[12]

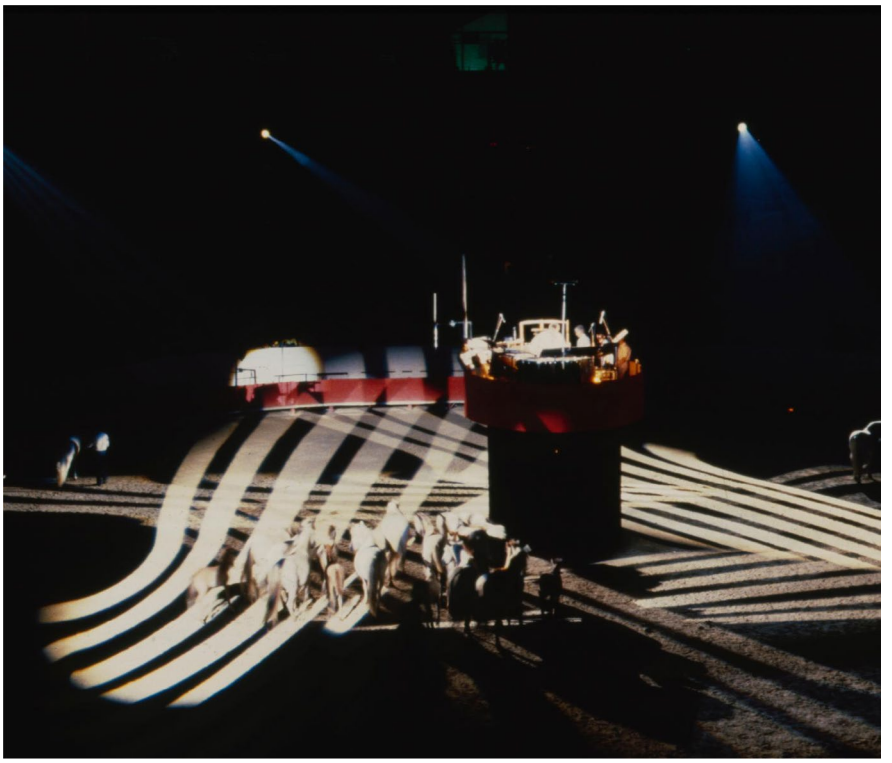


Fig. 14.4 Photograph of the creation of *Taurhiphanie* (13 July 1987). Université de Rouen Normandie, CIX Archives, CIX 20.

deux cents taureaux espérés, je n'en ai obtenu que 25 ! Un symbole, et encore sans voix ! Mais cette petitesse contemporaine fut corrigée par les quelques juments, venues avec leurs poulains et deux mâles, chez lesquelles beauté des ondulations, craintes et attractions érotiques se mêlaient, et qui, toutes effleurées par la grâce, se croisaient en une perfection inégalée des mouvements ; et ma musique avec cette participation animale devenait alors Nature. Puisqu'à la musique "humaine" des percussionnistes, aux animaux, s'ajoutaient la musique composée sur l'Upic à l'aide d'ordinateurs]. All translations are my own, under the attentive and valuable guidance of Sharon Kanach.

11 "Program Note, 1987 Edition" (1987), *Le Nouveau Festival Radio France Occitanie Montpellier,* https://lefestival.eu/les-archives/

12 Xenakis and Massin, 1987.

The spectacle would proceed as follows: the first to make their entrance are the horses, the mares each accompanied by their foals, along with two stallions led on a lead.[13] For the composer, this marks the opening parade, accompanied by the percussion sounds of *Idmen-B* (1985), initially composed for Europa-Cantat festival in Strasbourg. Once the horses leave the arena, the percussionists perform *Pleïades* (1978) under the direction of Sylvio Gualda.[14] Then the bulls arrive in numbers—though Xenakis was hoping for thirty to fifty at this stage, he will ultimately only manage to get around twenty of them—to create *Taurhiphanie*.[15] Finally, once the bulls exit, Xenakis exits and allows *Psappha* (1975) for solo percussionist to close the show.[16]

UPIC Back to Front

With *Taurhiphanie*, Iannis Xenakis hijacked the UPIC from its primary vocation, which was to generate synthetic sounds in order to arrange them visually by drawing on a graphic table. Here, Xenakis used UPIC "back to front": he starts with sounds from natural patterns to generate the shape of the work. In this, he used UPIC in the manner of his long-time friend, the composer François-Bernard Mâche. Indeed, as soon as Mâche discovered the UPIC system in October 1978, he proposed an expanded use of it, or even a complete hijacking.[17] Whereas Xenakis conceived UPIC as a means of facilitating the conception and realization of graphic scores made with sounds generated by sound synthesis, Mâche was essentially interested in a marginal functionality of the UPIC prototype: its sampler.[18] Mâche rejected the idea of projecting a theoretical speculation onto the machine and then listening to the sonic result. In his first work for UPIC (*Proteus*, composed in 1980), he preferred to use the machine as a graphic editing table for pre-recorded sounds of batrachians. Moreover, in the last part of *Hyperion* written in 1988, Mâche used the UPIC as a tool to hybridize synthesized sounds with recordings of birds and amphibians.

Here, for the composition of *Taurhiphanie*, Xenakis obtained most of the waveforms (or samples) by recording bull sounds. A video archive from the Centre Iannis Xenakis shows Iannis Xenakis and a team recording the sounds of bulls in the Camargue countryside, in southern France.[19] As he tells a journalist in this video, he hopes to

13 "*Tauriphanies* de Xenakis, à Arles les fils de Minos sont restés muets" (17 July 1987), *Le Monde*, https://www.lemonde.fr/archives/article/1987/07/17/tauriphanies-de-xenakis-a-arles-les-fils-de-minos-sont-restes-muets_4050030_1819218.html

14 A request for access to the Percussions de Strasbourg archives is underway to determine how the two percussion ensembles present at the event distributed the interpretations of the works, and for any insights on their spatialization within the arena.

15 "*Tauriphanies* de Xenakis, à Arles les fils de Minos sont restés muets" (17 July 1987), *Le Monde*, https://www.lemonde.fr/archives/article/1987/07/17/tauriphanies-de-xenakis-a-arles-les-fils-de-minos-sont-restes-muets_4050030_1819218.html

16 Xenakis and Massin, 1987.

17 Delhaye, 2020, p. 173–84.

18 Mâche, 2020, p. 354–77.

19 "Reportage sur les prises de sons de *Taurhiphanie*" (1987), *Centre Iannis Xenakis*,

record "sounds of their voices, sounds of nostrils, sounds of trampling [...] all kinds of noises that are part of the bull's environment."[20] The sounds collected in the field were then reworked in the studio, input into the synthesis engine of UPIC, and then arranged graphically on UPIC pages. Finally, those UPIC pages were sequenced to form the final composition.

Improvising with UPIC

Most of the UPIC pages of *Taurhiphanie* are intended to be played in concert without structural or envelope modifications. However, as shown by an archive from the Centre Iannis Xenakis (Figure 14.5), for the last two minutes of the work Xenakis decided to exploit an experimental feature of UPIC in 1988: real-time composition.

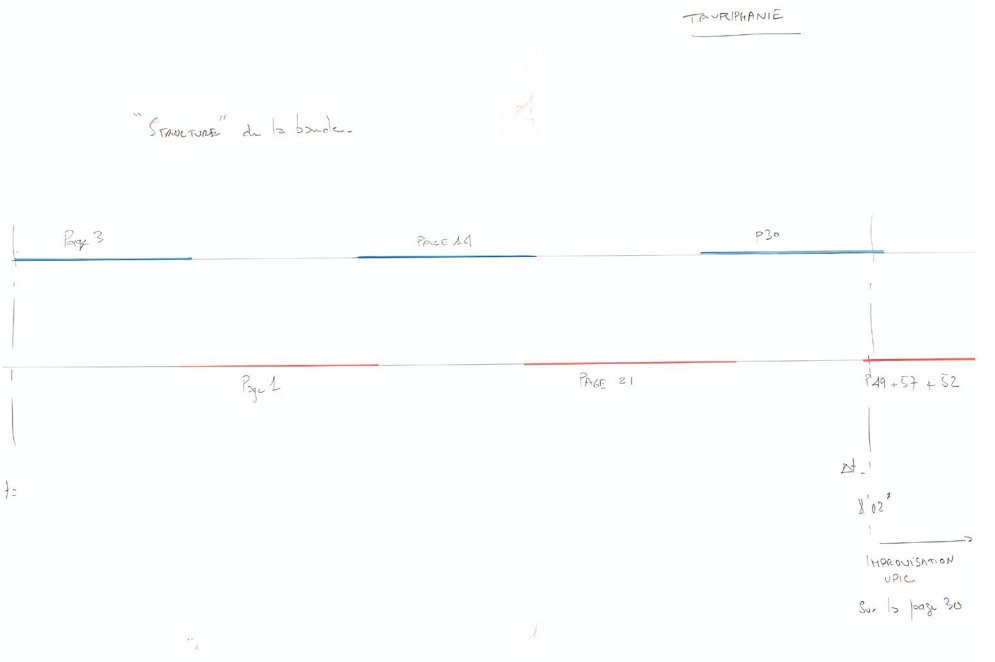


Fig. 14.5 *Taurhiphanie*: Structural diagram of the tape, Anonymous (*ca.* 1987). Université de Rouen Normandie, CIX Archives, CIX 43.

On the document intended to accompany the performance of the piece (Figure 14.6), it is specified: "For the last part of *Taurhiphanie*, starting at 8′02″ (the section composed of pages 49, 57, 52), UPIC and its 'master' will play page 30, which is also the previous one."

https://www.centre-iannis-xenakis.org/items/show/4990

20 Ibid.

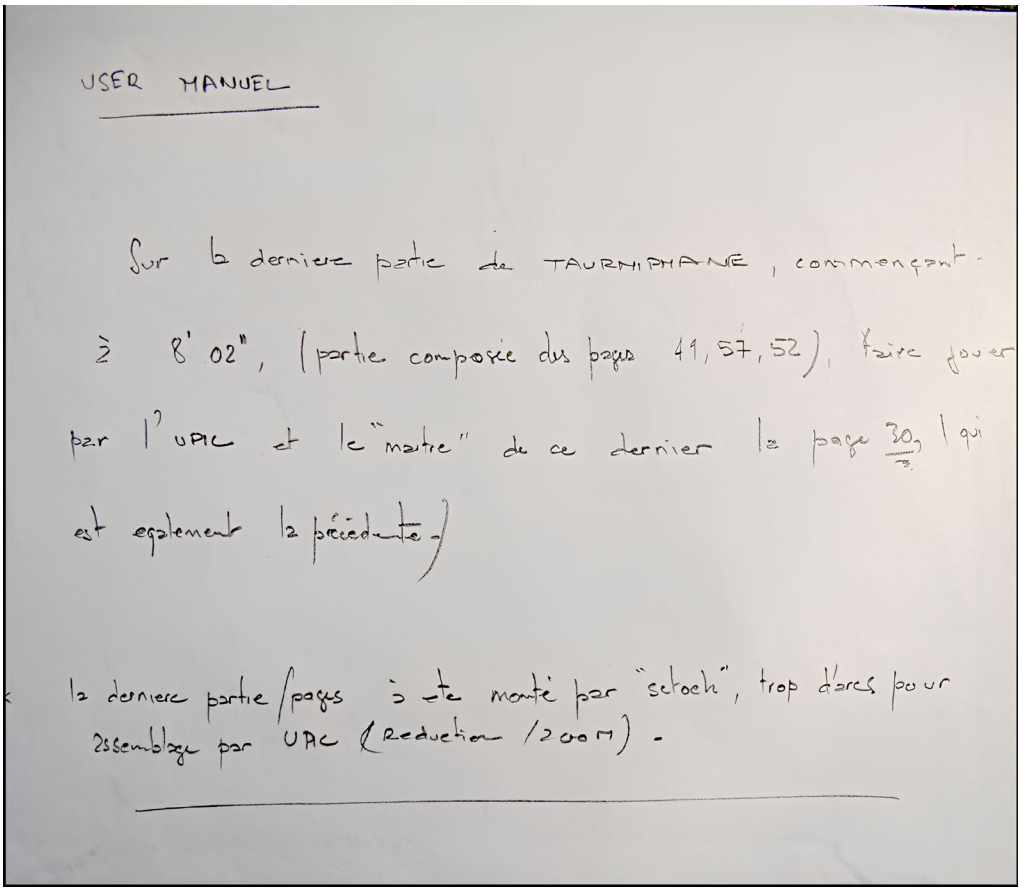


Fig. 14.6 User manual for *Taurhiphanie*, Anonymous (*ca.* 1987). Université de Rouen Normandie, CIX Archives, CIX 43.

The real-time UPIC was developed by the CEMAMu engineers in 1987. According to Jean-Michel Raczinski, it is:

> […] a radical evolution, simply because the result is instantaneous. Better still, you can modify an object (a waveform, an envelope, etc.) and hear the effect as it is modified. […] one can now work on truly complex pages, which was not possible due to the computation time of the deferred-time systems; we can also use UPIC like a musical instrument on which we improvise from previously written material.[21]

In the last section of *Taurhiphanie*, Xenakis imagined being able to react to the stimuli of the immediate environment in the arena: movements of the bulls and horses, lighting

21 Raczinski, 2001, p. 82–3 [[…] C'*est une évolution radicale, tout simplement parce que le résultat est instantané. Mieux, on peut modifier un objet* (*forme d'onde, enveloppe, etc.*) *et en entendre l'effet au fur et à mesure de la modification.* […] *on peut maintenant travailler des pages véritablement complexes, ce qu'on ne faisait pas à cause des temps de calcul des systèmes temps-différé ; on peut aussi utiliser l'UPIC comme un instrument de musique sur lequel on improvise à partir d'un matériau écrit au préalable*].

effects, reactions of the public, etc. To achieve this, Xenakis equips the horns of the bulls with wireless microphones: he hopes to collect the sounds of the animals in real-time to generate material for his improvisation on UPIC.[22] Additionally, as James Harley (b. 1959) specifies: "Spotlights were to project patterns of light sounds onto the floor of the arena and the animals would create dynamic stochastic patterns as they moved around the ring."[23] Xenakis also explained to Brigitte Massin his desire to open the final part of *Taurhiphanie* to improvisation, based in the fact that this was now technically possible: "What interests me is that I am free to make my choices, my score allows for multiple paths, I can improvise on elaborated structures, and of course mix the elements to my liking."[24] The innovation of a real-time UPIC obviously changed Xenakis's mind about improvisation, once he could be behind the controls himself, as a sort of *comprovisateur*.[25]

However, under the conditions of this concert, Xenakis could not precisely control the movement of the bulls and horses in the arena; in contrast, for example, to the *Polytope de Persépolis* (1971), where he had perfectly timed the movements of the children and the goats on the hills. It is perhaps from this constraint that the idea of improvising on the UPIC directly in the arena was born. But, according to the testimonies of people who attended the creation of *Taurhiphanie*, the bulls remained quite static, as James Harley specifies: "The animals did not cooperate in creating interesting stochastic patterns; they tended to huddle at one end of the ring or another, apparently traumatized by the pounding of the amplified percussion and the extreme dynamic range of the electronic sounds [...] *Taurhiphanie*, though, remains as perhaps Xenakis's most successful piece created using the UPIC."[26] Therefore, Xenakis preferred to use the previously recorded sounds of the bulls for the creation of the final part of *Taurhiphanie*, rather than those generated live by the animals in the arena.

22 Couprie, 2020, p. 439.

23 Harley, 2002, p. 53.

24 Xenakis and Massin, 1987 [*Ce qui m'intéresse c'est que je suis libre de mes choix, ma partition me permet des parcours multiples, je peux improviser sur des structures élaborées, et bien entendu mixer à ma convenance les éléments*].

25 Although Xenakis's scepticism about the value of improvisation is widely recognized, Matossian (2005, p. 211–12), his "living biographer" also underlines the "usefulness" of improvisation for the composer: "He liked to work with physical sounds, to familiarise himself with the properties of sonorities, as he did with construction materials. He has retained this preference, often experimenting with instruments before he composes for them." Ibid., p. 61.

26 Harley, 2002, p. 53

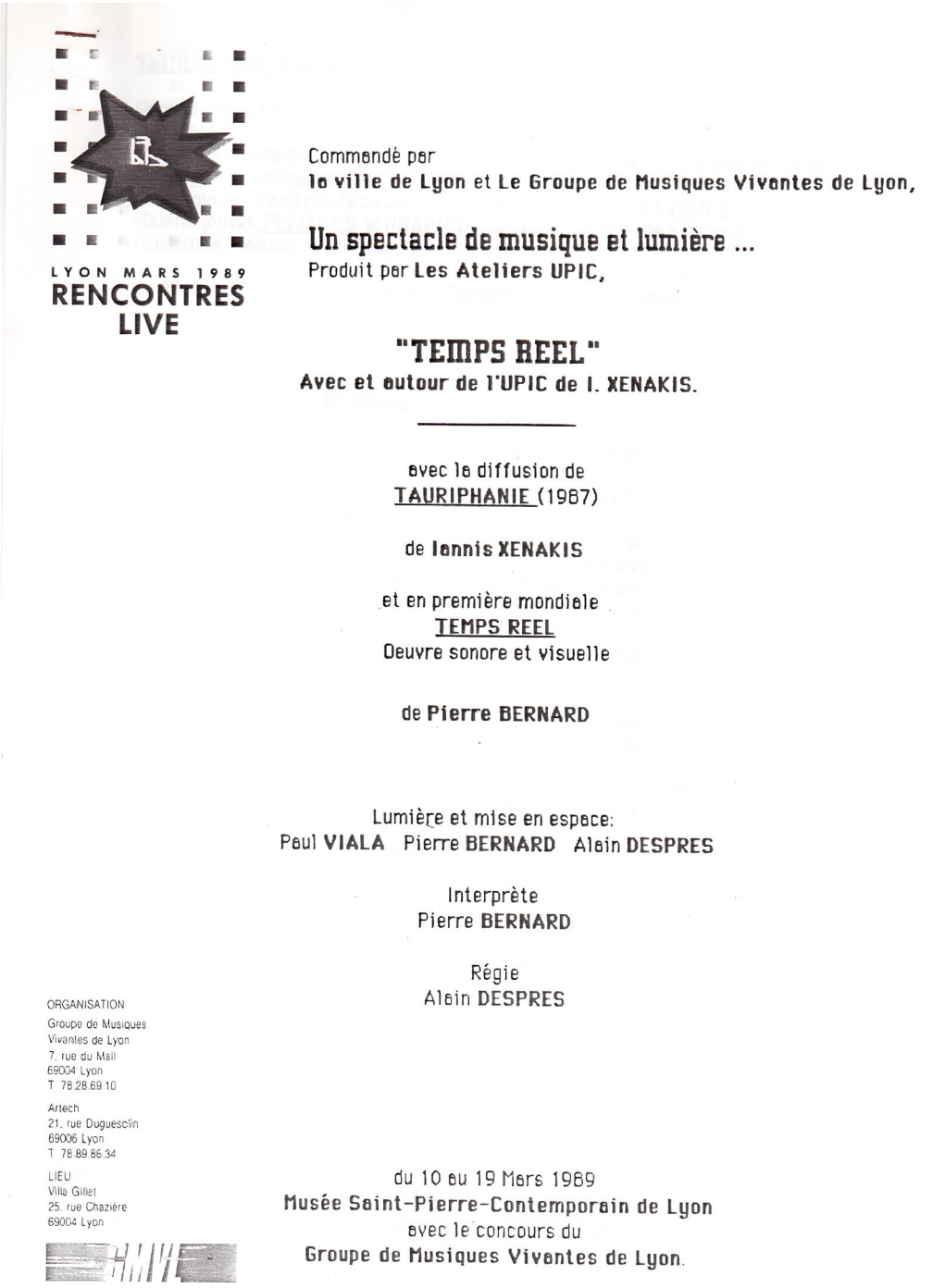


Fig. 14.7 Program note: *Rencontres Live de Lyon*, Anonymous (1989). Université de Rouen Normandie, CIX Archives, CIX 106, 2 p.

Despite this setback during the premiere, *Taurhiphanie* was nevertheless programmed several times for concerts and festivals. Alain Després, director of the Ateliers UPIC at their creation in 1985, had been particularly involved in promoting Xenakis's UPIC works and had programmed *Taurhiphanie* on multiple occasions. In this sense, Alain Després's approach fits perfectly within the missions defined by Xenakis himself for Les Ateliers UPIC, which aim to promote and enhance UPIC, thus enabling CEMAMu to actively pursue its research on the technical development of the system. The archives of the Centre Iannis Xenakis reveal, for example, the program notes (Figure 14.7) for the Festival des Rencontres Live organized in Lyon in 1989. This concert shows a strong desire to associate *Taurhiphanie* with other works composed for real-time UPIC, such as Pierre Bernard's *Temps réel* (1989), a work entirely based on the new capabilities of UPIC, making it a full-fledged musical instrument.[27] More recently, a DAT and a concert poster found in the CIX archives attest that *Taurhiphanie* was performed as part of a concert for flute, voice, and tape at the Théâtre des Nouveautés in Tarbes on 22 October 1997.[28] Other works composed with the help of UPIC were also programmed there: one could notably hear *Danse de Salomé* (1993) by Hans Mittendorf (b. 1952), *L'Autel de la perte et de la transformation* (1993) by Brigitte Robindoré or *Deux chansons* (1993) by Gerard Pape (b. 1955).

Outlooks and Transition to the Semantic Web

This work on *Taurhiphanie*, based on the CIX archives, shows the richness of the Centre's collections. But these collections offer so much more to discover! The paths of many of the numerous composers who worked in this creative center founded around UPIC have yet to be explored: the traces they left in the collections are preserved but await analysis. Currently, most documents from the main collection are inventoried, and some recent collections are cataloged. In their current state, the archives of CIX are described linearly: meaning that digitized documents are associated with metadata that are indeed interoperable with other information systems, but do not demonstrate the complexity of relationships between different objects. The relationships between composers, works, machines, software, locations, mediums, performers, educational activities, concerts, mediation activities, etc., are indeed rich and highly heterogeneous. Therefore, the CIX archives lend themselves to a semantic description by the triplet Object/Predicate/Subject. However, these relationships are not currently modeled in the information system, which hinders deep musicological exploitation of the archives. In order to address this issue, since

27 "Liste des œuvres composées sur l'UPIC" (1989), *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/items/show/4984

28 "Concert for Flute, Voice and Tape," *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/items/show/2927; "UPIC Concert" (1997) *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/items/show/64

2022 CIX has engaged in the dynamics of the Musica 2 Consortium of the TGIR Huma Num to participate in discussions on ontological modeling of contemporary and electroacoustic music.[29] Various avenues are emerging: the choice and adaptation of the CIDOC-CRM ontology, the possibility of integrating the ElectroAcoustic Resource Site (EARS) thesaurus, sharing of reference frameworks, etc.[30] This work aims, over the medium term, to outline a common semantic language which, in addition to data interoperability, allows for the description of contemporary musical creation objects and the relationships they generate using the same concepts and within a common ontology.

Since 2013, by sharing and opening its research data, the CIX has aligned its approach with the philosophy of open knowledge, and has already embraced the concept of FAIR data (Findable, Accessible, Interoperable, Reusable).[31] Now, by aiming to initiate its transition towards the semantic web, the CIX is intensifying its efforts not only to make primary sources in this realm of contemporary music accessible to researchers, but also to enable them to analyze and annotate the complex relationships generated by this type of musical creation.

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29 MUSICA2, Consortium en musicologie numérique, "Vers une standardisation des métadonnées," *Hypothèses*, https://musica.hypotheses.org/metadonnees

30 *CIDOC-CRM Conceptual Reference Model*, https://cidoc-crm.org/; *EARS, ElectroAcoustic Resource Site*, http://ears.huma-num.fr/index.html

31 Wilkinson et al., 2016.

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15. Game Theory and Formal Structure in Iannis Xenakis's *Duel* (1959)

Mikhail Malt and Benny Sluchin[1]

Introduction

The starting point of this work was the consideration of pragmatic problems and questions related to the performance of open works. However, in this text, we will mainly focus on the issue of form in Xenakis's *Duel*.

Historical Overview

Duel, a work for two orchestras and two conductors, was commissioned by the Office de radiodiffusion-télévision française—French Radio and Television Office (ORTF). The world premiere took place on 18 October 1971 (some twelve years after its completion!) in Hilversum, Netherlands, by the Hilversum Radio Orchestra, which was conducted by Diego Masson (b. 1935) and Fernand Terby (1928–2004).[2]

Stratégie (1962), also a work for two orchestras and two conductors, was commissioned by the Venice Biennale, and premiered there on 25 April 1963, conducted by Bruno Maderna (1920–73) and Konstantin Simonovitch (1923–2000).[3] Unlike *Duel*, *Stratégie* has had several performances. The French premiere in 1965 is famous. In addition to *Stratégie*, the program was to include *Antiphonie* (1961–62) by Gilbert Amy (b. 1936), and *Music for Strings, Percussion and Celesta* (1936) by Béla Bartók (1881–1945). Due to the particular installation of the orchestras, Bartók's piece was not performed, only the Xenakis and Amy works. The audience heard two versions of each piece, and explanations for *Stratégie. La Tribune de Lausanne* reported that the public "behaved like an audience in a wrestling match and one knows how

1 This text is an expanded version of an earlier publication, Sluchin and Malt, 2011b.
2 "Duel (1959)," *IRCAM*, https://brahms.ircam.fr/en/works/work/12797/54466
3 "Stratégie (1962)," *IRCAM*, https://brahms.ircam.fr/en/works/work/12878/

 https://doi.org/10.11647/OBP.0390.17

boisterous those audiences are."[4] The only commercial recording made to date is the performance by Seiji Ozawa and Hiroshi Wakasugi with the Yomiuri Nippon Symphony Orchestra (Figure 15.1).[5] Note that this is an edition with György Ligeti (1923–2006), Xenakis, Toshi Ichiyanagi (1933–2022), and Tōru Takemitsu (1930–96); truly a West/East confrontation.

Fig. 15.1 Orchestral Space, at Nissei Theater, volume 2, Victor SJV-15113, 1966, LP jacket.[6]

To set in time the composition of these works, it is important to remember the historical context, in particular the publication in 1962 of Umberto Eco's book, *L'Opera Aperta*. It was a time when several composers found an interest in the question of the mobility of musical units within works, for example:

- 1955–57, *Gruppen*, by Karkheinz Stockhausen (1928–2007), for three orchestras.
- 1956–58, *Allelujah II*, by Luciano Berio (1925–2003), for five instrument groups.
- 1957–58, *Concert for Piano and Orchestra*, by John Cage (1912–92), for any solo or combination of piano, flute, clarinet, bassoon, trumpet, trombone,

4 Review cited in Matossian, 2005, p. 226.

5 Seiji Ozawa, Yomiuri Nippon Symphony, Hiroshi Wakasugi, Yuji Takahashi – *Orchestral Space*, Label: Varèse Sarabande – VX 81060, Vinyl, LP, Recorded May 1–4, 1966, US, 1978.

6 "Orchestral Space," *RYM*, https://rateyourmusic.com/release/comp/yomiuri-nippon-symphony-orchestra-seiji-ozawa-hiroshi-wakasugi-yuji-takahashi/orchestral-space/

tuba, three violins, two violas, cello, and double bass, with optional conductor.

- 1960, *Répons*, by Henri Pousseur (1929–2009), for mixed instrumental ensemble of five to nine instruments, dedicated to John Cage.
- 1961–68, *Domaines*, by Pierre Boulez (1925–2016), two versions exist: one for clarinet solo, the other (definitive) version for clarinet and instrumental ensemble.

Duel, *Stratégie*: Description

Concerning *Duel* and *Stratégie*, we can notice that the general organization of the two works is almost identical, differing only by the size of the orchestras.

Duel	***Stratégie***
Two orchestras	Two orchestras
Two conductors	Two conductors
Fifty-six musicians	Eighty-two musicians
Based on game theory	Based on game theory
Six sound events	Six sound events
Six tactics	Nineteen tactics

Table 15.1 Comparison between *Duel* and *Stratégie*.

As for the stage, the two works also have the same setup, with the two ensembles sharing the stage, and the conductors standing back-to-back (Figure 15.2).

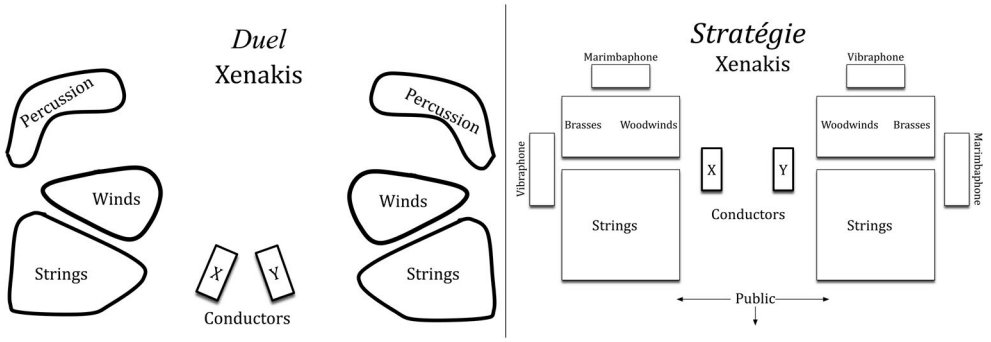


Fig. 15.2 Comparison between *Duel* and *Stratégie* stage setup. Figure created by authors.

Duel

Concerning *Duel*, we can notice that each orchestra is made up of three groups:

1. Winds: one piccolo, one oboe, one clarinet in *E*-flat, one bass clarinet in *B*-flat, one bassoon, one contrabassoon, two trumpets, one trombone.
2. Percussions: two bongos, three congas, one snare drum, one drum.
3. Strings: six first violins, six second violins, four cellos, two double basses.

The two orchestras are positioned to the left and right of the stage, with the two conductors standing back-to-back, or on two opposite podiums.

In *Formalized Music*,[7] Xenakis presents us with a general diagram, in a very artistic way, showing the relationship between the different elements of the composition (Figure 15.3).

The *Duel* material comes in the form of five containers (I to V), three for the strings, one for the percussion and one for the winds. Each of these containers corresponds to a stochastic sound structure. Xenakis calls these structures *tactics*. The sixth container is silence.

I.	Cloud of sound grains (strings)
II.	Sustained strings in parallel with fluctuations (strings)
II.	Networks of crossing string *glissandi* (strings)
IV.	Stochastic Percussions (percussions)
V.	Stochastic Wind Instruments (winds)
VI.	Silence

Table 15.2 Six tactics in *Duel*.

7 Xenakis, 1963, p. 150; Xenakis, 1992, p. 124.

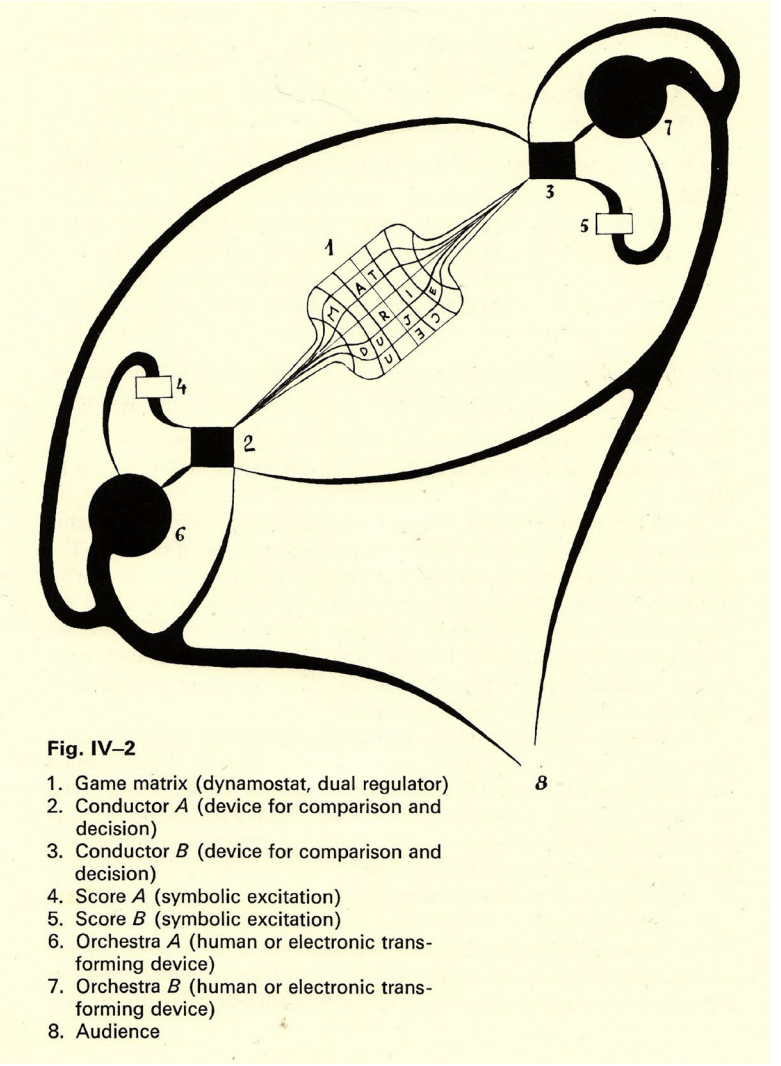


Fig. 15.3 Xenakis's sketch for *Stratégie*[8] (reproduced with permission from Pendragon Press).

Each conductor then has six sound configurations at his disposal; i.e., six tactics, from which he will choose during the performance of the work.

Regarding the material of *Duel's* containers, as shown by Benoît Gibson,[9] it comes mainly from two other works by Xenakis: *Syrmos* (1959) for containers I, II, and III and *Achorripsis* (1959) for container V. The latter uses the instrumentation of *Achorripsis* without the percussion. As our objective is the formal structure, we will not deepen the aspect of "self-borrowing" already commented on by Gibson, but will follow an example from *Duel*'s score. Figure 15.4 shows the beginning of *Duel*'s first section, which comes from *Syrmos* (1959).

8 Xenakis, 1992, p. 124.
9 Gibson, 2011, p. 14–19; p. 164–71.

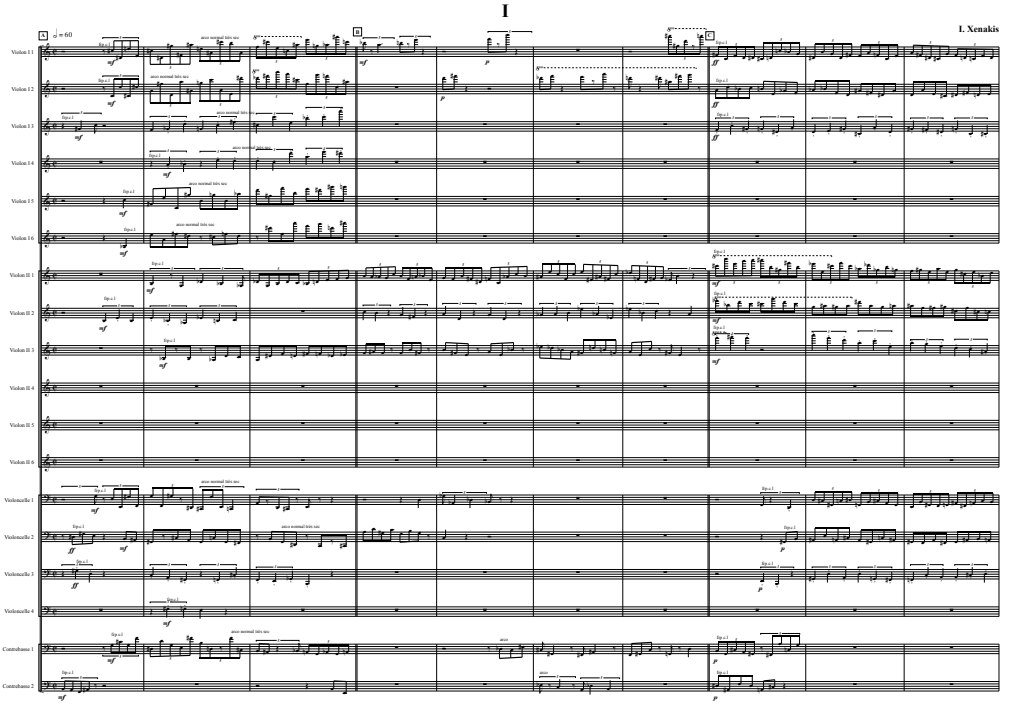


Fig. 15.4 *Duel* I, from *Syrmos* (1959). Re-notated by authors.

Game Theory

In *Musique Formelles*, Xenakis gives two references regarding game theory:[10] *La Stratégie dans les actions humaines* by J. D. Williams and *La théorie des jeux et programmation linéaire* by Steven Vajda.[11]

It is important to note that in the 1950s, game theory was a booming discipline. When the *Compleat Strategies* was first published in 1954, the original version of Williams's book, *Game Theory* was an esoteric and mysterious subject, familiar only to some researchers, especially those in the army. This indicates that Xenakis was aware of the cutting-edge developments and research of his time.[12]

In Chapter III of *Musique Formelles*,[13] Xenakis describes the method for creating the matrix of *Duel* from subjective judgments on combinations of sound textures, or tactics (Table 15.3).

10 Xenakis, 1963, p. 226.
11 Williams, 1956; Vajda, 1959.
12 Williams, 1954.
13 Xenakis, 1963, p. 140–50, or Chapter IV of the English version: Xenakis, 1992, p. 110–30.

Nous établissons une liste des couples x,y des événements simultanés issus des deux orchestres X et Y, avec nos appréciations subjectives :

Couple (x,y) = (y,x)	Qualification	Couple (x,y) = (y,x)	Qualification
(I, I)	passable (p)	(II,V) = (V, II)	passable^{+} (p^{+})
(I, II) = (II, I)	bon (b)	(III,III)	passable (p)
(I,III) = (III, I)	bon^{+} (b^{+})	(III,IV) = (IV, III)	bon^{+} (b^{+})
(I,IV) = (IV, I)	passable^{+} (p^{+})	(III,V) = (V, III)	bon (b)
(I, V) = (V, I)	très bon (b^{++})	(IV,IV)	passable (p)
(II,II)	passable (p)	(IV,V) = (V, IV)	bon (b)
(II,III) = (III, II)	passable (p)	(V,V)	passable (p)
(II,IV) = (IV, II)	bon (b)		

Table 15.3 Table of Evaluations[14] (reproduced with permission from Pendragon Press).

These calculations lead to a matrix (Figure 15.5) describing the points for each move.

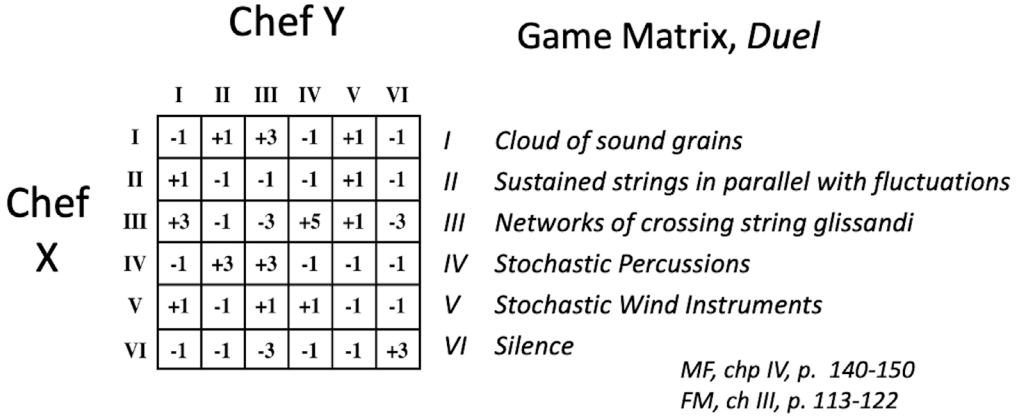


Fig. 15.5 Original game matrix for *Duel*. Figure created by authors.

This matrix is the game matrix, which defines a zero-sum two-player game, a special case of mathematical game theory. A matrix gives the agents' gains and losses (game rows or columns). Each row or column corresponds to a given tactic. In this specific case, if player X plays tactic IV, while player Y plays tactic III, the result is +3; i.e., 3 points to player X (Figure 15.6).

14 Xenakis, 1992, p. 114.

X \ Y	I	II	III	IV	V	VI
I	-1	+1	+3	-1	+1	-1
II	+1	-1	-1	-1	+1	-1
III	+3	-1	-3	+5	+1	-3
IV	-1	+3	+3	-1	-1	-1
V	+1	-1	+1	+1	-1	-1
VI	-1	-1	-3	-1	-1	+3

Fig. 15.6 Specific example of a move. Figure created by authors.

Since Xenakis wants a fair game, i.e., a zero sum of winnings, he calculated the probabilities for the different tactics (rows and columns). Xenakis bases his calculations on John von Neumann's (1903–57) minmax theorem, which is a special case of Nash's equilibrium theorem[15] ensuring the existence of a stable solution (Figure 15.7), with a game value equal to -0.07, which means that this game is almost balanced.

Chef X \ Chef Y	I	II	III	IV	V	VI	Marginal Probabilities
I	−1	+1	+3	−1	+1	−1	14/56
II	+1	−1	−1	−1	+1	−1	6/56
III	+3	−1	−3	+5	+1	−3	6/56
IV	−1	+3	+3	−1	−1	−1	6/56
V	+1	−1	+1	+1	−1	−1	8/56
VI	−1	−1	−3	−1	−1	+3	16/56
	19/56	7/56	6/56	1/56	7/56	16/56	

Fig. 15.7 Weighted random choices for each agent, marginal probabilities. Figure created by authors.[16]

Note that, unlike in *Musiques Formelles* and *Formalized Music* (Figure 15.5), in the score of *Duel* (Figure 15.8) tactics I, II, and III are replaced by A, B, and C, which are sound combinations. A can be tactic I or II or III. B will be one of the following combinations:

15 "Nash Theorem (In Game Theory)," *Encyclopedia of Mathematics*, https://encyclopediaofmath.org/index.php?title=Nash_theorem_(in_game_theory)

16 Figure based on Xenakis's original figure in Xenakis, 1963, p. 147.

A+IV, or A+V, or IV+V. And C will be the combination A+IV+V (all combinations of three), remembering that A is multiple. This presumably is in order to bring more variety to the games.

		Y					
	=>	A	B	C	IV	V	VI
	A	-1	1	3	-1	1	-1
	B	1	-1	-1	-1	1	-1
X	C	3	-1	-3	5	1	-3
	IV	-1	3	3	-1	-1	-1
	V	1	-1	1	1	-1	-1
	VI	-1	-1	-3	-1	-1	3

Fig. 15.8 Matrix game in *Duel's* score. Figure created by authors.

Duel—Pragmatic Performance Issues

The performance of *Duel* is not without difficulties and requires complex preparation from both conductors. Some preliminary decisions are necessary before playing *Duel*:

1. The allocation of rows and columns (for example by drawing heads or tails between the two conductors).
2. The determination of the duration (by choosing a duration in minutes, the number of moves, or the maximum number of points to obtain).
3. The decision of who will start.

Other elements are at the discretion of the conductors:

1. The places in the score to start tactics.
2. The duration of each move.

Xenakis is precise in pointing out that there are two ways: the "degenerate way;" that is to say, without considering the matrix, and playing in a musical or intuitive way; and the "valid" way, using the matrix and its values, as well as applying the marginal probabilities:

> A *degenerate* game is one in which the parties play arbitrarily following a more or less improvised route, without any conditioning for conflict, and therefore without any new compositional argument. This is a false game.[17]

17 Xenakis, 1963, p. 140; Xenakis, 1992, p. 113 [*Un jeu* dégénéré *est celui dans lequel les parties jouent arbitrairement en suivant des parcours plus ou moins 'improvises', mais sans conditionnement conflictuel,*

> The only valid (way), the only one that brings something new, in the case of several orchestras, is the one that is sanctioned by gains and losses, by victories and defeats.[18]

And according to Xenakis, the winner is the one who best follows the rules of the game:

> The winner won because he simply better followed the rules of the game imposed by the composer who, therefore, claims responsibility for the "beautiful" or "ugly" of his music.[19]

Now, considering the ways to play with the matrix, we can basically count three of them:

1. Random choices weighted by the marginal probabilities, those just mentioned.
2. Choices minimizing the opponent's gain in the next step, *minmax*.
3. Choices maximizing its own gain, *minmax-gain*.

Obviously, nothing prevents mixing these strategies.

Computer Simulations of the Game

To be able to study the dynamics and the evolution of the structure of *Duel*, we carried out computer simulations, using each of the strategies mentioned. Figure 15.9 shows the Max software interface built for this intent.

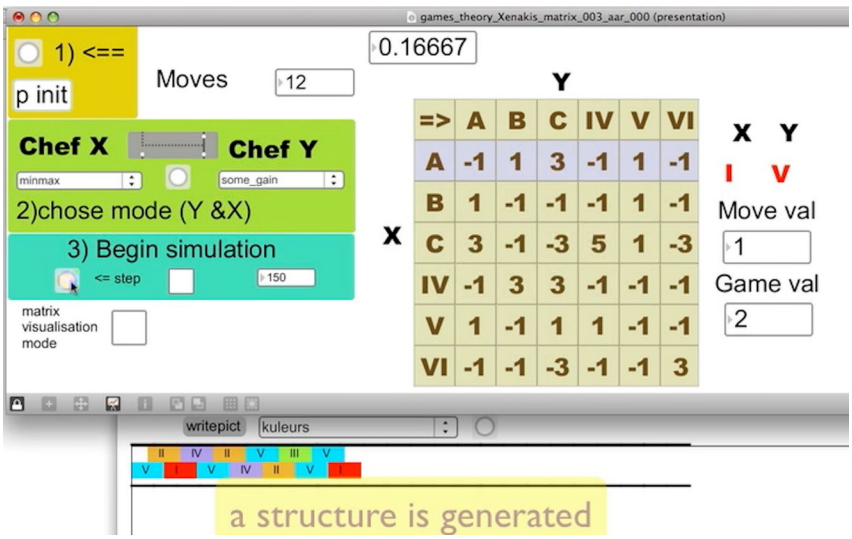


Fig. 15.9 Max interface for simulation. Figure created by authors.

donc sans valeur compositionnelle. C'est un faux jeu].

18 Xenakis, 1959, p. 4 [*La seule (façon) valable, la seule qui apporte quelque chose de nouveau, dans le cas de plusieurs orchestres, est celle qui est sanctionnée par des gains et des pertes, par des victoires et des défaites*].

19 Ibid., p. 5 [*Le gagnant a gagné parce qu'il a simplement mieux suivi les règles du jeu imposées par le compositeur qui, par conséquent, revendique la responsabilité du 'beau' ou du 'laid' de sa musique*].

We have also represented the result in the form of curves and a formal diagram, to help us identify the emerging structure. This simulation would converge to the value of the game after a large enough number of steps. Figure 15.10 presents an example of the *carpet*, our diagram, of played sequences.

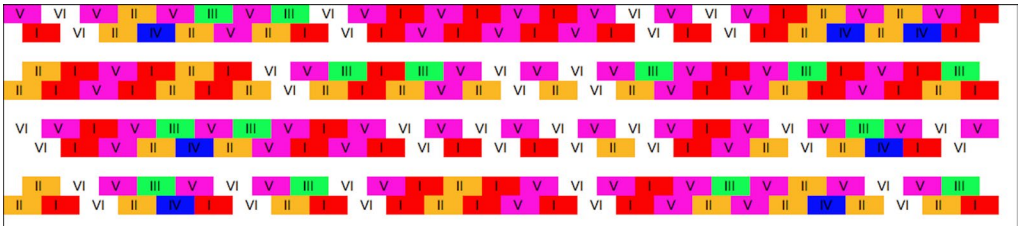


Fig. 15.10 The *carpet*, diagram of successive moves. Figure created by authors.

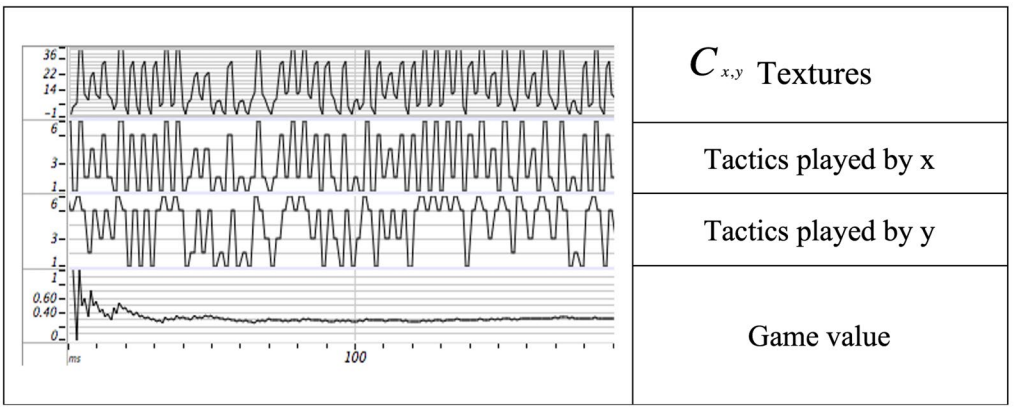


Fig. 15.11 displays the curves representing the evolution of the textures, the moves of each player, and the evolution of the value of the game. Figure created by authors.

Figure 15.11 displays the curves representing the evolution of the textures, the moves of each player, and the evolution of the value of the game. Figure created by authors. To study the dynamics of the game, we can represent (or think of) the evolution of different tactics as a sequence of mixtures ($C_{x,y}$) of two tactics, which we will call *textures* (T_i). Each combination of two tactics corresponds to a texture ($C_{x,y}$) $\Rightarrow T_i \in \{1, 2, ..., 36\}$).

In the particular case of *Duel*, we can generate 36 textures resulting from the 36 combinations of the six tactics (A, B, C, IV, V, and VI) (Figure 15.12). For example, in Figure 15.13, the first combination corresponds to tactic VI played by X and by tactic V played by Y, which corresponds to the texture 35. The second combination corresponds to tactic B played by X and by tactic V played by Y, which corresponds to texture 11. The third combination corresponds to texture 8, and so on. Each *texture* is not a single element, but a category, an equivalence class, such that *the texture i*, is the texture T_i generated by a pair of x and y strokes, $C_{x,y}$.

=>	A	B	C	IV	V	VI
A	1	2	3	4	5	6
B	7	8	9	10	11	12
C	13	14	15	16	17	18
IV	19	20	21	22	23	24
V	25	26	27	28	29	30
VI	31	32	33	34	35	36

Fig. 15.12 Textures matrix. Figure created by authors.

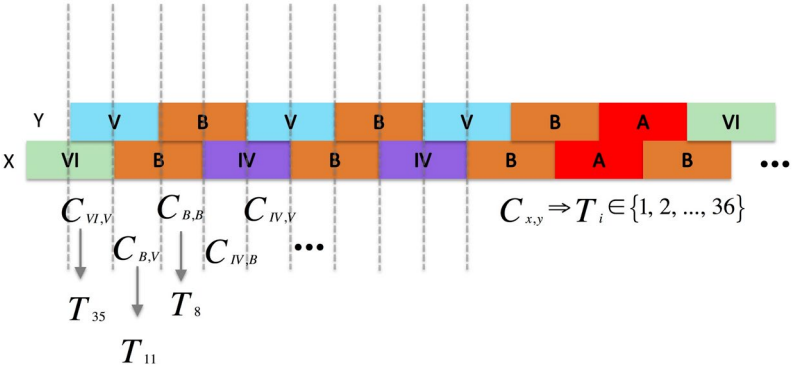


Fig. 15.13 Game evolution. Figure created by authors.

On the other hand, if we consider that the two orchestras are symmetrical, and that a *texture* resulting from a move (i, j) is identical to the texture resulting from a move (j, i), then $C_{i,j} \equiv C_{j,i}$, our texture matrix becomes symmetrical and only has 21 textures, $C_{x,y} \in \{1, 2, ..., 21\}$ (Figure 15.14)

This consideration is already taken into account by Xenakis, in his construction of the table of "subjective judgments" (Table 15.3) where it is clearly indicated that the pairs (x, y) are equivalent to the pairs (y, x). We are aware that from the listener's point of view the setup will not always be symmetrical. On the other hand, as a first approach to the analysis, we will consider this disposition.

=>	A	B	C	IV	V	VI
A	1	2	3	4	5	6
B	2	7	8	9	10	11
C	3	8	12	13	14	15
IV	4	9	13	16	17	18
V	5	10	14	17	19	20
VI	6	11	15	18	20	21

Fig. 15.14 Simplified texture matrix. Figure created by authors.

Let us see some simulation results.[20]

Simulation using Weighted Random Choices (wrc)

In this simulation we use the marginal probabilities, calculated by Xenakis (Figure 15.7) to make Weighted Random Choices. In this simulation, the game goes through the twenty-one cells, therefore through the thirty-six combinations of sounds offered. The morphology of the paths depends on the weight ratio of rows and columns and does not show special patterns (Figure 15.15). However, we notice a particular distribution in the texture histogram (Figure 15.16). A few seem favored over others, such as texture 6 over texture 16, which is to be expected since the probabilities of lines A and VI for both players are preponderant.

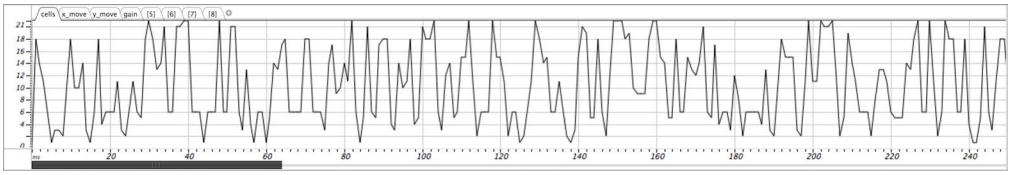


Fig. 15.15 Textures' evolution (wrc). Figure created by authors.

=>	A	B	C	IV	V	VI
A	-1	1	3	-1	1	-1
B	1	-1	-1	-1	1	-1
C	3	-1	-3	5	1	-3
IV	-1	3	3	-1	-1	-1
V	1	-1	1	1	-1	-1
VI	-1	-1	-3	-1	-1	3

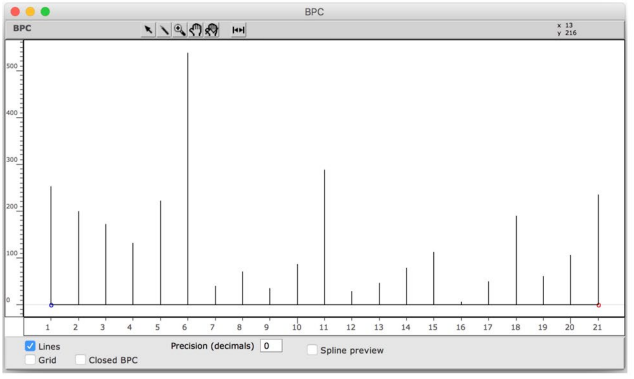
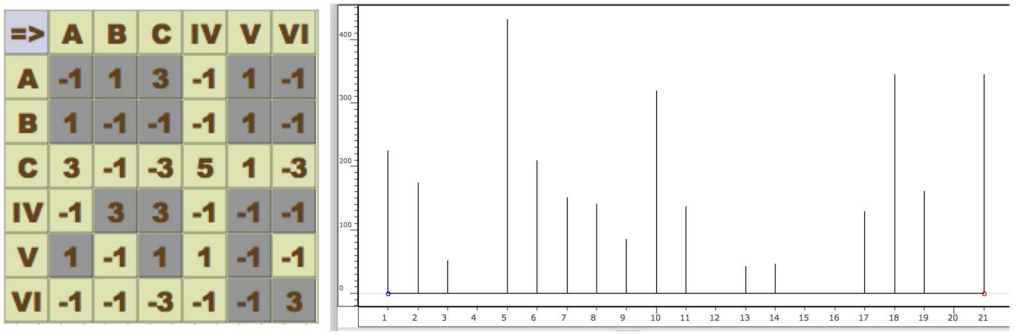


Fig. 15.16 Textures' coverage (wrc) and histogram. Figure created by authors.

Choices Minimizing the Gains of the Adversary (Minmax)

In this simulation, each move is supposed to minimize the opponent's gain. The game does not cover the twenty-one cells, leaving some combinations tacet (Figure 15.17). The morphology of the paths presents cycles and almost repetitive forms (Figure 15.18).

20 The simulations were carried out with samples of 3,000 moves.



=>	A	B	C	IV	V	VI
A	-1	1	3	-1	1	-1
B	1	-1	-1	-1	1	-1
C	3	-1	-3	5	1	-3
IV	-1	3	3	-1	-1	-1
V	1	-1	1	1	-1	-1
VI	-1	-1	-3	-1	-1	3

Fig. 15.17 Textures' coverage (minmax) and histogram. Figure created by authors.

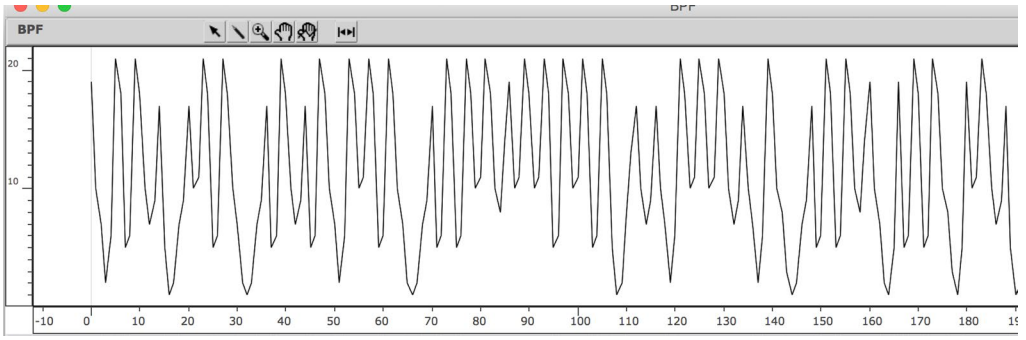


Fig. 15.18 Textures' evolution (minmax). Figure created by authors.

Observing the curve of the evolution of textures, one can easily identify cycles, a kind of X A Y A', etc.: a structure by blocks (Figure 15.19).

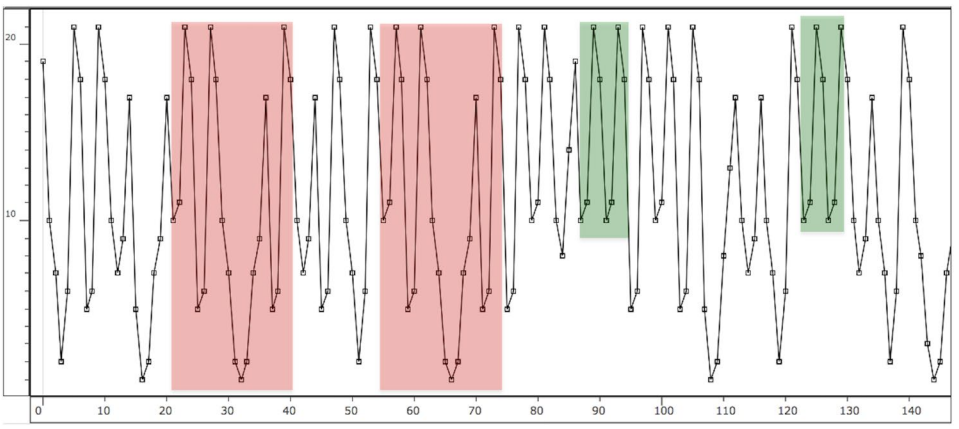


Fig. 15.19 Cycles in the textures' evolution curve (minmax). Figure created by authors.

Choices Maximizing own Gains (Gainmax)

In this simulation, each move is supposed to maximize a player's own gains. The game does not pass through the twenty-one cells, still leaving combinations tacet (Figure 15.20). The morphology of the patterns also presents cycles and almost repetitive forms (Figure 15.21).

=>	A	B	C	IV	V	VI
A	-1	1	3	-1	1	-1
B	1	-1	-1	-1	1	-1
C	3	-1	-3	5	1	-3
IV	-1	3	3	-1	-1	-1
V	1	-1	1	1	-1	-1
VI	-1	-1	-3	-1	-1	3

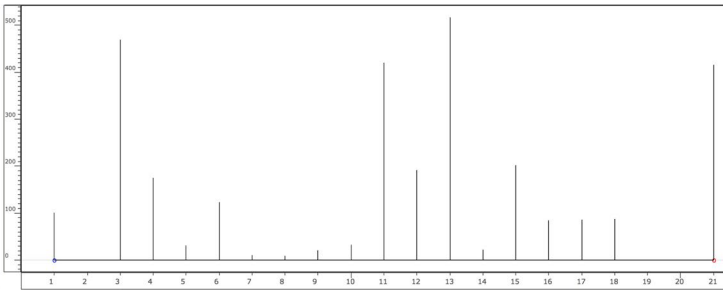


Fig. 15.20 Textures' coverage (gainmax) and histogram. Figure created by authors.

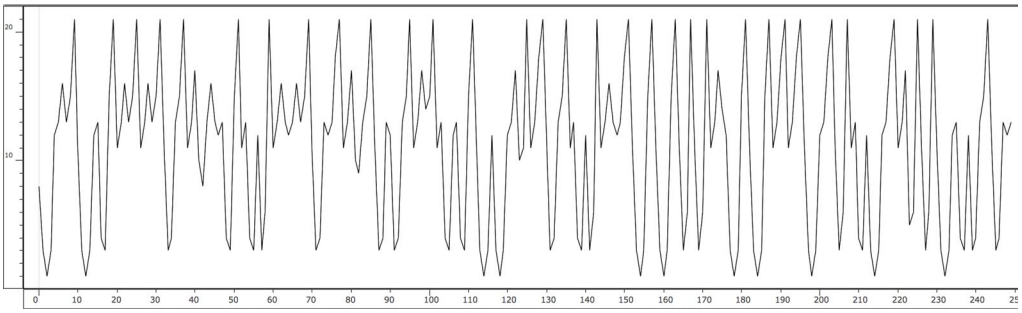


Fig. 15.21 Textures' evolution (gainmax). Figure created by authors.

Observing the curve of the evolution of textures, we can again identify cycles (Figure 15.22).

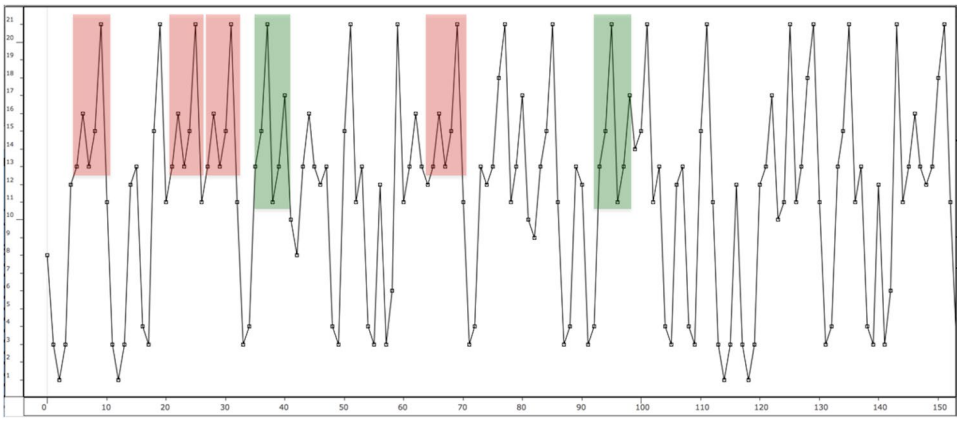


Fig. 15.22 Cycles in the textures' evolution curve (gainmax). Figure created by authors.

A Few Comments

In any case, we can perceive that the combination of VI+VI tactics, i.e., texture 21, is a silence, which articulates the sequence musically, creating blocks of more or less repetitive patterns. We find this same situation (silence) in other completely composed works (*Achorripsis, N'Shima* (1975), etc.). Figure 15.23, Figure 15.24, and Figure 15.25 present an excerpt from a simulation with x and y using the same type of choice, gainmax.

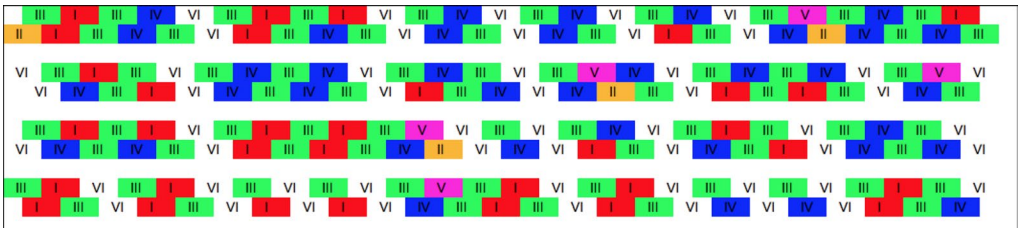


Fig. 15.23 Diagram of successive moves. Figure created by authors.

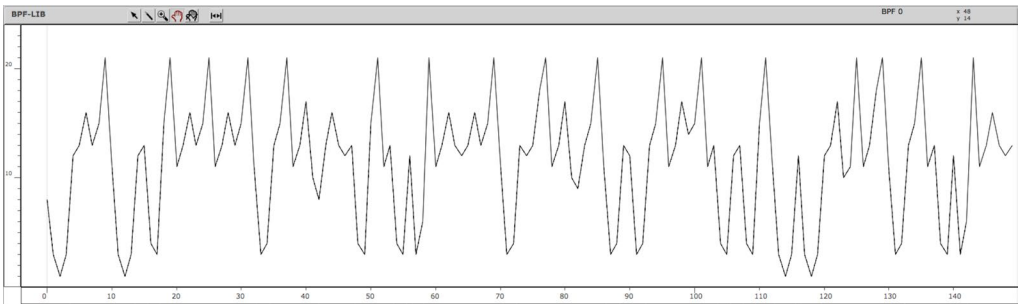


Fig. 15.24 Texture evolution curve. Figure created by authors.

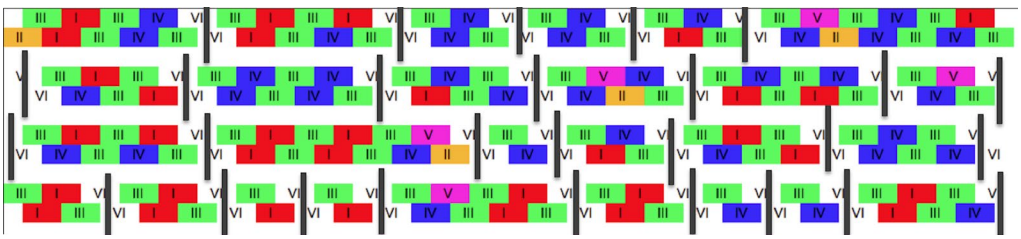


Fig. 15.25 Diagram of successive moves articulated by silences. Figure created by authors.

We can notice (Figure 15.26) that silences punctuate the sequence creating groupings of textures.

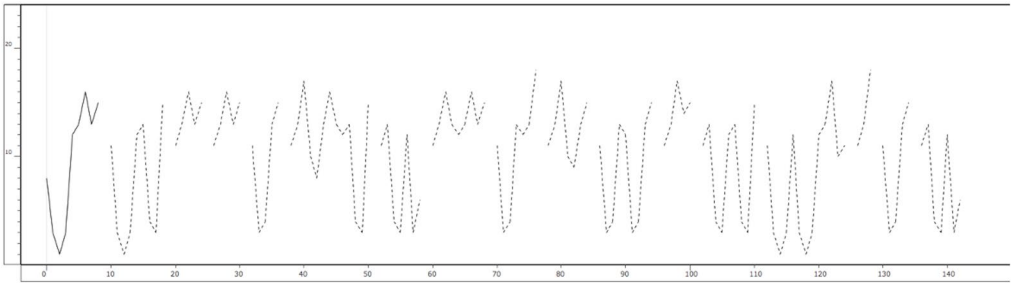


Fig. 15.26 Evolution curve of textures (Figure 15.24) articulated by silences. Figure created by authors.

Another example (Figure 15.27, Figure 15.28) with x and y using minmax moves.

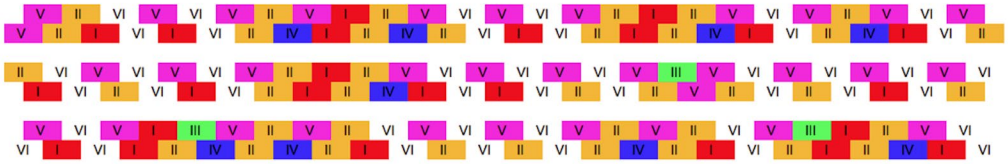


Fig. 15.27 Diagram of successive moves articulated by silences. Figure created by authors.

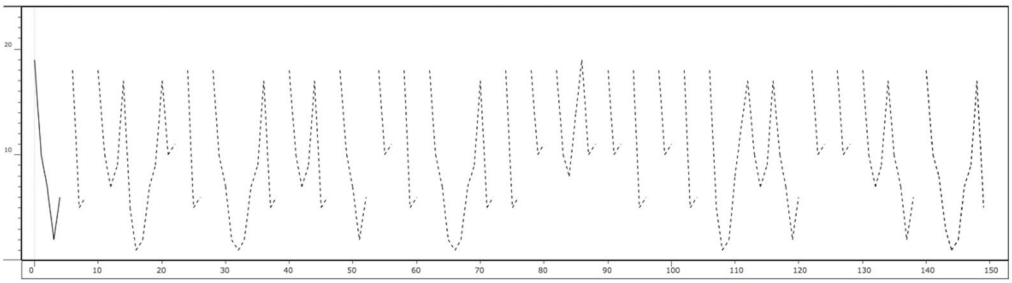


Fig. 15.28 Evolution curve of textures articulated by silences. Figure created by authors.

Conclusions

This work is the first approach to the problem, a simplification for the purposes of this study. As we mentioned, each texture is not a single element, but a category, an equivalence class; for example, the T_1 texture, which is the combination of 2 tactics A, will correspond to 6 sub-textures. In addition, we know that to play each tactic, the leader/conductor can ask to start at any section. Each tactic has 23 sections. That is to say that each of these 6 sub-textures can be broken down into 23 × 23, or 529 possibilities. However, can one really hear the difference? In addition, in rehearsal, the conductors can draw on the expression and duration of each move and on the *tempi*.

At first glance, the choices of the conductors involve problems of a structural or formal order. The random strategy leads to a random structure. A weighted random strategy does not produce noticeable structures, but texture polarizations. And the minmax or gainmax strategies, with or without profits, lead to a game that generates more or less repetitive cycles and patterns.

This brings us to the fact that according to the choices of the conductors, one or more methods could be chosen. If they want a form with redundancies, they will choose to keep the same method as much as possible. However, if they choose to have a more varied form, changing the method helps to achieve this goal.

A final point, considering the choice of tactics, leaders/conductors should be careful of hesitation which could introduce "pauses" in the articulation during the performance, silence having a clear structural function.

It is important to make a difference between the study of the dynamics of the system proposed by Xenakis and the actualization of this system within the context of a real musical presentation. For *Duel*, Xenakis asks for a minimum duration of ten seconds for each move, a minimum time which can be increased or shortened by prior agreement of the leaders/conductors. For ten minutes (600 seconds), with an average time of fifteen seconds, we will have an average of eighty moves per execution. The scale of study of the two situations is very different. In practice, the form will undoubtedly vary from the theoretical form, in particular because of performance issues.

Duel (and even *Stratégie*) have a lot of execution issues, including choosing real-time tactics depending on the chosen method, communication between conductors and performers, and navigating through the scores. The problem of an interface for execution has already been presented on another occasion.[21]

For the continuation of this study, we propose to deepen the study of the calculations of Xenakis, the study of the textures (shape) dynamics, designing experiences with musicians, consulting conductors to improve the interface, complete interfaces for *Duel* and *Stratégie*, and to do a full-scale experiment.

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16. A Myth of Recurrence in Iannis Xenakis's *La Légende d'Eer*

Anton Vishio[1]

De la terre ou de toi, qui a vraiment tourné?
(Abdellatif Laâbi)[2]

On a recent drive through a relentless downpour, I found my attention riveted to the sound of rain pelting the car. I am not sure how long the experience lasted, but it persisted through several waves as the storm recaptured its peak intensity. Gradually, frustrated by the unending deluge, I tried to mine the complex sound for some recognizable shape, some clue that would indicate the ordeal was nearing an end. And at that point, I thought of Xenakis.

Admittedly, one can imagine somewhat safer moments for such contemplation. But I perceived that the rich, granular sound unfolding around me was not unlike ones I had encountered often in the composer's work, not only in terms of its "mass effect" but also in its elusive nature; for Richard Barrett, writing about *La Légende d'Eer* (1977), this nature emerges through a kind of time-dilation, a conflict between time as clocked and time as experienced, time as observed just as one is "forcibly immersed" in it instead of a "safe distance" away.[3]

Indeed, this forced immersion makes the question of the passage of time in *La Légende d'Eer* especially compelling—and especially vexing. Barrett finds that the composition lacks "clearly defined points of departure and arrival"; James Harley similarly remarks that "the music proceeds in an extremely continuous fashion," while

1 The talk this chapter is based on was originally (mis)titled "Negative Form and *La Légende d'Eer*;" many thanks to the editors for allowing me to change it for this publication, as well as to James Harley, Yayoi Uno Everett, Nathan Friedman, and an anonymous reviewer for helpful comments and discussion.

2 Laâbi, 2016, p. 700. Donald Nicholson-Smith translates this as "As between the earth and you, which has actually turned?"

3 Barrett, 2002, p. 77. A better description of being stuck in a relentless downpour would be hard to imagine! Castanet, 2004, p. 22, cites an early observation of Maurice Fleuret (1932–90) about *La Légende d'Eer*, that it concerned "a rain of comets with a thousand suns." All translations not otherwise attributed are my own.

 https://doi.org/10.11647/OBP.0390.18

Pierre Albert Castanet notes the presence in the "electroacoustic flux" of "a strangely labyrinthine sonorous continuum," filled with moments that seem to fold back upon themselves to reveal a wealth of sonic layers beneath.[4] These perceptions speak to the difficulty of fixing anchors as the work flows through and past us; but for Xenakis these "perceptive reference events" are those things, and "only" those things, through which we "seize the flux of time which passes invisible and impalpable."[5] In his essay "Concerning Time," the composer develops an "axiomatization of temporal structures" in which separable "points of reference" in the flux of time, "instantaneously hauled up outside of time because of their trace in our memory," become mental constructs to which we can assign various metrics—"distances, intervals, durations"; these in turn allow us to create, "outside time," a "geographical map" of the composition.[6] The original French terms help to clarify a subtle conceptual journey: the markers we latch on to in the flux are *points-repères* (points of reference), internalized in our recollection as the more spectral *points-traces* (vestiges).[7]

But what if "separability" is not so easily perceived? There are surely phenomena in the work whose clock time we can roughly identify; there is even substantial agreement in the literature on what the most significant of those phenomena are, in the detailed analyses given by the authors already mentioned as well as by Makis Solomos, who provides an especially thick hearing informed by the composer's late draft.[8] But isolating these as landmark *points* in the fluctuation is another matter. We might instead refer to "phases," as Solomos does, for instance in describing the "silent phase" after the extended opening section of *La Légende d'Eer*; "phases" better characterizes the kind of emergence (and decay) encountered in the piece, and explains the fuzziness of its sectional boundaries.[9] The different properties of an architecture of phases as opposed to an architecture of points suggest a focus on the deployment of middle-ground shapes, ones which have space to proliferate through the course of longer sections.

The overall form that encases those sections has also been a point of some consensus in the literature on *La Légende d'Eer*. In particular, there is agreement that the work can

4 Barrett, 2002, p. 75; Harley, 2004, p. 112; Castanet, 2014, p. 25. I have slightly truncated the quotation from Castanet [*le flux électroacoustique va…abondamment entretenir les flux d'un continuum sonore aux détails poétiques étrangement labyrinthiques*].

5 Xenakis, 1989, p. 87; the original French version of this essay appeared as Xenakis, 1988, reprinted in Xenakis, 1994.

6 Xenakis, 1989, p. 89.

7 Xenakis, 1994, p. 102. Elsewhere in the essay (ibid., p.98) he uses, in quick succession, "*repères sensibles*" (perceptible landmarks), "*repères-événements*" (landmark events), and "*phénomènes-repères*" (landmark phenomena), for subtle gradations of similar concepts. Gerard Pape (Pape, 2009, p. 37) has suggested that the same "outside time" structures can lead to a variety of "in time" realizations; one can imagine that the journey of a point of reference from sonic marker to mental "trace" is an important enabler of this variety.

8 Solomos, 2006.

9 Ibid., p. 169. Castanet (Castanet, 2014, p. 28), in his engaging "Petite guide d'écoute" (Brief Listening Guide), speaks of a "*phase acoustique*" (acoustical phase) in relation to the section labeled as C1 on Figure 16.2 below.

be described in a symmetrical fashion, as "roughly circular" (Barrett), "a dramatic arch form" (Solomos), an "immense arch" (Castanet).[10] The correspondences between the beginning and ending of the composition, the presence of similar high-pitched, "whistling" sounds in both, suggest strong support for this formal conception. But, at the same time, such a balanced design seems at variance with the internally unsettled character produced by evolving phases; I shall develop a formal model which addresses those phases and their ultimate fate.

Fig. 16.1 The Pinwheel Galaxy (Credit: NASA, ESA, CXC, SSC, and STScI).

Our consideration can begin with this astronomical object, the Pinwheel Galaxy, Messier object 101; Robert P. Kirshner's description of a supernova within it, as detected in 1970,

10 Barrett, 2002, p. 76; Solomos, 2006, p. 163; Castanet, 2014, p. 28.

is the subject of one of the assemblage of texts that Xenakis provided as background for *La Légende d'Eer*.[11] Kirshner's neutral account of the science of successful prediction of features of supernovas is striking in its orthogonal relationship to the cosmic violence of the event itself. He notes that "The fact that calculations based on models of stars that seem likely to explode agree so well with the observation of stars that actually explode is encouraging." [12] But that violence in the context of M101, in its vast extent, barely registers; indeed, the supernova in question is at the bottom of the galaxy in Figure 16.1, leaving its elegant spiral untouched.[13] In the case of *La Légende d'Eer*, by contrast, the difference in relative size between internal "phases" and overall shape is much less; we should expect a "supernova" in this more intimate, palpably involute context to be far more disruptive, bending that shape to its will.

The quotation from the Moroccan poet Abdellatif Laâbi (b. 1942) in the epigraph addresses the interconnectedness of the work in another, more playful aspect, via *perspective*: imagining how the immersive nature noted above reflects how everything around us is fundamentally in motion, whether we perceive it or not.[14] In this connection, we might also consider Xenakis's vision for *La Légende d'Eer*, as relayed to Dominique Druhen: "I was thinking of someone who would be in the middle of the ocean: All around are the sounding elements, unleashed or not": i.e. some elements seem to cycle around the observer, some seem to become unmoored, floating off into the distance.[15] The ideas then of form as involute, immersive, perspectival, and ultimately provisional, something that can be undermined from within, these are features that ultimately guide what I refer to as the "myth of recurrence" in *La Légende d'Eer*.

11 Kirshner, 1976. The image of the Pinwheel Galaxy in Figure 16.1 appeared several decades after Kirshner's article. I shall briefly review the other texts in Xenakis's assemblage in the last section of this paper.

12 Ibid., p. 93. Xenakis had a choice of supernovas to work with. Kirshner's article leads not with SN 1970g but with a Type I (now Ia) supernova that was discovered two years later by Charles T. Kowal, designated SN 1972e; Kowal's photographs of that supernova, taken over a period of eleven months, appear at the outset of Kirshner's article. But SN 1972e occurs in the "irregular" galaxy NGC 5253, whose shape is much more elusive, a Blue Compact Dwarf galaxy described as "peculiar" at *ESA*, https://esahubble.org/images/potw1248a/. Did Xenakis choose M101 to emphasize its more striking spiral?

13 "SN 1970G," *Chandra X-ray Observatory Center*, https://chandra.harvard.edu/photo/2005/sn70/sn70_hand.html

14 Earlier in this poem, entitled "La halte de la confidence" (A Halt to Disclosure), Laâbi writes "Night after night you scrutinize the stars. Their beauty is not the question. Naming them seems trivial. Their great distance from you? A detail. What you want is to establish a link with them, a physical link..." (Laâbi, 2016, p. 693)—lines which resonate beautifully with Xenakis's admission to Nouritza Matossian, "I want to bring the stars down and move them around. Don't you have this kind of dream?" (Matossian, 1981, p. 50, as cited in Harley, 2004, p. 114).

15 Druhen, 1995, p. 2 [*Quand j'ai composé La Légende d'Eer, je pensais à quelqu'un qui se trouverait au milieu de l'Océan. Tout autour de lui, les éléments qui se déchaînent, ou pas, mais qui l'environnent*].

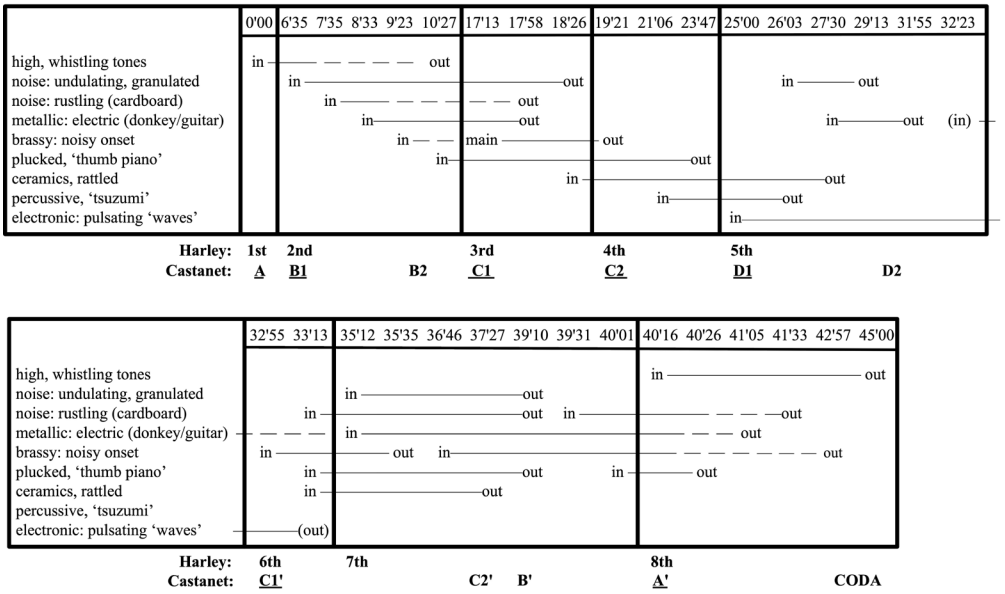

Fig. 16.2 After Harley's form chart for *La Légende d'Eer* (with Castanet's arch). Figure created by author.

Figure 16.2 is based on Harley's compact picture of the form of *La Légende d'Eer*, aligned underneath with the sectional labels proposed by Castanet. At least at section beginnings, the two are largely congruent; Castanet's letters match the beginning of Harley's divisions in seven of eight sections, underlined on the figure.[16] The chart reveals the basis for the suggested frame; the "keystone" of Castanet's arch, section D, is also the only part of the piece other than the outer sections to be dominated by one sound, the pulsating waves. This is not the only sound stream in Harley's fifth section, but in its wide-ranging exuberance—the "deafening phase of the cosmogony," in Solomos's apt description—it easily crowds out the entrances of other materials.[17] And the pulsating waves are limited to this section, just as the A materials are confined to the work's boundaries. This structural similarity however cannot mask the vast gulf between them: the high whistling sounds in A which minimally saturate their texture against the metallic waves in D which maximally saturate theirs. If this is to be an arch, it is held in place by extreme contrast, as if the A and D sections, strong negatives of each other, keep the composition balanced through the force of their mutual repulsion.

If these framing materials remain aloof, interacting minimally with others, the contents of Castanet's sections B and C and their reversals are much more gregarious; they are asymmetrically arrayed, gradually layered in moving from A to D and amassed

16 Harley, 2002, p. 50; also in Harley, 2004, p. 113. I am most grateful to James Harley for permission to reproduce his chart here. I should also point out that Harley's discussion of the form is much more agnostic about large-scale shape than the others; indeed, as we shall see, the details Harley provides help to show where the arch model is less successful.

17 Solomos, 2005.

in a volatile jumble in the reverse. It is in these two very different composings-out where the arch seems weakest. The materials of B and C are basically cyclical; they are characterized by reasonably clear onsets, and they are continually, albeit irregularly, renewed, jostling each other for space.

The sound stream whose cyclic procedure is easiest to perceive in these sections is what Harley labels as "brassy, noisy onset" on the fifth line of his chart. Solomos terms this "white noise followed by Brownian motions," and traces nine appearances of the figure, lasting from eight to twenty-six seconds within a roughly seven-minute period beginning at around 9'30, occurring against the "ground" of what Xenakis designates as "guimbardes africaines," and the "undulating, granulated" texture that was the first new sound to emerge after the opening section.[18] We might describe such multiple, irregularly aligning cyclic threads as "epicyclic," in a literal sense of "circles upon circles."[19] It seems to me that this is one way in which Xenakis enacts the temporal ambivalence so characteristic of this piece. Within each cycle, there seems to be a more or less conventional "behavior," i.e., for this phase noise *then* Brownian motion; each cycle has a perfectly clear trajectory in itself. But the interaction of these separate trajectories amounts to no more than a fluctuating density in the overall shape.

It is undeniable that the sounds at the beginning and the ending of the work—high whistling tones, shooting stars—resemble each other more than they resemble any other materials; but does their resemblance imply a balance between them? There are differences in pitch and timbre, which I will not attempt to detail here; but I was struck more palpably by the difference between the histories of the sounds at the opposite ends of the piece—how the sounds of the opening disappear and how the similar sounds of the ending emerge.

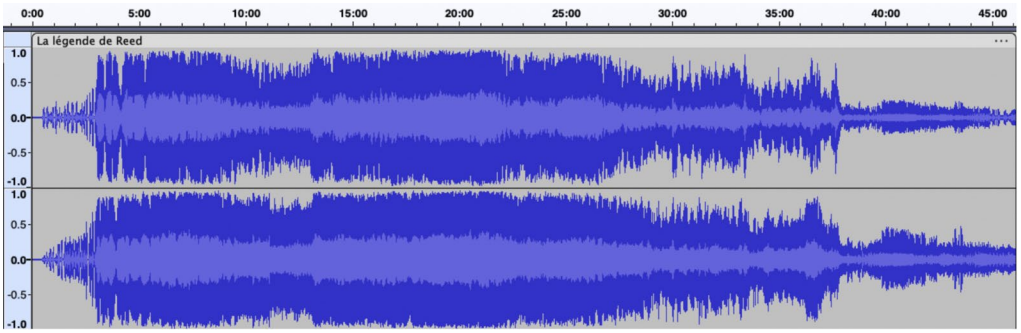

Fig. 16.3 A Doppelgänger of *La Légende d'Eer*. Figure created by author.

18 Solomos, 2006, p. 172–3 [*bruit blanc puis mélodie probabiliste* (*mouvements browniens*)]. Detailing of later occurrences of the sound, interweaved in a more complex sonic environment, can be found in ibid., p. 176–7.

19 To stretch the Ptolemaic metaphor further—perhaps too far!—the "circles" in question could be said to rotate about the "deferent" formed by the larger cycle of the entire composition.

One way I explored the nature of this opposition was to listen to the work backwards, a transformation creating a new piece whose waveform appears as Figure 16.3. Such a maneuver is reminiscent of an article by Edward T. Cone (1917–2004) which criticized then-contemporary analytical writings on the Second Viennese School for being unable to tell the difference between a twelve-tone piece and its mirror image.[20] Here instead I was interested in testing formal *identity; La Légende de Reed* should still retain the arch shape of its progenitor. If anything, though, the reversal more starkly underlines the difference between the two framing A sections. Now the first A section, starting *dal niente*, gradually grows a continuity, blending into the developing texture rather than staying aloof from it; now the final A section seems to achieve a kind of perpetual steady-state, an uneasy rejection of the intensely restless nature of the piece to that point.[21] Meanwhile, this exercise has also clarified for me the differing character of the A sections in their actual order. The first part of *La Légende d'Eer* stands out as self-contained, an exceptional state within the composition as a whole; while at the ending, the material reminiscent of the opening is merely the "last sound standing," as if it had never really gone away. The whistling tones are alone not because they push away any sounds, but because the others have just dispersed.

In thinking about the function of different kinds of interfering or incomplete rotations here, I was reminded of the study of rotational form in tonal music that has been spurred by various publications of James Hepokoski and Warren Darcy, reaching an important articulation point in their treatise on Sonata Theory. In a terminological appendix, they define rotation as the "recycling" of a "referential thematic pattern established as an ordered succession at the work's outset."[22] Such a referential object seems exactly like what we would *not* expect to hear in Xenakis; but Hepokoski and Darcy go on to trace the archetypal nature of the form, and there affinity emerges. After presenting a simple calendrical model of temporal return, they note:

> Another, perhaps more sophisticated, metaphor is that of tracking a large spiral through two or more cycles. No set of events that unfolds in nonrecoverable, ever-elapsing time can exist in a condition of complete identity to any [preceding] set [...] An essential feature of all such constructions is the tension generated between the blank linearity of non-repeatable time and the quasi-ceremonial circularity of any repeatable events [...] inlaid into it. Rotational procedures are grounded in a dialectic of persistent loss [...] and the impulse to seek a temporal "return to the origin," a cyclical renewal and rebeginning.[23]

20 Cone, 1967. Cone initially transformed his examples through inversion rather than through retrograde, to avoid various technical issues; but he does eventually entertain the possibility that retrogression would make the same point (p. 36).

21 In fact, the ending is perhaps even more disturbing in the Doppelgänger; it provides a musical parallel to the phenomenon of heat death, its universe reduced to high whistling sounds in perpetuity. Meanwhile, the clarity of the "epicyclic" material is lost; this casts light on the strategy of how that cycle was constructed in the "forwards" version of the piece, beginning with a breath before moving on to extended Brownian motion.

22 Hepokoski and Darcy, 2006, p. 611.

23 Ibid. Hepokoski and Darcy go on to list a number of other uses of "rotation" in music theory that are

Here we might recall how "non-repeatable time" functions in Xenakis's own musical thought, as the "irreversibility" characteristic of "in time" structures.[24] "Outside time," we are free to imagine the play in the ocean of those sounding elements, which can be set into various relations with each other as we sit surrounded by them, in a "fictitious time….based on memory"; but once we set them in motion "in time," their order is fixed.[25] The "dialectic of persistent loss" is surprisingly close to the dialectic with which Xenakis concludes "Concerning Time":

> The repetition of an event, its reproduction as faithfully as possible, corresponds to [the] struggle against disappearance, against nothingness […] The same principle of dialectical combat is present everywhere, verifiable everywhere. Change—for there is no rest—the couple death and birth lead the Universe, by duplication, the copy more or less conforming. The "more or less" makes the difference between a pendular, cyclic Universe, strictly determined, and a nondetermined Universe, absolutely unpredictable.[26]

In the case of *La Légende d'Eer*, it is striking that the materials that rush in to fulfill the aural space once the "origin" has been abandoned have the "quasi-ceremonial" quality referred to by Hepokoski and Darcy, seeking a new foundation that is ultimately unachievable. The end of the composition seems indeed to suggest a "return to the origin"—perhaps, in the spirit of a question of Michel Serres (1930–2019), "an attempt to fight against temporal irreversibility"—but inevitably it falls short, unable to muster the density of material that would permit regeneration.[27] No rotation can proceed. Instead, the material drifts away, its sounds dispersed, and then falls silent.

Do other works of Xenakis manifest a similar tension, a feint towards reversibility in the face of its impossibility? It seems to me that *Palimpsest* (1979) could be approached from a similar perspective. *Palimpsest* begins with an extended, swirling piano solo, itself continually renewed in density and register; but the function of this opening is puzzling, since it suggests a leading role for the instrument that is only intermittently borne out by the rest of the work. But it turns out it is the material, not the instrument, that is being highlighted; Harley remarks that the work can be heard "as a series of variations on the arborescence entity" that is first unfolded in the piano.[28] The opening "state," like the opening of *La Légende d'Eer*, represents an unusual condition, a situation of order which *Palimpsest* tries to reinscribe throughout the piece in the face of "persistent loss."

Despite Solomos's warning that the relationship between the thematic texts that

quite different; we too can note that "rotation" is applied in a number of unrelated contexts in the Xenakis literature, as a group-theoretic operation (for instance, applied to a cube to generate material in *Nomos Alpha*, as in Vandenboegarde, 1968 or Delio, 1980) or in the varieties of sound movement studied by Maria Anna Harley (M. A. Harley, 1994).

24 Xenakis, 1985, p. 74–5.
25 Ibid., p. 71.
26 Xenakis, 1989, p. 91–2.
27 Xenakis, 1985, p. 73.
28 Harley, 2004, p. 123–4.

Xenakis assembled and the *Diatope* is complex—"they cannot," he emphasizes, "be conceived of as [its] argument"[29] —and despite the vast range of threads contained in the "cosmic string" with which Xenakis lassoed them together, I close with a brief examination of the ways in which formal ideas explored above, about conflicts between the rotational impulse and time irreversible, emerge in and through them. We have already examined the article by Kirshner; I have italicized key turns of phrase in the remaining texts excerpted below.[30]

Plato

> [...] they saw the ends of the chains of heaven let down from above: for this light is the belt of heaven, and holds together the circle of the universe [...] From these ends is extended *the spindle of Necessity, on which all the revolutions turn* [...] *The spindle turns on the knees of Necessity; and on the upper surface of each circle is a siren, who goes round with them, hymning a single tone* [...] round about, at equal intervals, there is another band, three in number, each sitting upon her throne: these are the Fates, daughters of Necessity [...] Lachesis singing of the past, Clotho of the present, Atropos of the future...[31]

Plato describes a threefold rotation about an axis held together by the belt of heaven, whose complex gear work coordinates several epicycles.[32]

Hermes Trismegistus

> 9. But the Mind [...] begat by Word another Mind Creator. *Who being God of the Fire and Spirit, created some Seven Administrators, encompassing in circles the sensible world...*
>
> 11. But the Creator Mind along with The Word, that encompassing the circles, and making them revolve with force, *turned about its own creations and permitted them to be turned about from an indefinite beginning to an interminable end*; for they begin ever where they end...
>
> 14. And He [i.e. the Man, begat by the Father of all things, the Mind] looked obliquely through the Harmony, *breaking through the might of the circles*...[33]

These rotations described in *Poemandres* are, not surprisingly, far more obscure, but Hermes Trismegistus emphasizes the dangerous creative energy involving the

29 Solomos, 2006, p. 192: "On ne peut cependant les concevoir comme l'argument du Diatope."

30 The texts are: Plato, *Republic* 10: 613c–621d; extracts from *Poemandres* by Hermes Trismegistus; *Pensées* by Blaise Pascal (1623–62); and *Siebenkäs* by Johann Paul Richter, known as Jean Paul (1763–1825). Druhen (1995) supplies the full excerpts used by Xenakis. Editions used for the English translations are provided below.

31 Plato, 1970, p. 391–2.

32 The spindle is a representative of the archetype that Mihu Iliescu identifies as "L'axis mundi" in his exploration of gnostic themes in *La Légende d'Eer*; the axis was also realized in the *Diatope*'s central light tower. Iliescu, 2015, p. 230.

33 *Pymander*, Chambers, [1882] 1972, p. 4–5, 7–8.

simultaneous projections of the circles that encompass the "sensible world," producing "irrational animals" as the forced rotations separate out the worlds of air, earth and water; eventually, the creation of the Creator God, Man, discerns the Harmony that allows Him to break through the circles to follow His own creative impulse.

Pascal

> [...] let the earth seem to [Man] a dot compared with the vast orbit described by the sun, and let him wonder at the fact that this vast orbit itself is no more than a very small dot compared with that described by the stars in their revolutions around the firmament [...] *It is an infinite sphere, the centre of which is everywhere, the circumference nowhere.* [34]

Pascal's orbits in their clarity produce an even more terrifying vision, orbits piled upon orbits upon orbits...

Jean Paul

> Upon the dome above there was inscribed the dial of eternity—but figures there were none, and the dial itself was its own gnomon [...] And I fell down and peered into the shining mass of worlds, and beheld *the coils of the great serpent of eternity all twined about those worlds; these mighty coils began to writhe and rise, and then again they tightened and contracted, folding round the universe twice as closely as before*; they wound about all nature in thousandfolds, and crashed the worlds together...[35]

Finally, the nightmare relayed by Jean Paul, whose central image, the "mighty coils" of the "great serpent of eternity," seems to prefigure the *corde cosmique* that Xenakis invokes in yoking together these thematic texts.[36] This excerpt is particularly striking for the dream frame that Xenakis omits: the idyllic setting which disintegrates into this nightmare, and then Jean Paul's waking from the End of Time to a soothing vision, "from all nature round, on every hand, rose music-tones of peace and joy, a rich, soft, gentle harmony, like the sweet chime of bells at evening pealing far away."[37] But as noted above, the end of *La Légende d'Eer* is not soothing, much less an awakening; indeed, Xenakis's preoccupation with death in his works of the 1970s can receive ample confirmation in the final trajectory of this piece, quite apart from the content of the programmatic texts themselves.[38]

34 Pascal, 1961, as cited in Druhen, 1995, p. 21.

35 Jean Paul, [1796–7] 1897, p. 262, 265. In her wide-ranging discussion of the texts, Marie Louise Herzfeld-Schild notes that Xenakis's English source referred to "rings" rather than "coils"; but his source is unidentified. Herzfeld-Schild, 2014, p. 174–5.

36 Xenakis referred to that "cosmic string" as a "sort of sonorous string pulled tight by mankind, through cosmic space and eternity, a string of ideas, of science, of revelations *coiled* around it." Solomos, 2005 (emphasis mine).

37 Jean Paul, [1796–7] 1897, p. 265.

38 Solomos, 2006, p. 193; Harley, 2004, p. 129–33. In her recent essay, Nakipbekova, 2022 provides a broader picture, stretching back to the 1960s.

But that is an awfully gloomy place to end. There is no recurrence, nor was meant to be; but the world we experienced brought into (and out of) being through *La Légende d'Eer* was one worth mourning when it departed. Hopefully, like the original Er, we avoided drinking at the river Unmindfulness; and we have our memories to reconstruct and relive that world until we can hear it again.

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17. Iannis Xenakis's *Hibiki Hana Ma* and the Japanese Team for *Tekkhokan* (Steel Pavilion) at Expo '70, Osaka

Mikako Mizuno

Introduction

Artefacts of Iannis Xenakis's creative process around his electroacoustic work *Hibiki Hana Ma* (1969–70) include rich traces of collaboration between the composer and Japanese musicians and engineers. This represents a climax of alliances between Xenakis and his Japanese colleagues that began in the 1960s (as discussed below). *Hibiki Hana Ma* was repeatedly played every day in *Tekkhokan*, one of the pavilions for the Osaka World's Fair in 1970, sponsored by the Iron and Steel Institute of Japan. *Tekkhokan* was quite unique, both in terms of its architectural shape and its special sound diffusion system, which evolved from a musical idea of Tōru Takemitsu (1930–96).[1]

Official reports, along with the meeting minutes of the Japanese team (which included composers, architects, and sound engineers), plus the architectural blueprints made by Sansei Engineering, all document what occurred and the process of their collaboration.

Five meetings were held between 25 March and 11 April 1968 in order to decide the architectural design and define musical possibilities. The first meeting took place in the offices of the architect Kunio Maegawa (1905–86). Takemitsu's name, as producer, was mentioned in the third meeting on 29 March, and the fourth meeting was held in Takemitsu's office on 5 April when he presented his plan. Takemitsu asserted that the equipment must be completed at least six months before the opening of Expo '70 in order for the musicians to undertake experiments with sound and music, and that the construction should start in July 1968. In that same meeting, Takemitsu mentioned he intended to commission a new piece by Xenakis.[2]

1 "Steel - Expo Osaka 1970," *Worldfairs*, https://en.worldfairs.info/expopavillondetails.php?expo_id=18&pavillon_id=1548

2 Meeting minutes from 8 February to 11 April of 1968, Sansei Engineering (三精エンジニアリング).

https://doi.org/10.11647/OBP.0390.19

Music Program in *Tekkhokan*

For *Tekkhokan*, two types of music were prepared: music played every day, fixed on tapes, and monthly live music concerts. The table below shows the five works of tape music played daily (Table 17.1). There were seven monthly music programs which were composed of Japanese traditional music and one concert of contemporary music. Takemitsu's *Crossing* (1970–71), Yuji Takehashi's (b. 1938) *Ye Guen* (1969), and Xenakis's *Hibiki Hana Ma* had been visually designed with laser lights created by Keiji Usami (1940–2012).

	Music	Composer/performers/planner	Duration
1	*Crossing*, for two orchestra, soloists, and female chorus	Tōru Takemitsu, Seiji Ozawa, and Japan Philharmonic Orchestra	9′00
2	*Yeguen*, for Baschet's sound sculpture	Yuji Takahashi, Baschet's sound sculpture, and Japan Philharmonic Orchestra	10′30
3	*Hibiki Hana Ma*, twelve channel tape	Iannis Xenakis	17′20
4	tape montage *YEARS OF EARs "What is music?"*	planned, recorded, collected, and edited by Makoto Ooka, Shuntaro Tanikawa, Tōru Takemitsu, Keiji Usami, Akimichi Takeda, Takashi Funayama	20′00
5	music for Baschet's sound sculpture and Japan Philharmonic Orchestra	Tōru Takemitsu	

Table 17.1 Daily program in *Tekkhokan*, fixed on tape.

Collaboration with Japanese Musicians and the Preparatory Process of *Hibiki Hana Ma*

Collaboration before 1969

In April of 1961, Xenakis came to Japan and met Yuji Takahashi, Tōru Takemitsu, Seiji Ozawa (1935–2024), and Aki Takahashi (b. 1944), all through Kuniharu Akiyama (1929–96). That year, the World Music Festival in Tokyo was held, which was organized by Nicolas Nabokov (1903–78), founder of the European Cultural Foundation, which itself was financed by the United States of America. The festival was a part of the anti-communist cultural organization of the Cultural Freedom Congress (CCF), East–West Music Encounter. At that time Ro-on,[3] the Japanese Society of Contemporary

3 Ro-on was the Workers' Music Council founded in Osaka in 1949 with the slogans of "good music at a reasonable price" and "planning and management by the members." It spread to other cities

Music (JSCM), and the Musicological Society of Japan (MSJ) declined to work for the event because the CCF was thought to be an anti-communist group. But this congress was the first step of numerous future collaborations between Xenakis and Japanese musicians. At this conference, Luciano Berio (1925–2003), Elliott Carter (1908–2012), Henry Cowell (1897–1965), Roger Sessions (1896–1985), and composer/musicologist Hans Heinz Stuckenschmidt (1901–88) were present, together with Xenakis.

In February of 1962, Yuji Takahashi premiered *Herma* (1960–61) in Tokyo. In 1966, the festival Orchestral Space was realized for three days in Tokyo's Nissei Theater under the artistic direction of Takemitsu and composer/pianist Toshi Ichiyanagi (1933–2022). During the festival, Xenakis's *Stratégie* (1962) was performed on 1 May by the Yomiuri Nippon Symphony, conducted by Seiji Ozawa and Hiroshi Wakasugi (1935–2009), which was released on LP in Japan in 1967, and issued in 1978 in the United States. *Eonta* (1963) was also played in the festival by Takahashi on 4 May, soon after the world premiere in Paris.

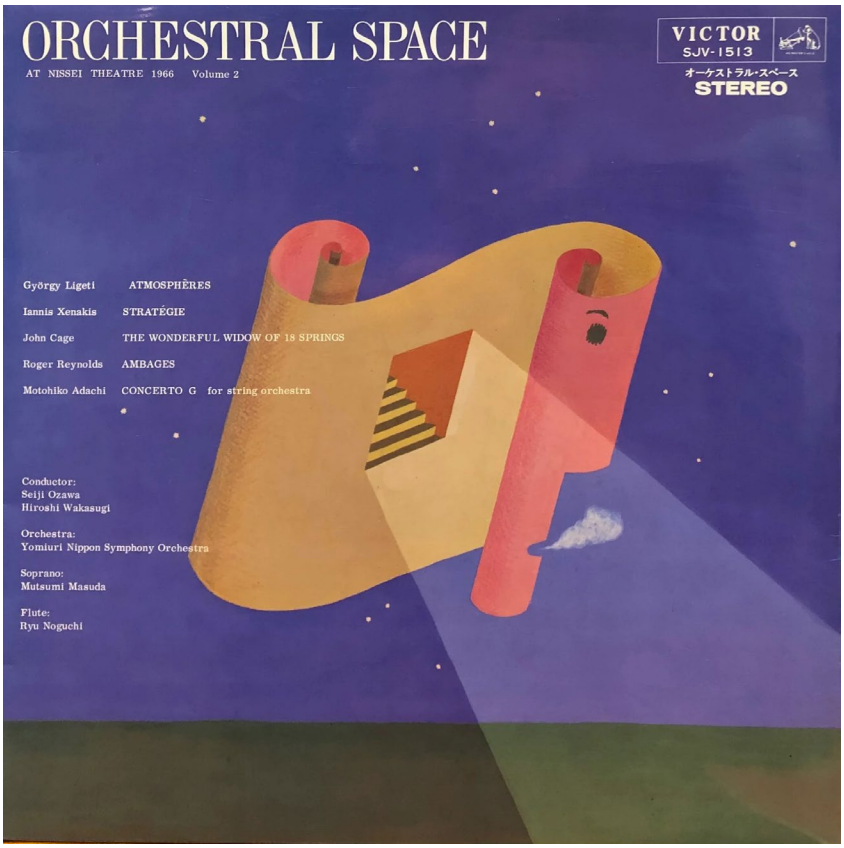

Fig. 17.1 LP cover issued in 1967 in Japan of live performances from the Orchestral Space program, volume 2 (author's personal collection).

throughout Japan, and in 1955, the National Liaison was formed with twenty member organizations and 130,000 members. In the 1960s, the scope of the organization's activities was further expanded.

The Creative Process of *Hibiki Hana Ma*: The Composer's Worksheets and the Japan Team's Materials

In June of 1969, Xenakis came to Tokyo again and talked about his piece for the Osaka World's Fair. He started sketching general sound schema and instrumentation immediately after Takemitsu had asked him to compose a new piece.

In the production process of *Hibiki Hana Ma*, Xenakis made a music score, presumably after sketching several potential spatial sound designs. The music score was performed and recorded by the Japan Philharmonic Orchestra conducted by Seiji Ozawa in Kawaguchi City Hall. The recorded sounds were edited according to Xenakis's sound score, notating two sets of six-tracks. The Table below (Table 17.2) shows the chronology of communications and collaborations around Xenakis's work.

Category	Date	Events
Commission	June 1968	Takemitsu asked Xenakis to compose for the Osaka World Fair
	July 1969	Yuji Takahashi described the outline of the sound system to IX
Composition	5 November 1969	completion of the score of *Yeguen* by Yuji Takahashi
	31 December 1969	completion of the score of *Crossing* by Takemitsu
	5 January 1970	Japan team received the score of *Hibiki Hana Ma* by Xenakis
Recordings	16 November 1969	recording of *Yeguen* in the rehearsal place of Japan Philharmonic Orchestra
	12 January 1970	recording of *Crossing* with 111 players in Kawaguchi City Hall
	13 January 1970	recording of *Hibiki Hana Ma* in Kawaguchi City Hall
Completion in *Tekkhokan*	21 January 1970	*Crossing* and *Hibiki Hana Ma*
	6 April 1970	Xenakis visited *Tekkhokan*

Table 17.2 Chronology of Communications and Collaborations for *Hibiki Hana Ma*.

Xenakis's score was received by the Japanese team on 5 January 1970. On 10 January, Xenakis came to Japan to supervise the recording.

The recording date was 13 January and the completion in the real *Tekkhokan* speaker system was accomplished on 21 January 1970.[4] That means that the creation

4 Expo '70 (1970), *Nippon Bankoku Hakurankai*, Space Theater, Tekkhokan no kiroku.

and sound editing took only one week. Xenakis's notation for editing the tape, as he wrote "special separate graphs" in his manuscript, indicated how he wanted to edit two sets of six-track tapes (twelve channels) from the materials. He said:

> This music is based on 19 basic structures and textures which are written in score form and will be recorded in Tokyo by Seiji Ozawa. Each structure will be mixed with itself in various speeds so as to produce new, more complex textures. This work should be done in Tokyo or in Osaka at an electronic music studio. Pultec Filters and reverberation devices, together with speed variations of the tape will be welcomed. The final multitude mixing will be made on the two six tracks tape recorders of the Pontillia. Both this final mixing and the distribution of the tracks over the speaker systems is described on special separate graphs.[5]

Xenakis refers to Pultec filters and to Pontillia recorders in this statement. This was written before the final decision of the technical environment in *Tekkhokan*. Meanwhile, the published program note presupposes the realized architecture and equipment.

The text above is not to be found in the official program note, which was published as the pamphlet of *Tekkhokan*. The published program note is as follows:

> Electroacoustic piece for 12 channels, 800 speakers. Composition for the 1970 Osaka World's Fair, *Tekkhokan*. Dedicated to my friends Kuniharu Akiyama, Seiji Ozawa, Yuji Takahashi, and Tōru Takemitsu. Extremely complicated systematized sounds; that is, various *glissando* of string instruments, polyphony of the wind instruments, groups of percussions, basic structure of Japanese music. And the orchestral sounds of the Japan Philharmonic Orchestra conducted by Seiji Ozawa, Biwa sound by Kinshi Tsuruta, tsuzumi, and various noises. These sounds have been edited in the electronic [music] studio, and set onto the splendid or, on the contrary, sad maze of the glass box, following the labyrinth and distributed into the space.[6]

It is noticeable that Xenakis made several levels of his score in the production process of *Hibiki Hana Ma*. These are various types of documents: from primal textual memos to the final sound diffusion plan. The music score was written as an orchestral score, the aim of which was to produce sound materials for creating his electroacoustic composition. The second score for sound editing was used by the sound engineers, and it notates the arrangement of the materials for the two sets of six-tracks. The third score, which is not in music notation but a colorful graph, shows the calculation of the speed of each sound material.[7]

5 Xenakis quoted in Kanach, 2009, p. 95.
6 Xenakis, 1970.
7 See various examples in Kanach, 2009.

Plans for *Tekkhokan*'s Sound System, Based on Tōru Takemitu's Idea

Yuji Takahashi gave Xenakis the information on the architecture and the sound diffusion system of *Tekkhokan* in July 1969. In Xenakis's worksheet for *Hibiki Hana Ma*, several phrases concerning sound diffusion can be found. One example is: "Conclusion: 12 ch for fixed + 6 ch autom. Then any movement is possible."[8]

However, the idea of the sound diffusion system, which was unique and originally designed by Japanese engineers working at that time at Sansei Engineering, had started with Takemitsu's comment about sound diffusion: "sound movements should not be from point to point, but should be from phase to phase, which include global time differences and in which the audience should be travelers going through the spectrum of different times."[9]

Takemitsu described much more in the official book of *Tekkhokan*:

> The traditional form of a concert hall gives us a specified sound environment where listening is a quantitative experience of some fixed sound sources and is divided into two quantitative places; the stage, which eventually provides space for performing, and the audience, which is placed in a strongly determinate space. In the concert hall, the qualitative proper space which each sound has in its inner space has been replaced by conformed quantity. [...] Music has developed a new realm since 1948 through electronic procedures, and has made it possible to simultaneously listen to multiple heterophonic sound images and heterogeneous time structures. This new music (*musique concrète*) has great influences on live instrumental music. Sound sources are granted free disposition, which is very different from the standard instrumental music [...]
>
> Space and the spatial timbre –time texture of sound images [...] are added as important parameters which compose the music. [...]
>
> The qualitive space which was divided into two quantitative spaces can now multiply quantitative movements in the other space of information supply. But the fixed audience space has no freedom to "Earlize" (= move around) the multiple realized sound space.
>
> The term "Earlize," in reference to "Televise"; meaning trimming objects to fit a television screen. [...]
>
> How can we make the audience space into a qualitive space of movements? Let's get rid of the fixed audience space in the concert hall. The structural space of the concert hall should be planned as a situation in which qualitatively different and numerous spaces are multiplied. Therefore, both the fixed sound sources and the performance places should be put in an elastic situation. And the sound space should not move from point to point but be required to be intersecting planes. [...]
>
> Is it possible, for example, to establish global time differences or different time zones in the space of a concert hall?
>
> If so, the sound layers are movements circulating around the audience, and the audience

8 Kanach, 2009, p. 91.

9 Takemitsu, 1970, p. 1–4. All translations from Japanese by the author.

> becomes travelers passing through the spectrum of sounds and time zones. Such a new concert hall is an organ which changes the quantitative space where the stage is simply separated from the audience into a qualitative space.[10]

The quotation above comes from the official booklet of *Tekkhokan*, but the idea itself had been announced already at the general meeting of the Japan Team.

The Japanese acousticians calculated twelve directions of sixty degrees as the best shapes that would enable the audience to feel that they were surrounded by sound sources from all directions. The next section describes what was actually realized in *Tekkhokan* in April 1969.

Technical Realization of the Space Theater within *Tekkhokan*

Takemitsu's rather philosophical text was technologically interpreted by Jyoji Esaki (1925–2008), an electronic sound engineer. Table 17.3 below shows Esaki's description in the first stage of realization.

Space Concept by Takemitsu	**Technical Idea by Esaki**
different fixed sound sources	lots of speakers
elastic performance space	multiplicity of sound fields
intersecting sound planes	one group of speakers turned to one direction and simultaneously operated with the other speaker groups turned to the diagonal or contrasted directions

Table 17.3 Space concept and technical idea.

Sound Control System of *Tekkhokan*

Design Outline

The most unique point is the method to store diffusion patterns and the play control system by using 16 mm film, which was designed by Esaki. The system included the specific design of cine-sync (cinecoder), auto-cueing magnetic tape, control mixer, output-control depending on the performance idea, input-control depending on the performance idea, filters, echo-machine, and PA.[11] It was a kind of real-time sound modulating and cueing control system using cinema film, including control over the movement of the speakers.

10 Takemitsu, 1970: four paragraphs by Takemitsu as a staff member.

11 *Cinecoder* was made by the combination of: 16mm film, a solar cell screen, and a fader amplifier. Ishii, 1985, p. 34.

Number and Placement of the Speakers

The total number of speakers was actually 1,008, excluding monitor speakers.

- 84 speakers in the ceiling, 32 of which included 4 speakers inside and 52 of which included 2 speakers inside; this makes a total of 232 speakers.
- 24 speakers in the walls, all of which included 2 speakers inside, making a total of 48 speakers.
- 16 speakers on the stage, all of which included 2 speakers inside, making a total of 32 speakers.
- 696 single speakers under the floor.[12]

The number of the speakers was calculated considering that the most suitable angle for two channels was sixty degrees so that several people could share the speakers in case of a large audience. It also takes into account that people are not as sensitive to sound coming from below or behind. The ultimate goal was that each audience member may sense sounds coming from all directions, although the audience could move around as well. Each of the 1,008 speakers was connected to a separate amplifier.

The stage and the auditorium of *Tekkohkan* were divided into four equal areas: East, West, South, and North. Each zone was acoustically independent and did not interfere with the others. The resonance could be artificially controlled. *Crossing* by Tōru Takemitsu was performed mainly with manual operations and only used the automatic control for support. *Yeguen* by Yuji Takahashi was performed both manually and by the automated system.

The pieces were performed by six persons, one of which was a conductor. The other five people controlled the diffusion to the speakers where the sound was directed.

Control System

The auto-control system of *Tekkohkan* was composed of two parts:

1. Music was analyzed and recorded on 16 mm film. The program was processed by projecting this film onto the solar cell screen through an electric control panel.
2. The program, which receives electricity produced by the solar cell automatically, decided the volume through an auto-fader.

The film moved at twenty-four frames per second. There could be ten levels set for sound decaying.

Sounds were recorded on four six-channel tape-recorders, meaning twenty-four tracks; that is, twelve stereo sound sources were divided onto two sets of two tape-

12 Fujita, 1970, p. 14.

recorders, eight were connected to the ceiling, and four were linked to the bottom. Two film projectors were used in order to adjust the electricity. The recorded sounds were played by the two film projectors plus human manual operations. Figure 17.1 below shows examples of spatializations for *Hibiki Hana Ma*.[13]

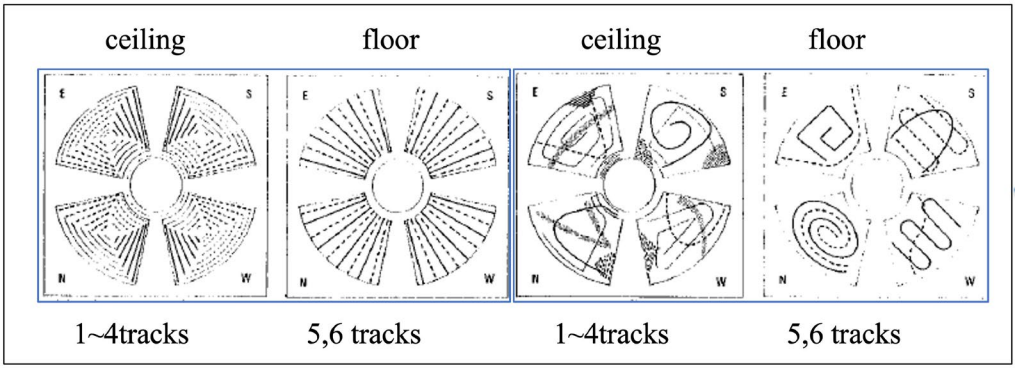

Fig. 17.2 Spatialization in *Hibiki Hana Ma* (Source: Esaki, 1970).

Channels 1–4 were assigned to the ceiling (air), 5 and 6 were assigned to the floor (ground). In the two left patterns of Figure 17.2, *Outside/Inside* are opposite the site of right/left among the group East/West and the group South/North. In the two right patterns of Figure 17.2, each block has different patterns. There were three patterns of *spatial movement:*

3. Permutation of single channels.
4. Permutation of 4 channels and permutation of 2 channels.
5. Ceiling or floor for each.
6. Permutation of both 2 channels and 4 channels.

Conclusion

The planning and construction of *Tekkhokan* proceeded under such a tight schedule that the creators did not have enough time to discuss the collaborative work, as shown in the testimonies by composers Takemitsu and Minao Shibata (1916–96), and musicologist Akimichi Takeda (1937–2003), and others.[14] The information concerning the sound system which Yuji Takahashi discussed with Xenakis in July 1969 may have been different from the system that was realized in March 1970.

On Xenakis's worksheets we can see his idea which requires independent mono track control, not stereo control. For example, air (ceiling) track 3 of East/West runs to

13 Esaki, 1970, p. 13.
14 Takemitsu, 1998, p. 51–2. Shibata, 1975, p. 48–59. Takeda, 1995, p. 18–23.

ground (floor) track 2 of South/North, while air (ceiling) track 4 of East/West runs to ground (floor) track 1 of South/North.

Xenakis wrote, "jamais croiser gr. to air,"[15] meaning that the sound should never intersect from down to up; such spatial movement was not included in *Tekkhokan*'s diffusion patterns.

It is uncertain if Xenakis's original ideas of sound spatialization, noted on his worksheets, were realized when *Tekkhokan* started in March 1970. This may be a future topic of research. We can propose here that there can be possible realizations of the spatialization of this mammoth piece other than the one originally realized in *Tekkhokan* in 1970.

Fig. 17.3 Photo of Performance hall in *Tekkhokan* (Space Theater) in Osaka. Photo by Juan Manuel Escalante (2024).

15 Kanach, 2009, p. 91.

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18. Iannis Xenakis's *Pithoprakta*: A Phenomenological Approach

Erik Christensen and Lise C. Bjerno[1]

Introduction

The background for the present investigation is the music phenomenology proposed by the musicologists Thomas Clifton (1935–78) and Lawrence Ferrara (b. 1949), and the philosopher Don Ihde (1934–2024). These scholars have developed their theories and practice on the basis of the phenomenological philosophy of Edmund Husserl (1859–1938), Martin Heidegger (1889–1976), and Maurice Merleau-Ponty (1908–61).

Phenomenology is the active investigation of the experienced world, realized by descriptions of the first-person experience and reflections on the process of experience. Phenomenology is not a finished system, but an evolving practice. Thus, phenomenology is a style of thinking, a special type of reflection, and the means of understanding phenomenology is the practical application of phenomenology.[2]

Clifton is the enthusiastic discoverer who has applied phenomenology in a wide range of descriptions of music from Gregorian chant to twentieth-century compositions. He emphasizes that all kinds of sound can be heard as music; that space, time, motion, and feeling are basic constituents of music, and that musical experience is an action of the body.[3]

Ferrara is the pragmatic researcher who, in a phenomenological description of Edgard Varèse's (1883–1965) *Poème électronique* (1957–58), has proposed a procedure that alternates between *Open listening* without deliberate focus, *Music-focused listening* which aims at describing particular musical features, and *Hermeneutical listening* which aims at discovering possible interpretations of the music. It is his predominant interest to uncover meaning, history, and lifeworld in the music.[4]

Ihde is the reflecting philosopher who points out that the aim of music

1 A shorter version of the present text was published in Spanish in *Pilacremus* (2022), vol. 6, p. 51–70.
2 Clifton, 1983; Ihde, 2007.
3 Clifton, 1983.
4 Ferrara, 1984.

 https://doi.org/10.11647/OBP.0390.20

phenomenology is to reveal unnoticed aspects of the music and to appreciate the richness and complexity of sensory experience. This is achieved by conducting phenomenological variations, that is, varying the listener's focus of attention in multiple ways and performing a succession of listening tasks directed by specific questions. Ihde states that music permeates and engages the experiencing body, and that the unity of the senses is primordial. He distinguishes between a first phenomenology, the phenomenology of essence, structure, and presence based on Husserl, and a second phenomenology, the phenomenology of existence, history, and the hermeneutical based on Heidegger.[5]

The question posed in this chapter is the following: can a phenomenological investigation uncover and describe important aspects of Iannis Xenakis's orchestral work *Pithoprakta* (1955–56)? To aim at answering this question, we have performed a procedure of Experimental Listening, based on the recording of The French Radio Symphony Orchestra conducted by Maurice le Roux, duration 9′45″.[6]

Pithoprakta

Xenakis's orchestral work *Pithoprakta* was composed for forty-nine musicians: forty-six divisi strings, two trombones, and one percussionist playing woodblock and xylophone. Hermann Scherchen (1891–1966) conducted the first performance of the work in 1957. We present the outcome of a phenomenological investigation of *Pithoprakta*, encompassing comparatively detailed descriptions and hermeneutical interpretations of the work, including prominent musical features, sonorities, densities and transformations of sound masses. In order to minimize presuppositions and promote unbiased listening, we did not study the score or research on *Pithoprakta* prior to the listening sessions. Subsequently, in a survey of the work, we summarize the macroform and possible emotional interpretations of the music, and include references to the printed score. In addition, we quote texts and statements by Xenakis in order to enable comparisons between our investigation and the composer's intentions. References to selected research widen the perspective of the investigation by pointing out important aspects of Xenakis's music and his personality.

Experimental Listening

On the basis of the theories and practice proposed by Clifton, Ferrara, and Ihde, the present authors have developed the procedure named *Experimental Listening*: two music professionals listen an unlimited number of times to a piece of music, applying deliberately varied listening strategies, directed by specific questions and tasks. The

5 Ihde, 2007, 2012. For a detailed introduction to music phenomenology, see Christensen (2012).

6 LP recording from 1965 on Chant du monde label (VCS 10030), reissued on CD on the same label in 2001 (LDC 278368).

goal is to provide reliable descriptions and hermeneutical interpretations of the piece.[7] In the progression of listening, we follow the rules for phenomenological investigation proposed by Ihde (2012): 1) Describe, do not explain. 2) Perform phenomenological variations. 3) Regard all experienced phenomena as equally real. 4) Include intersubjective verification.

As a preparation, the first author (EC) listened to *Pithoprakta* fifteen times in order to collect observations, possible questions, and listening tasks, as well as to propose a division of the piece into shorter sections in order to facilitate the process of description. Subsequently, both authors listened multiple times to the separate sections, and occasionally to the whole piece.

Xenakis has divided *Pithoprakta* in four sections, separated by silences. In the following table, we propose a division into subsections, characterized by the predominant features heard at the beginning of a subsection:

Sections	Subsections	
Section 1 (2′14) 0′00–2′14	1a (0′45) Wooden tapping sounds	0′00–0′45
	1b (1′29) Arco strings added	0′45–2′14
Section 2 (2′23) 2′14–4′37	2a (0′16) A myriad of sounds	2′14–2′30
	2b (1′27) A broad belt of sound	2′30–3′57
	2c (0′40) Salient *glissandi*	3′57–4′37
Section 3 (2′37) 4′37–7′14	3a (1′36) Complex polyphony	4′37–6′13
	3b (1′01) Sharp crack, trombones added	6′13–7′14
Section 4 (2′26) 7′14–9′40	4a (0′17) Brief gestures	7′14–7′31
	4b (0′48) Polyphonic *glissandi*	7′31–8′19
	4c (1′21) Two sharp cracks, increasing noise	8′19–9′40

Table 18.1 Sections and subsections of *Pithoprakta*.

The timing of a section or a subsection includes the subsequent silence.

7 Christensen, 2012; Christensen and Bjerno, 2020.

Method

We conducted three listening sessions on 20 April, 22 April, and 2 May 2022. Each listening session had a duration of four hours. We listened to the whole piece and the sections and subsections multiple times. The first author (EC) planned and guided the progression of listening, and the second author (LCB) provided verbal descriptions and hermeneutical interpretations. EC added occasional comments. The outcome of every single listening was notated by EC and included in an edited summary.

What follows here is a report of the listening sessions, encompassing an initial and a final listening of the whole piece and detailed accounts of music-focused observations and hermeneutical interpretations of the separate sections of the work.

Initial Listening of the Whole Piece

Open listening without deliberate focus.

A smashing composition, displaying salient differences and contrasts. Powerful sections, quiet sections, organic sections, elegant musical forms. A variety of tempi, different degrees of transparence. A great variety of sounds from tiny drips to booms and roars. Many short sounds and many short fragments of melody and rhythm. Prominent pauses.

The initial wooden sounds set a scene and open a space. Sharp cracks appear throughout the piece. The repeated recognition of the sharp cracks ties the different sections together.

Summaries of Subsequent Listening, Multiple Times

Section 1a (0′45) Wooden tapping sounds 0′00–0′45)

Music-focused: Wooden sounds produced by tapping the stringed instruments with fingertips.

Hermeneutical: The sound of small feet on a wooden floor. Many children enter the scene, run around like playing hide-and-seek. Later, the increasing density of sounds resembles raindrops falling on a wooden roof.

Section 1b (1′29) Arco strings added (0′45–2′14)

Music-focused: Non-metric wooden sounds continue as a background. In the foreground, sharp arco strings begin playing brief sections of melodic-rhythmic gestures. Between these sections, the background sounds stand out, with additional *pizzicato* sounds.

Midway in the section the volume rises. Distinctness disappears in a complex powerful sound in motion, including ripping sounds. Four prominent sharp cracks and rumbling sounds lead to a final characteristic cluster chord.

Hermeneutical: The soundscape becomes ominous. Possible foreboding of war. The children take flight. Many people in a market place express statements and dialogues.

[EC: I have not experienced associations to war, but I accept the interpretation.]

Section 2a (0′16) A myriad of sounds (2′14–2′30)

Music-focused: A myriad of melodious movements and noises.

Hermeneutical: A multitude of grasshoppers.

Section 2b (1′27) A broad belt of sounds (2′30–3′57)

Music-focused: A broad belt of continuous sound at the bottom, rhythmical patterns of clear sounds at the top. Towards the end of the section the continuity disintegrates. After a sharp crack, a kaleidoscopic pattern begins expanding upwards and downwards, accumulating tension which is released in the next section.

Hermeneutical: Background: Lovely continuous sound, gently pulsating or breathing. Foreground: A forest with a woodpecker and bird voices, sounding rather mechanical. Finally, the birds freak out.

An alternative interpretation: A pleasant soft fundament at the bottom. High sounds gather in a continuous stream, like stationary fireworks with glimpses of light, or an electric bell.

Section 2c (0′40) Salient *glissandi* (3′57–4′37)

Music-focused: Sudden strong *glissandi* up and down, followed by single-instrument *glissandi* in different registers. *Pizzicati* interact with the *glissandi*. Deep tone at the end.

Hermeneutical: In the last part of the section: Elegant *glissando* gestures and *pizzicati* in playful motion up and down, like a well-timed and well-balanced ballet.

Section 3a (1′36) Complex polyphony (4′37–6′13)

Music-focused: A polyphony of many different string sounds. Strings struck with the bow, *pizzicato*, rumbling thick strings, sharp sounds, small fragments of melody and rhythm. Glimpses of regular meter. The basses indicate a tempo from the beginning.[8]

Hermeneutical: Continuous commotion. The rumbling sounds seem scary. War is present or approaching. However, people live and survive in a country that is being bombed. They dance, sing, laugh, and find food.

8 In the printed score, the composer describes the complex section 3a as a "nebula of sounds, the galactic configurations of '*arco norm.ff*' [...] must be put in relief." Score measures 122–70, Xenakis, 1956, p. 17.

Section 3b (1′01) Sharp crack, trombones added (6′13–7′14)

Music-focused: Salient sound of two sliding trombones on a background of rapid movements of stringed instruments. Gradually, the movements condense in a regular meter and marked rhythms.

Hermeneutical: The sound of threatening airplanes indicates war. Subsequent shooting and the jerks of wounded bodies. After a moment of silence and another brief shooting, the section ends with the sound of tramping boots followed by silence.

[EC: I have no associations to airplanes and a battlefield. I simply hear the sliding sounds of trombones, followed by metric and rhythmic patterns. However, I can understand your experience of war.]

Section 4a (0′17) Brief gestures (7′14–7′31)

Music-focused: Metric melodious *pizzicati* followed by sonorous deep sounds and disintegrated toneless *pizzicati*.

Hermeneutical: We both heard this brief section as a comic interlude, like a cartoon or a moment of stand-up comedy: "A group performs a clumsy movement. Met with unanimous mockery, they fumble and stumble." We could not help laughing, presumably as a relief after listening to several serious sections.

Section 4b (0′48) Polyphonic *glissandi* (7′31–8′19)

Music-focused: A variety of solo *glissandi* and grouped *glissandi* interspersed with *pizzicato* melodies in different tempi and registers on a background of heavy sounds.

Hermeneutical: A beautiful dance. The gliding sounds in this section remind us of the enchanting underwater songs and dances of the seductive females, called Sirens in the Greek mythology.

Section 4c (1′21) Two sharp cracks, increasing noise (8′19–9′40)

Music-focused: The gliding movements assemble in a strident multilayered sound mass. In a rising, whirling movement, the sound mass gradually dissolves, leaving sparse piercing sounds.

Hermeneutical: The beautiful music is interrupted by an air-raid alert. People run away and disappear. At the end, merely extremely unpleasant high sounds are left, like glimpses of blinding light. The sounds jar on the ear and cause tortuous bodily feelings, like screeching chalk on a black board or a metal file grating your teeth.

[EC: I can accept your experience of a noisy air-raid alert in this section, but I do not share your feeling of tortuous sounds at the end. At the end I hear thin ephemeral sounds disappearing in open space.]

Particular Music-focused Listening Tasks

In the course of the investigation described above, we have included specific music-focused listening tasks. Some examples are the following:

Task: Listen for Different Sonorities

Section 1a: The sound of tapping on wood.

Section 2b: A field of harmony and timbre sustained by string instruments.

Section 3b: Rapidly moving string sounds blend with the sustained interferent sound of trombones.

Section 4c: A field of noise ranging from diffuse deep sounds to sharp high sounds.

Task: Listen for Musical Transformations

Section 1b: In the strings, the mode of playing gradually changes from mixed tapping, *pizzicato* and arco playing to complete dominance of arco playing.

Section 2c: Massive multiple *glissandi* dissolve into transparent single *glissandi*.

Section 3b: Non-metric sound is transformed into regular meter.

Section 4c: A field of noise in motion is transformed into massive sustained noise which subsequently dissolves into ascending whirling motion.

Final Listening of the Whole Piece

We rounded off the sessions with a music-focused listening of the entire piece, performing the following task: describe the density or transparence of sound in each section.

Section 1a (0′45) Wooden tapping sounds

Transparent at the beginning. Groups of sounds appear gradually. The density of sounds increases, like raindrops. However, a certain degree of transparence remains, the view is not blocked.

Section 1b (1′29) Arco strings added

Variable layers of foreground and background. A rather dense layer of wooden sounds in the low register. Pauses permit the experience of an open view. Towards the end of the section, the density increases to impenetrability.

Section 2a (0′16) A myriad of sounds

Three layers: Low, middle and high sounds. Rather massive at the bottom. The top layer of sounds resembles a scrub which you can look through.

Section 2b (1′27) A broad belt of sound

The continuous sound constitutes a rather transparent background, like a mist.

Section 2c (0′40) Salient *glissandi*

Beginning: Rather dense sound, like broad brushstrokes. End: Extremely transparent.

Section 3a (1′36) Complex polyphony

Not massive. A swarm of varied sounds, glimpses of transparence. Blurred sound at the bottom.

Section 3b (1′01) Sharp crack, trombones added

Beginning: Two layers: Dense sound of trombones, transparent sound above.

Middle: *Pizzicati* clear the space, opening a free view.

End: Long pauses of silence, plenty of empty space.

Section 4a (0′17) Brief gestures

Salient quasi-melodic *pizzicati* and heavy bass sounds in an open space, followed by scattered *pizzicati* which disappear.

Section 4b (0′48) Polyphonic *glissandi*

A continuous layer of sound of variable density. The layer is not thick, but constantly blurred.

Section 4c (1′21) Two sharp cracks, increasing noise

Beginning: Massive noise, gradually changing towards transparence.

End: Sharp high sounds in a completely transparent space.

Comments on the Descriptions and Interpretations

In order to underpin unbiased perception and description as far as possible, we did not study the score or research on *Pithoprakta* before the listening sessions. Subsequently, we have compared our descriptions and interpretations with the printed score and related research.

Our listening was sometimes “open” without deliberate focus, sometimes guided by specific questions or tasks. It is our experience that the alternation between open

and focused listening is rewarding. Multiple listening of the separate sections resulted in music-focused as well as hermeneutical descriptions.

Hermeneutical listening includes emotional and aesthetic responses, and the hermeneutical interpretations are related to the listener's personal knowledge, lifeworld, and previous experience. It is conspicuous that LCB was inclined to interpret the sounds of certain sections as ominous, threatening, or warlike, while EC more hesitantly accepted associations to war and battlefields. The listening sessions took place in the spring of 2022 while war between Ukraine and Russia was ongoing, so associations to warlike sceneries were obvious and likely. We consider associations to war relevant, as it is well-known that Xenakis experienced alarming events of resistance and battles in Greece during World War II, when his face was wounded, and he barely survived. Xenakis mentions these circumstances in his comments on musical creation, quoted below.

We find that the variety of structure and aesthetic expression in *Pithoprakta* is admirable, ranging from clarity and simplicity to complexity and ambiguity, and from beauty and elegance to massive noise. In the hermeneutical listening of *Pithoprakta*, we experience a variety of emotional impact, ranging from pleasure, delight and enchantment to anxiety, alarm and tortuous bodily feelings.

We can briefly summarize our music-focused descriptions and emotional interpretations of the subsections of *Pithoprakta* in the following overview, with indication of the corresponding score measures:

Duration	Brief music-focused description	Brief emotional interpretation	Measures
1a (0′45)	Wooden tapping sounds	Pleasant	1–16
1b (1′29)	Arco strings added	Ambiguous	17–51
2a (0′16)	A myriad of sounds	Lively	52–9
2b (1′27)	A broad belt of sound	Lovely	60–104
2c (0′40)	Salient *glissandi*	Elegant	105–21
3a (1′36)	Complex polyphony	Ambiguous	122–70
3b (1′01)	Trombones added	Threatening	171–99
4a (0′17)	Brief gestures	Surprising	200–7
4b (0′48)	Polyphonic *glissandi*	Beautiful	208–30
4c (1′21)	Increasing noise	Alarming	231–67

Table 18.2 Overview of *Pithoprakta*.

In the score, the four sections are clearly separated by silent bars. According to our investigation, each of the sections displays a distinct character: Section one displays a contrast between simple wooden sounds and complex mixed sounds. Section two is predominantly pleasant. Section three is predominantly serious. In section four, beauty is disturbed by alarm.

It seems relevant to point out that Xenakis would not have accepted this kind of description. He energetically refused to discuss any emotional impact of his music, as recalled by Bálint András Varga (1941–2019) in his conversations with Xenakis.[9]

Xenakis Describes *Pithoprakta*

Here, we quote texts by Xenakis, and an excerpt of an interview in order to enable comparisons between our phenomenological description and the composer's own statements. Xenakis has provided this introduction for the 1965 recording:

> *Pithoprakta* (Actions through probabilities).
>
> Written in 1955–56 and dedicated to Hermann Scherchen who conducted its first performance in March 1957 at the Musica Viva concerts in Munich, the work is scored for 50 instruments: 46 strings, 2 trombones, 1 xylophone, 1 woodblock. The author, using the findings of probability theory, is seeking a confrontation here between continuity and discontinuity through *glissandi* and *pizzicati*, tapping with the wood of the bow (*col legno*), or very short bow strokes, as well as striking with the hand the resonator of the stringed instruments, which are divided to the maximum. This is an approach towards "stochastic" (probabilistic) music. With the *glissandi* which can (visually) be assimilated with straight lines, volumes of sound are created which are in constant fluctuation. With a large quantity of isolated sounds spread across the whole sound spectrum, a dense "granular effect" emerges, a real cloud of moving sound material, governed by the laws of large numbers (Laplace-Gauss, Maxwell-Boltzmann, Poisson, Pearson. Fischer). Thus, the individual sound loses its importance to the benefit of the whole, perceived as a block, in its totality. The author's ambition is thus to discover a new "morphology" of sound, fascinating both in its abstract (probabilistic theory) and concrete (sensation of hitherto unknown materials) aspects.[10]

This distinct and informative introduction to *Pithoprakta* accentuates salient musical features and the underlying theory of compostion. The composer's statements add precision and theoretical perspectives to our music-focused observations. Characteristically, Xenakis does not include considerations of aesthetics or musical form. In the following quotation from his book *Formalized Music*, Xenakis relates his striking observations of mass events in nature and society, which urged him to invent a completely new kind of music:

9 Varga, 1996, p. 137–8.

10 Xenakis, 1965, reissue in CD booklet from 2001.

> I originated in 1954 a music constructed from the principle of indeterminism; two years later I named it "Stochastic Music." The laws of the calculus of probabilities entered composition through musical necessity.
>
> But other paths also led to the same stochastic crossroads—first of all, natural events such as the collision of hail or rain with hard surfaces, or the song of cicadas in a summer field. These sonic events are made out of thousands of isolated sounds; this multitude of sounds, seen as a totality, is a new sonic event. This mass event is articulated and forms a plastic mold of time, which itself follows aleatory and stochastic laws. If one then wishes to form a large mass of point-notes, such as string *pizzicati*, one must know these mathematical laws, which, in any case, are no more than a tight and concise expression of chain of logical reasoning. Everyone has observed the sonic phenomena of a political crowd of dozens or thousands of people. The human river shouts a slogan in a uniform rhythm. Then another slogan springs from the head of the demonstration; it spreads towards the tail, replacing the first. A wave of transition thus passes from the head to the tail. The clamor fills the city and the inhibiting force of voice and rhythm reaches a climax. It is an event of great power and beauty in its ferocity. Then the impact between the demonstrators and the enemy occurs. The perfect rhythm of the last slogan breaks up in a huge cluster of chaotic shouts, which also spreads to the tail. Imagine, in addition, the reports of dozens of machine guns and the whistle of bullets adding their punctuations to this total disorder. The crowd is then rapidly dispersed, and after sonic and visual hell follows a detonating calm, full of despair, dust, and death. The statistical laws of these events, separated from their political or moral context, are the same as those of the cicadas or the rain. They are the laws of the passage from complete order to total disorder in a continuous or explosive manner. They are stochastic laws.[11]

This text provides an important background for understanding the composer's intention of composing sound masses and transformations from continuity to discontinuity and from order to chaos. Furthermore, Xenakis refers to his experience of dramatic demonstrations and violent conflicts. It is well-known that when Xenakis participated in political demonstrations in Athens, he was wounded in his face by shrapnel, he lost an eye and barely survived. The references to warlike events in our phenomenological report are spontaneous, not directly related to this text, but Xenakis's statements strengthen the credibility of interpreting sections of *Pithoprakta* as threatening or harrowing.

In Varga's *Conversations with Iannis Xenakis*, the composer emphazises that creative intuition is more important for him than theory and calculation:

> Xenakis: *Pithoprakta* is a jump into the unknown. I was guided only by my ideas about its macroform. And by the time I had written it I became conscious of the musical aspects of my experiences with nature and mass demonstrations which appeared rather unconsciously in *Metastasis*.
>
> Varga: For the listener the most immediate impression given by *Pithoprakta* is the

11 Xenakis, 1992, p. 8–9. Supplement: Xenakis has presented an introduction to probability and music in an interview in English with German subtitles. See Andrew Toovey, "Iannis Xenakis (1 of 2) Filmed Interview in English with German Subtitles" (28 October 2010), *YouTube*, https://www.youtube.com/watch?v=j4nj2nklbts

presence of sound effects: the special ways of playing on the bodies of string instruments.

Xenakis: Yes. And it's not difficult to explain why I used them. I wrote *Pithoprakta* primarily for strings because it's easier to produce mass events and various timbres with them than with many other instruments. I also needed percussion effects. Instead of calling for a great many percussion players, which would have entailed organizational and other difficulties, I used the body of the instruments. It was that noise—the cloud of percussive sounds–that I transformed gradually, using statistical methods, into musical sounds. It's like dissolving one picture into another in film technique.[12]

[…]

Scientific thought is only a means with which to realise my ideas, which are not of scientific origin. These ideas are born of intuition, some kind of vision.[13]

In his book *Musique. Architecture*, Xenakis states that "[…] At the end of the day, instinct and subjective choice are the only guarantees of the value of a work."[14]

The Relationship between Mathematical Calculations and Music

Xenakis's applications of mathematical calculations to construct a large variety of sound masses in *Pithoprakta* are omnipresent and conspicuous. However, it seems that his use of calculations was a generative tool, not a goal. As he writes:

The composition I have written (*Pithoprakta*) existed in me before studying mathematics, which has only permitted a clearer, more precise formulation. […] My work *Pithoprakta* is not entirely built with the probabilities.[15]

I wrote *Pithoprakta* [1955–6, for orchestra], which was based mostly on probabilities. For months I tried to understand what it could mean. I was reading books on agronomy and the applications of probabilities in biology. I was trying to understand how I could use this tool [probabilities] in order to shape the sound output. Months—trying to imagine the results.[16]

Xenakis possessed knowledge of different theories of probability and the corresponding statistical method. As such he was able to choose between these methods in order to calculate and create sound masses that display a variety of structures, sonorities, densities and transformations. Thus, the mathematical calculations contributed to realizing Xenakis's intuitive vision of the macroform and variability of *Pithoprakta*.

12 Xenakis, in Varga, 1996, p. 75.

13 Ibid, p. 47.

14 Xenakis, 1976, p. 19 [[…] *En définitive, l'instinct et le choix subjectif sont les seuls garants de la valeur d'une oeuvre*] (our translation).

15 Letter to the conductor Hermann Scherchen 1956, in Xenakis, 1994, p. 44–5 [*La composition que j'ai écrite* (Pithoprakta) *existait en moi avant l'étude mathématique, qui a seulement permis une formulation plus precise* […] *Mon œuvre* Pithoprakta *n'est pas bâtie entièrement avec les probabilités*].

16 Interview with Xenakis 1990, reported in Kanach, 2012, p. 22.

Related Research

Analytical Descriptions

Two authors have provided detailed score analyses of *Pithoprakta*: Nouritza Matossian[17] and Makis Solomos, who concludes that "*Pithoprakta* constitutes a model of the diverse techniques applied to particular sections and affecting either particular characteristics of the sound (register, density, spatial movement, 'filtering', etc.) or the sound state in its overall nature."[18] The following survey permits comparison of our overview in the above Table 18.2 with the two scholars' respective characterizations. In this survey, some of Matossian's statements are abbreviated.

1a (0′45)	Wooden tapping sounds	Pleasant	measures 1–16

Matossian (M): *Pithoprakta* opens with soft tufts of woody tapping as string players strike the body of their instruments with their hands.

1b (1′29)	Arco strings added	Ambiguous	measures 17–51

Solomos (S): Noises with continuous transformation of density and spatialization and progressive emergence of *pizzicato* and *arco* (measures 0–51).

M: Line, breadth and horizontality are established by rhythmic arpeggio-like bowing from two instruments. Others bow the four and five-note groups which overlap one another so that the rhythmic groups chase after each other.

2a (0′16)	A myriad of sounds	Lively	measures 52–9

S: Overall transformation through "filtering" of a "cloud of sounds" (measures 52–9)

M: Now, however, there is a sudden cloud of *pizzicato* appearing without warning. The instruments move up and down the chromatic scale at independent rhythms and pitches wandering across the registers, changing to *pizzicato-glissandi*.

2b (1′27)	A broad belt of sound	Lovely	measures 60–104

S: *Tenuti* with progressive emergence of *pizzicato* then *glissandi* (measures 60–104).

M: These freely moving points are marshalled into straight lines (bar 60) as each one freezes on a pitch and sustains it so that the whole chromatic scale is covered, sounding like a gigantic organ cluster.

2c (0′40)	Salient *glissandi*	Elegant	measures 105–21

S: Discontinuous transformations of a field of *glissandi* (measures 105–21).

17 Matossian, 1986, p. 95–99.
18 Solomos, 2020, p. 177.

M: Soon three strings in groups of three are simultaneously drawing sharp *glissandi*. Joined in pairs one string plays a *pizzicato* on a pitch while his neighbour bows the same pitch, then dives off on a *glissando* away from it. The sharp overlapping diagonals have a spring and buoyancy as they scatter delicately in space, describing steep trajectories in elegant isolation.

3a (1′36)	Complex polyphony	Ambiguous	measures 122–70

S: *Bruiteux* superposition of six timbre groups with sporadic "views under the microscope" (measures 122–71).

M: After a silence (bar 122) it is as though the insect kingdom were at war. There is a buzzing, whirring, droning, humming, shot through with pointed screams.

3b (1′01)	Trombones added	Threatening	measures 171–99

S: Continuous transformation of the register of sounds in *battuto col legno* (measures 172–79). Discontinuous transformations through "filtering" of a cluster (measures 180–207)

M: The two trombones enter with a tight, pianissimo *glissando* while a punctuated *col legno frappé* reincarnates into periodic *pizzicato*.

4a (0′17)	Brief gestures	Surprising	measures 200–07

M: After a brief silence some *pizzicato* lighten the timbre as ephemeral *glissandi* climb gently up and down the register, finally building up to a forte. They are rapidly scattered by the tapping bows.

4b (0′48)	Polyphonic *glissandi*	Beautiful	measures 208–30

S: Fields of *glissandi* with irregular then linear transformation of register (measures 208–31)

M: The *glissando* once more regains its hold but is gradually absorbed into horizontals, as at the beginning of the work, with sustained pitches.

4c (1′21)	Increasing noise	Alarming	measures 231–67

S: Large cluster that "evaporates" progressively in the high register (measures 231–50). Harmonics in discontinuous spatial transformations (measures 250–68).

M: The zigzags slowly straighten out with furious opposition from the violent bowing of the basses. The sustained notes persevere, then veer off into excited *glissandi* which thin out over the next five bars. The piece ends with querulous violins reiterating a high scraping *B*-flat.

Table 18.3 Comparative analytical descriptions of *Pithoprakta* by N. Matossian and M. Solomos.

As regards the division in sections, the survey indicates considerable coincidence between the phenomenological investigation and the two scholars' descriptions. Solomos provides short, precise analytical characterizations of each section, while Matossian presents more elaborate descriptions.

As regards emotional reactions and hermeneutical interpretations, it is obvious that these constitute a prominent part of our report, but are scarce in the above quotations of Matossian and Solomos. However, Matossian includes interpretative imagery in section 2c: "The sharp overlapping diagonals have a spring and buoyancy as they scatter delicately in space, describing steep trajectories in elegant isolation," and section 3a: "it is as though the insect kingdom were at war. There is a buzzing, whirring, droning, humming, shot through with pointed screams." In the final section 4c, an emotional impact is reported: "The piece ends with querulous violins reiterating a high scraping *B* flat."[19]

Composed Sonorities

In his book *From Music to Sound*, Makis Solomos clarifies essential aspects of Xenakis's music.[20] He points out that for Xenakis, sound is not a neutral material, but the very foundation of music. Xenakis does not treat sound as a starting point of composition, but as a goal of the composition process. He creates sound masses, textures and surfaces by means of sound synthesis procedures, comparable to the work of a sculptor. His composition processes permit continuous variation and goal-directed transformations.

In continuation of the descriptions quoted in the above survey, Nouritza Matossian has provided a comprehensive discussion of timbres, articulations, instrumental interplay and polyphony, spatialization, timing and proportions in *Pithoprakta*.[21] Matossian states, like Solomos, that it was Xenakis's intention to create vast and open musical spaces, rendering transformations by gradual change perceptible. She indicates his application of probability distributions and generative mathematical functions, but points out that "Xenakis never claimed that a rigorous mathematical or analytic basis is sufficient to produce a well-formed piece of music."[22]

The Qualitative Impact of Music on the Listener

In the above-mentioned book, Makis Solomos points out that Xenakis introduces a dichotomy between quantitative and qualitative aspects of music, quoting an early article by Xenakis that discusses a possible connection between different types of music:

19 Matossian, 1986, p. 99.
20 Solomos, 2020, p. 170–77.
21 Matossian, 1986, p. 99–107.
22 Ibid., p. 106.

> The connection exists. It is the very foundation, the content of sound and the musical art that uses it. [...] Sound in acoustics is analysed in physical-mathematical equations (it is an elastic vibration of matter), which are measured: intensity, colour, time. [...] But as soon as the threshold of the ear is crossed, it becomes impression, sense, and consequently qualitative size.[23]

Solomos comments that the qualitative aspect remains rather imprecise in Xenakis's remark, while the quantitative aspect of sound is quite clearly delimited. At any rate, Xenakis considers it relevant that sound induces a sensory impact on the listener.

Solomos mentions the listener's possible sensory impressions in his chapter on immersion in sound: "In *Pithoprakta* (1955–56) the strings play up to 46 real parts, forming gigantic overall sounds in which the listener is invited to immerse himself or herself to observe its inner life."[24]

Another indication of the listener's possible perception of Xenakis's continuous sonorities stands out in Solomos's quotation of the French composer and musicologist Francis Bayer (1938–2004):

> The particular power that is given off by musical works that swear allegiance to this aesthetic of continuity, stems, it seems to us, from the fact that their significance, since it is immanent to the sensitive, immediately imposes itself on us in favour of a sort of wild perception of our whole body, prior to any analytical approach to our understanding.[25]

In his description of *Pithoprakta*, Solomos provides explanations of the technical and quantitative aspects of the work, but he does not focus explicitly on the qualitative aspects of music, pointed out as "impression" and "sense" by Xenakis. However, Solomos discreetly draws attention to these aspects by mentioning immersion in music and bodily perception.

We consider phenomenological investigations important for clarifying the qualitative aspects of music, including potential emotional impact, evoked imagery and hermeneutical interpretations. In addition to focusing deliberately on specific musical features, we have profited from "immersing ourselves" in the sounds of *Pithoprakta* and experiencing "the wild perception of our whole body," as pointed out above by Bayer.

Drama, Noise, and Concealment

The Mexican composer Julio Estrada (b. 1943) attended Xenakis's lectures at The Schola Cantorum in Paris in 1967–68. They became friends and maintained a friendship for more than thirty years, discussing, sharing memories, collaborating and travelling

23 Xenakis, [1955] 2001, "Problèmes de composition musicale grecque," p. 12, in Solomos, 2020, p. 173. Solomos's excerpt and translation.

24 Solomos, 2020, p. 114, 172.

25 Bayer, 1981, p. 132. Solomos's translation.

together in France and Mexico. For Estrada, Xenakis was not a teacher, but a beneficent influence during his formative period, a fascinating source of knowledge, insight and methods, with a permanent stimulus toward scientific study.[26]

In the article "Music, Science, Architecture: Pythagorean Wall of the Drama,"[27] Estrada presents a description of *Pithoprakta*, which refers to the events known as "dekemvriana," the violent clashes fought in Athens in December 1944 and January 1945, as well as referring to Xenakis's own text about the sound of crowds in demonstrations (1992, p. 8–9):

> With Greek rhythm, *pizzicato* and *glissandi* as evocation of noise, Xenakis resolves to turn the dense anarchy of the dekemvriana into orchestral music: *Pithoprakta*, shouting slogans in the front row reappearing in the back rows; student shouting and clapping make up the core of the work, a disorder with a direction. [...] *Pithoprakta's* noises are visualized with a web of gliding pitches, movement that seems to lead the masses through streets and squares if one follows the chronographic account, advancing in groups from left to right, scattering treble above, and bass below, with a gap in the center separating both masses. The title, from the Greek "random actions," evokes the stochastic method–conjecture or directed probability–that the author associates with the idea of mass, useful to fill the space occupied by the collective movement of the manifestation, partially expressed as a sequence advancing with pitch *glissando* in zigzag.[28]

This short description and interpretation of the sound masses in *Pithoprakta* is directly related to the violent "dekemvriana" in Athens. It is well-known that during a conflict, Xenakis was hit by shrapnel and was very seriously injured, losing an eye and receiving other facial wounds. Moreover, Estrada relates a confidential revelation by Xenakis that "for a decade, he hears uninterruptedly a complex noise caused by the deterioration of the auditory system."[29] Estrada suggests that Xenakis's auditory ailment has urged him to expose noise in his music[30] and to conceal aspects of his personality and composition process.

The production or adaptation of various kinds of noise is evident in *Pithoprakta* and other works of Xenakis. Solomos describes fifteen types of noise in *Diamorphoses* (1957) for tape, based on recorded sounds of noisy character.[31] He furthermore refers to a text by the Czech author Milan Kundera (1929–2023), who wrote that "the world of noises in Xenakis's compositions became, for me, *beauty*."[32]

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26 Estrada, 2001.

27 Estrada, 2022, p. 199–221 "Música, ciencia, arquitectura: muro pitagórico del drama." Our translation. See also Estrada's chapters in this volume (Chapters 27 and 28).

28 Estrada, 2022, p. 205–06. Estrada's translation, kindly communicated by the author. All translations of the 2022 text are Estrada's, unless otherwise specified.

29 Estrada, 2022, p. 200 [*durante una década, oye ininterrumpidamente un ruido complejo provocado por el deterioro del sistema auditivo*].

30 Estrada, 2001, p. 216.

31 Solomos, 2020, p. 65.

32 Kundera, 1981, p. 24 [*le monde des bruits dans les compositions de Xenakis est devenu pour moi beauté*]. Translated in Solomos, 2020, p. 82.

Estrada supposes that it was Xenakis's intention to share his own disturbing experience of continuous noise with the music listener. He remembers a concert performance in Paris of *Bohor* (1962) for tape, a twenty-minute work that gradually advances towards extremely noisy chaos, where Xenakis personally set the volume at maximum amplitude.[33] Xenakis has commented in an interview that listening to *Bohor* implies that sound penetrates the ear: "In order to hear all these minimal details of sonority, I had the feeling that more volume was necessary."[34]

The "Pythagorean wall" in the title of Estrada's article refers to a myth in which the ancient Greek mathematician Pythagoras hid himself and talked behind a wall. Likewise, Estrada suggests that Xenakis hid himself in various ways. In particular, Estrada critically characterizes Xenakis's elaborate mathematical explanations as a kind of wall to hide behind: 'the priority he gives to his theoretical-constructive rationalism serves to keep the spectator at an intellectual distance.'[35] Moreover, Estrada relates significant memories of Xenakis's classes in The Schola Cantorum. When Estrada once asked about details of the dodecaphonic series in the middle section of *Metastasis*, Xenakis briefly answered "mere coincidence."[36] When he on another occasion asked how Xenakis in his stochastical model proceeded to convert numbers into notes, Xenakis became very angry and refused to answer. "[He] would not make the slightest concession that dealt with explaining procedures that, even if they were simple, he would still jealously keep private."[37]

Estrada has communicated these memories to express his empathy and point out that Xenakis converted his ailment into a strong driving force in his creative processes. He concludes, addressing Xenakis: "your example has left something formidable, fundamental, that deserves to be remembered here: to believe and to create according to one's own light."[38]

Estrada has presented personal knowledge of Xenakis's life, his tinnitus-like auditory ailment and his reactions to unwelcome questions. This adds perspective to our report of warlike associations and emotional reactions to noise in *Pithoprakta*, as well as a background for understanding the composer's insistence on keeping certain aspects of his creative process private.

33 Estrada, 2022, p. 216. See also Chapter 28 in this volume.
34 Xenakis in Delalande, 1997, p. 138 [*Pour entendre tous ces minimes details de sonorités, j'avais la sensation qu'il fallait plus de volume*]. Authors' translation.
35 Estrada, 2022, p. 210: [*la prioridad otorgada al racionalismo teórico-constructivo sirve para mantener a distancia intelectual al espectador*].
36 Ibid., p. 203 [*pura coincidencia*].
37 Estrada, 2001, p. 219.
38 Ibid., p. 227.

Limitations

We consider the outcome of the present investigation to be a description and interpretation of *Pithoprakta* that is representative, but not exhaustive. We have listened for the characteristic features of sound as well as the sonorities, transformations and densities of sound masses. Each of these fields could be described in more detail, in particular the sonorities and transformations. Furthermore, it would be possible to continue the investigation by conducting supplementary listening tasks, such as listening for foreground and background, registers, layers, and surfaces of sound, brightness and darkness, tension and directionality.

The music-focused descriptions are summaries of multiple detailed observations provided by LCB, notated and subsequently edited by EC and finally commented by LCB. This process implies intersubjective verification, so that the music-focused descriptions represent the consensus of both authors.

On the other hand, hermeneutical interpretations may not imply a consensus. They are influenced by the listener's personality, background, experience, history, and context. Throughout our listening sessions, we noticed individual differences in the experience of potentially threatening, warlike, and disturbing sounds. We consider such differences inevitable and valuable, and have briefly commented on our different experiences. We suggest that it is important to respect variability and disagreement in the experience and interpretation of music.

The recording of *Pithoprakta* by The French Radio Symphony Orchestra conducted by Maurice le Roux is the basis of our investigation, and we consider it the original version of the work. Other recordings of this work display marked differences in tempo, sound, volume, timbre, balance and phrasing. It is likely that investigations of these recordings may result in considerable differences in music-focused descriptions as well as hermeneutical interpretations. To facilitate comparisons, we include links to four different recordings below (see Links to Online Recordings).

Concluding Remarks

We have conducted the phenomenological investigation of *Pithoprakta* in order to attract attention to an approach to Xenakis's music which constitutes a supplement to the analytical, theoretical and mathematical descriptions and explanations of his works. The present text introduces an example of Experimental Listening, which we regard as a rewarding procedure for approaching, discovering, and assimilating a complex musical work. We consider hermeneutic interpretations and descriptions of emotional impact relevant for the study of Xenakis's works, even if this may provoke the discontent of some researchers. Xenakis would certainly not have approved of this kind of research, even though he was aware that "as soon as the threshold of the ear is crossed, [sound] becomes impression, sense, and consequently qualitative size."

With reference to the scholars of music phenomenology mentioned in our introduction, it is our estimation that we have followed Ihde's guidance, that the aim of music phenomenology is to reveal unnoticed aspects of the music and to appreciate the richness and complexity of sensory experience. Furthermore, we agree with Clifton's point of view that all kinds of sound can be heard as music; that space, time, motion, and feeling are basic constituents of music, and that musical experience is an action of the body. From Ferrara's research we have adopted the practice of open, music-focused and hermeneutical listening, and the opinion that it is important to uncover meaning in music. We have not followed Ferrara's incentive to uncover history and lifeworld in music, but we consider these fields amply researched by Xenakis scholars.

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Links to Online Recordings

The French Radio Symphony Orchestra conducted by Maurice Le Roux (1965), duration 9′45, Le Chant du Monde LDX-A-8368. With score display: see Pour ceux que le langage a désertés, "Iannis Xenakis - Pithoprakta (1955–56) pour 49 musiciens" (25 September 2020), https://www.youtube.com/watch?v=yxAakHDWjrw

Luxembourg Philharmonic Orchestra conducted by Arturo Tamayo (2008), duration 10′30, *Xenakis: Orchestral Works Vol. 5*, Timpani 1C1113. With graphic score animation: see Pierre Carré, "Iannis Xenakis - Pithoprakta (w/ graphical score)" (30 April 2017), *YouTube*, https://www.youtube.com/watch?v=nvH2KYYJg-o

New York Philharmonic Orchestra conducted by Leonard Bernstein (1964), duration 8′30. With an introduction by Leonard Bernstein: see goodmanmusica, "Xenakis Pithoprakta - Bernstein / NYP (1964)" (29 July 2019), *YouTube*, https://www.youtube.com/watch?v=LfH74hlhKp0

Buffalo Philharmonic Orchestra conducted by Lukas Foss (1968), duration 8′30. See: Wellesz Opus, "Iannis Xenakis: Pithoprakta (1955/1956)" (1 March 2015), *YouTube*, https://www.youtube.com/watch?v=AE1M2iwjTsM

19. Performing Iannis Xenakis's Polyrhythms: A Perception-informed Approach to Renotation

Imri Talgam

Introduction

Xenakis's use of algorithmic composition often produces great difficulties for performers, especially in his solo works. These difficulties result from the use of probability distributions that generate dense and irregular textures, often bordering on the impossible both physically (as in *Evryali* (1973), for example) and mentally. My goal in this chapter is to address performance challenges that stem from Xenakis's use of complex polyrhythms, which frequently appear in his works from the 1970s onwards. The solo piano piece *Mists*, written in 1980, serves as a particularly rich case study, with passages that prefigure the rhythmic intricacies of New Complexity. The ideas I will propose here could be applied in many other Xenakis chamber and solo pieces from this period that feature complex polyrhythms, including *Dikhthas* (1979), *Tetras* (1983), *Komboï* (1981), and *À l'île de Gorée* (1986).

In such extreme pieces, performers need to develop new learning and performance strategies to deal with the vast amount of information and extreme rhythmic complexity. I argue that to tackle these difficulties successfully, performers should renotate the score methodically, based on perceptual and cognitive criteria. By renotating the score, we can create a script for the streamlined performance of otherwise overwhelmingly complex rhythms, while keeping the result perceptually similar to the original.

Discussions of the challenges involved in the performance of complex rhythm often focus on composers identified with "New Complexity," especially in the works of Brian Ferneyhough (b. 1943), where performers are required to decipher and calculate several layers of nested tuplets before they can begin practicing the rhythms. In many of these discussions, the emphasis is on the use of complex notation as a strategy for transforming the performer's relation to the score, either by "psychologizing"

 https://doi.org/10.11647/OBP.0390.21

the learning process,[1] or on the meaning and feasibility of the infinitesimal nuances called for in performance, as well as the choices performers must make in interpreting these rhythms.[2] In contrast to these approaches, I believe Xenakis was less interested in creating a dense text for the performer to interpret than in presenting complex stochastic rhythms without compromising his compositional ideas, even though these might not be possible to reproduce in live performance with the accuracy of a computer. Consequently, I will focus on purely practical considerations, and suggest conceptual tools that can assist performers.

Mists (1981) for Piano

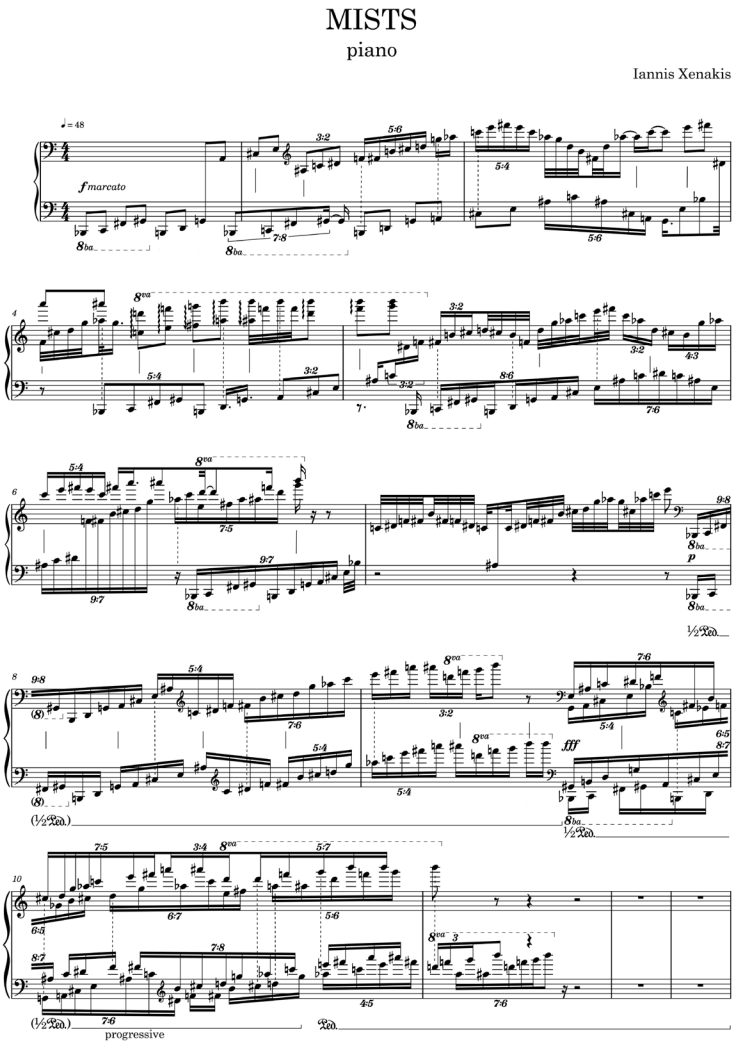

Fig. 19.1 *Mists* (1981), Opening and *Stretto*. Reset in Dorico by author.

1 See Ferneyhough, 1981, performance note.
2 See Duncan, 2010.

The opening of *Mists* consists of continuous random walks along the custom scales or pitch sieves that Xenakis designed for this piece, as shown by Ronald Squibbs.[3] Initially, the random walks create a two-voice polyphonic texture, with each voice emerging from the bottom of the keyboard and gradually climbing up. Due to the distance in register, the two voices are easily streamed, forming distinct polyphonic entities. Rhythmically, each voice articulates isochronous attacks, with frequent changes of speed notated using polyrhythms. While this is rhythmically challenging due to the independent rate in each hand and the lack of common attack points, it is still manageable without any renotation.

This changes in measures 9 to 11, which suddenly expand to a four-voice texture, with each voice moving at a different rate, creating a dense polyrhythmic web. I'd like to focus on this short stretto passage, as a model for all the difficult rhythmic passages to come later in the piece.

Media 19.1 *Mists*, Opening and *Stretto*, Performance by Aki Takahashi.[4] © Mode Records (2006).
https://hdl.handle.net/20.500.12434/53d33115

This sudden explosion of information and energy makes this passage extremely difficult to perform, although the polyrhythms might be more difficult to recognize aurally than in the earlier versions with two voices. The impression of polyphony is diminished due to the proximity in register of the voices, which causes them to fuse together and become a dense texture. Most performers approximate the rhythms, contributing even further to the impression of a dense sound mass with little internal structure or detail.

Looking at the Stretto passage (measures 9–11 above) more closely immediately reveals two related performance difficulties. First, the score conveys the different speed of each voice relative to sixteenth-notes, but the composite attack pattern that results from their interaction is not immediately visible. Xenakis took care to place the notes in graphically correct order, but this does not give all the information required for performance. The second difficulty is the extreme irregularity and proximity of some of these attacks, which include various gradations of "almost together," while never repeating the same timing. As Franklin Cox notes, scores provide both too much and too little information.[5] The complexity of the composite inter-onset intervals (IOIs) becomes apparent when we listen to a rhythmically perfect computer rendition of the passage.

3 Squibbs, 2002.
4 Xenakis, 2006.
5 Cox, 2002.

Media 19.2 MIDI version, original tempo (eighth-note = 96) of *Mists*, measures 9–11.
https://hdl.handle.net/20.500.12434/9167a84e

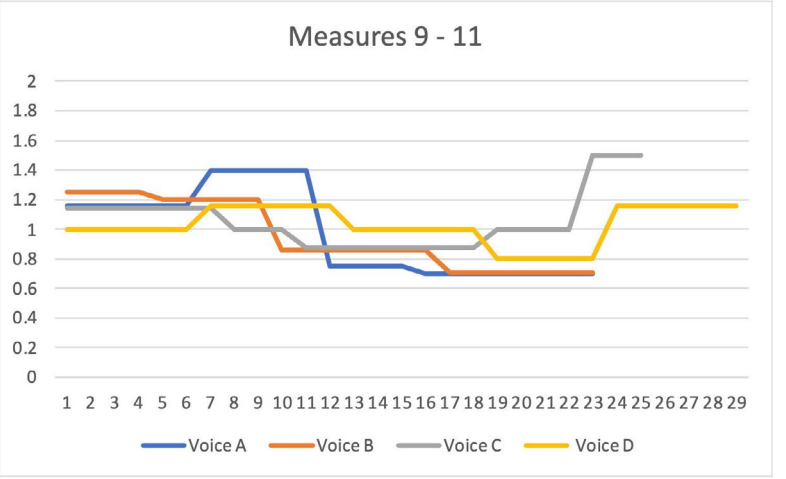

Fig. 19.2 Salient macro-features. Each voice slows down in steps (except Voice A initially), with a noticeable bump up in speed in measure 11. As a result, the overall density of events decreases. Figure created by author.

Despite the inevitable blurring of polyphony, the passage has some interesting macro characteristics that are perceptually salient, yet not immediately evident in the score. Looking at the graph, we have the tempo change in each voice over time, with the voices labeled from top to bottom: Voice A is the top voice. The X axis is time measured in sixteenth-notes, while the Y axis shows the tempo of each polyrhythm relative to sixteenth-notes, which are denoted with the value 1 (or a ratio of 1:1). Numbers greater than 1 represent polyrhythms with faster movement, such as 7:5, or 1.4 times the speed of a sixteenth. Conversely, values below 1 represent polyrhythms that are slower than sixteenth-notes, such as 5:7 or 0.714.

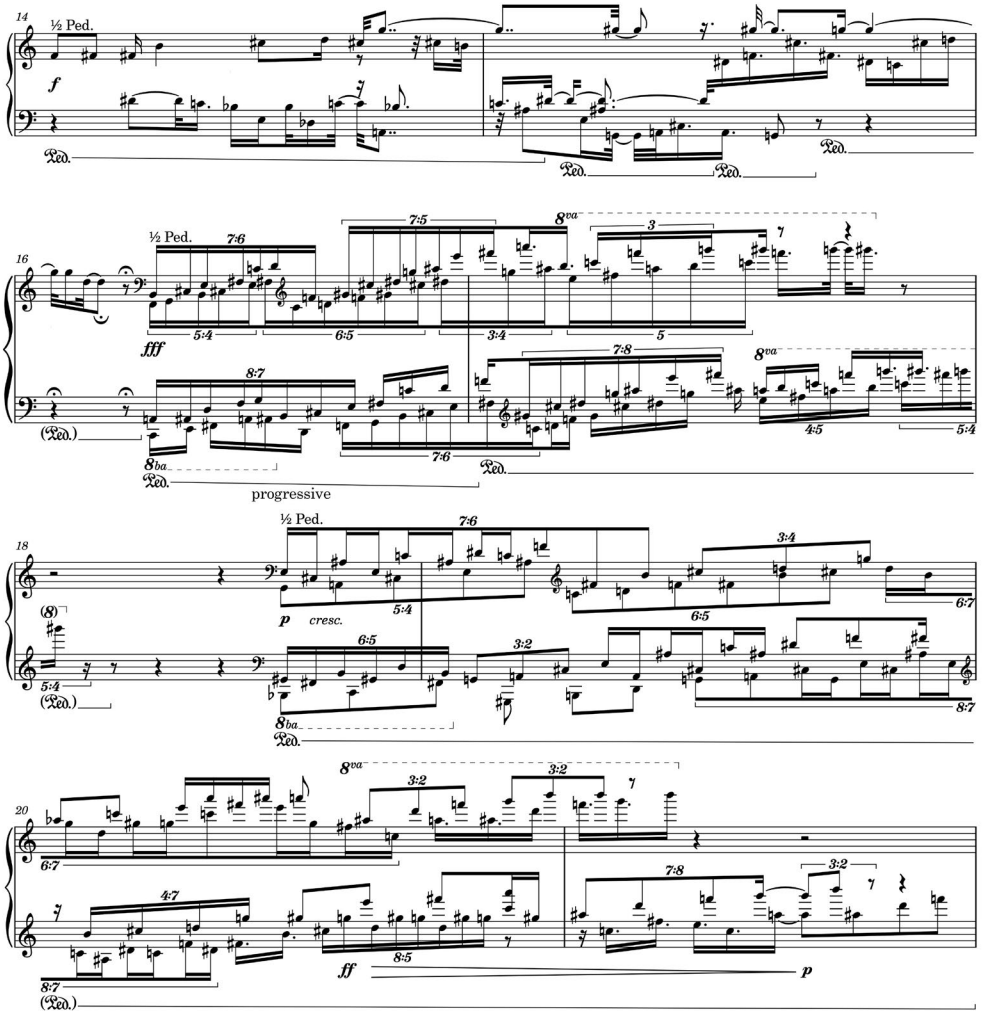

Fig. 19.3 Quantized arborescences and random walks, *Mists*, measures 14–21. Tempo changes in each of the four Voices (Y Axis). Decimals represent tempo relative to sixteenth-notes. The published score has been reset in Dorico by the author, with some errors corrected, e.g., measures 18–19 RH top voice notated 7:8 should be 7:6; measure 19 LH top voice, the 6:5 has been erroneously copied from the RH lower voice. However, all the visual alignments are correct.

The macro trend is clear: the passage begins with faster speeds in each voice and gradually slows down in steps, before bumping the speed up again at the very end. This means that the density of attacks gradually goes down, though without any corresponding drop in dynamics. The decreasing density is even clearer when listening back to the passage at half tempo:

Media 19.3 MIDI version at half tempo (eighth-note = 48) of *Mists*, measures 9–11.
https://hdl.handle.net/20.500.12434/366fd4a3

This type of macro rhythmic process is perceptually more salient than the isochronous polyrhythms that create the texture; in other words, listeners are more likely to notice a gradual change in density than precise polyrhythmic relations between four voices.

The next section of *Mists* is structured as a series of alternations between further random walks, mostly separated by simpler phrases modeled on arborescences (or melodic branching structures) using only thirty-second notes. The contrast between the rhythmic regularity of the arborescences and the complex macro rhythmic processes of the walks becomes the center of attention.

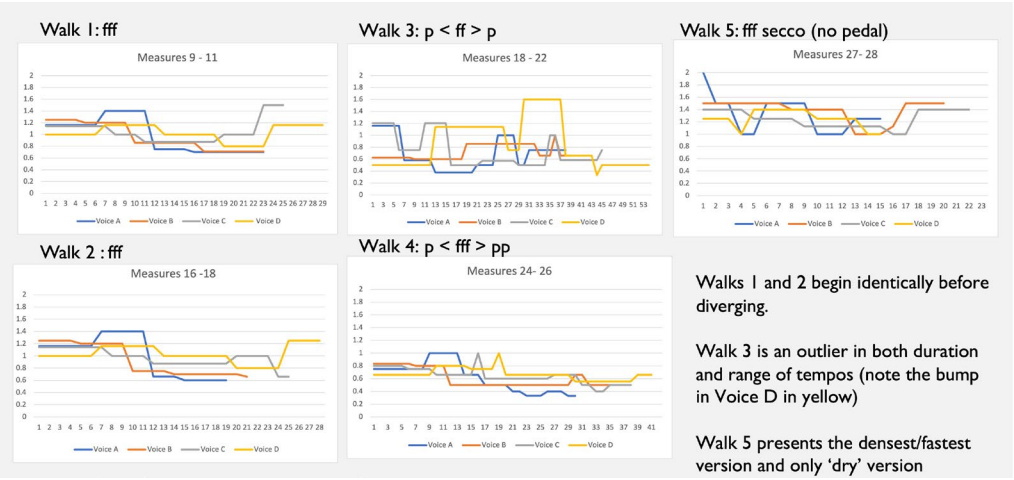

Fig. 19.4 Macro features of successive random walks, *Mists*, measures 14–21. Figure created by author.

Comparing the tempo graphs for each of these walks, we can immediately notice some striking features which are hard to notice otherwise. The first two walks begin with identical rhythmic configurations, but the similarity is broken off later in the second walk. Walk 3 is unique in lasting almost double the length of others and features many more frequent tempo changes, including an abruptly faster speed in Voice D, which we will come back to later. Walk 5 presents a considerably higher average speed and density compared to all the previous ones, and is the only one presented entirely without pedal. The walks are further differentiated by use of dynamics, which are either uniformly *fff* or use gradual swells to create a dynamic envelope.

Extracting these macro features can help reframe the goals of performance. Rather

than attempting to realize the polyrhythms as such, and attempting to reproduce each layer isochronously, it becomes clear that performers should focus on reproducing the perceptually salient macro features that differentiate these random walks and give each of them a distinct quality. This reframing of the performance priorities is also aesthetically significant: instead of attempting an entirely deterministic realization of every single detail, the performer aims to capture the most significant statistical features. This is line with Xenakis's compositional approach, in which the individual details are random, while the larger processes are clearly shaped by the composer.

Let us examine some possible performance responses to these difficulties, in order of increasing investment. First, we have an informal approach of keeping an eighth-note tactus and approximating the exact timings, likely only keeping the order of attacks within a beat while sacrificing precision and the isochrony in each voice. In this approach (which is the most common one among musicians due to time-constraints), the texture assumes a "generic" sound of slightly desynchronized events with little variation in average density. This often involves reducing the irregularity of the attacks to a simplified recurring pattern. This approximation often results in IOIs that are more regular than the original.

This type of "normalization" of the IOIs is an intuitive way of reducing the amount of information. In contrast, actual phasing requires the IOI to change with every two attacks. This becomes apparent when playing back the same computer version at half speed.

The second strategy is to calculate the Least Common Multiple (LCM) between the various layers, or renotate the polyrhythms using subdivisions. Unfortunately, this is both time-consuming and does not yield useful results, as we can see from MacFarland's renotation of a similar excerpt from *Tetras*:

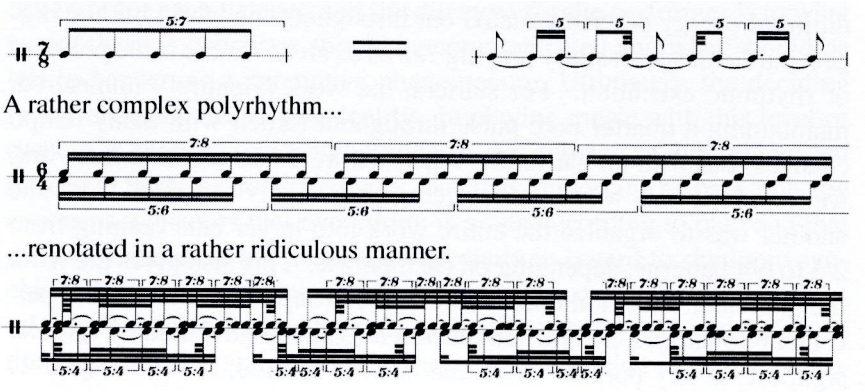

Fig. 19.5 Limitations of LCM or Polyrhythm Respelling Strategy. Subdivisions are too fast to be useful even without LCM. From McFarland's, "Second Generation Performances of Xenakis' String Quartets," in Kanach, 2010, p. 254 (reproduced with permission).

This is not useful because the subdivisions are so fast that we cannot count them at the notated tempo, suggesting we need to simplify things somewhat to produce a useful score. This brings us to the strategy I advocate, a renotation informed by perception.

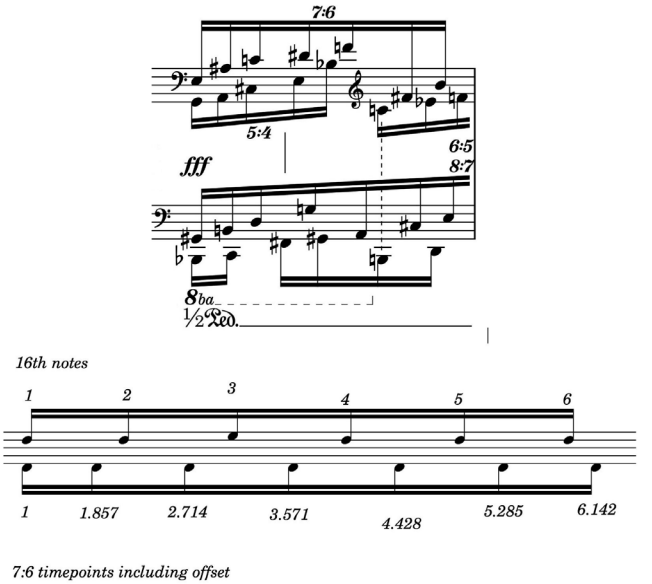

Fig. 19.6 Polyrhythms converted to decimal values (7:6 example). Reset in Dorico by author.

As a preliminary stage, we can translate the polyrhythms into decimals, which helps us determine the relation between attack points in different voices without a LCM. For example, in the top voice the ratio 7:6 denotes 7 attacks in the time of 6 sixteenth-notes. 6 divided by 7 is 0.857—the time point for the second note in the 7:6 group, right before the second sixteenth-note of the passage (timepoint 1). This can be made more intuitive by adding an offset of 1, so that we can start counting from 1 instead of 0 and can refer the decimal time-points to sixteenth-note subdivisions in the published score. By doing this with each voice, we can start investigating the composite attack pattern, or the IOIs between different voices. Another important feature this reveals is the 'horizontal' behavior of each voice as it changes from one polyrhythm or ratio to another. For example, Voice 1 (top) switches from 7:6 (0.857) to 7:5 (0.714), so it is noticeable faster.

Before renotating, it is necessary to define some thresholds for the perception of rhythmic differences, to ensure the simplified version will still sound very much like the original. In a sense, this is like the data-compression of an mp3 format, which uses perceptual coding to make sure the compressed file reproduces the perceptually salient features, while removing a considerable amount of information.[6]

6 To clarify the analogy, an mp3 file reduces the complexity of the frequency content of a sound, while

To simplify the rhythm, while preserving the same perceptual features, we must define a threshold for distinction between events. Hirsh found that two milliseconds (ms) are required to discern that two tone onsets are present, while a considerably greater interval of around 20 ms is required for listeners to determine the order of the note onsets correctly.[7] This suggests that within the 20 ms range, we need not worry about the rhythmic definition of IOIs between voices, or even the exact order. With some additional inaccuracy in performance, the result will be perceptually very similar.

The absolute limit to metric subdivision is considerably higher. Justin London proposes a limit of about 100 ms for the fastest subdivision of a tactus, under which we can no longer expect precise performance or listening.[8] In the prescribed tempo of eighth-note = 96 (m.m. or BPM), the duration of one thirty-second-note is 156 ms, well within the possibility of metric subdivision. However, sixty-fourth-notes last 78ms, already too fine for metric definition.

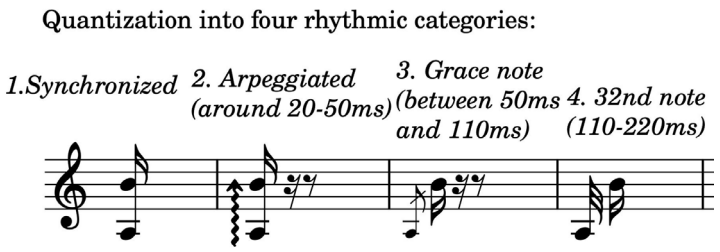

Fig. 19.7 Perception-based constraints and tempo values. Reset in Dorico by author.

On this basis, we can formulate a quantization strategy for renotation. The lowest level of metric subdivision should be thirty-second-notes, with all attacks on time-points under this level defined using a combination of grace notes (occurring right before a metrically defined attack) or arpeggiation (which we can use to denote events right after a metric point). Using the decimal time-point values for all voices, we can calculate IOIs in milliseconds and round off values to the nearest metric position, and then translate them to a grace note or arpeggio relative to that position. In cases that an attack falls very close to a sixty-fourth-note subdivision, this notation may be used as well to avoid even cruder approximation.

For example, attacks that are "almost together" are now notated through grace notes. This means that two distinct rhythmic events may now be grouped together in a single gesture of arpeggiation, with one of three different rhythmic profiles: a) Almost together (arpeggios for durations less than sixty-fourth-notes) b) Distinct grace-note (for durations under thirty-second-notes and greater than sixty-fourth-notes) and c)

the strategy proposed here reduces the complexity of rhythmic (IOI) definition.

7 Hirsh, 1959, cited in London, 2012, p. 29.

8 London, 2002.

isochronous thirty-second-notes for more distant attack points. This makes it easier to approximate the IOIs by replacing their specific timings with these four categories of simplified IOIs. We could also say that instead of infinitesimal quantitative differences in IOIs, we have a system of qualitative categories, which still allow for fine rhythmic differentiation.

Although all voices could be quantized in this way, I find it better to retain one more polyrhythmic layer in addition to the sixteenth-note pulse. In this way two voices remain metrically defined, while the two others are converted to a-rhythmical grace-notes and arpeggiations. This assumes that it is possible to perform a polyrhythm between two voices relatively easily, as in the earlier two-voice texture. To limit the number of possible renotations from the combinations of rhythmic and arhythmic voices, we can add two more constraints based on practical considerations. First, we should keep any voice that articulates sixteenth-notes, as these provide the easiest means of orientation and as a subdivision of the eighth-note tactus established at the opening. Second, each hand should have at least one layer that is metrically defined, to ensure synchronization with the other hand.

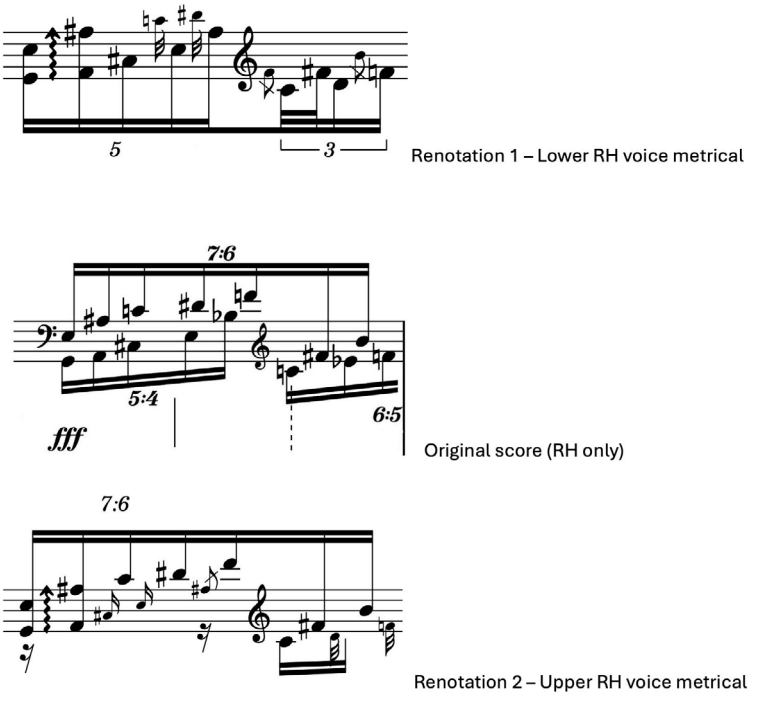

Fig. 19.8 Two possible renotations (right hand only). Reset in Dorico by author.

Looking at the beginning of this passage again, we have two possible renotations. For the sake of clarity, we will focus on the right-hand part only. There are two possible renotations depending on which layer of the right hand we choose to be metrical. In the middle we have the original notation, with the two alternative notations above and

below. In the renotation above, the lower voice (5:4) is metrical and the upper one is translated to grace notes; the lower renotation takes the upper voice 7:6 as metrical and translates the 5:4 to grace notes.

The preference for one of these two versions is less clear-cut and would often involve contextual performance considerations. For example, in most cases we might find a renotation that preserves the metric identity of the faster moving voice to be more intuitive. In most cases, it is best to take a faster moving layer as metrical one, since it is easier to accurately fit in a slower series of pulsations on to a faster one than the opposite. Additionally, faster-moving layers also tend to draw more attention and are easier to entrain to, meaning listeners are more sensitive towards deviations from their isochronous values relative to deviation in slower-moving layers. On the other hand, perceptual considerations might influence this; for example, in case a slower moving layer is set in a register that helps segregate it from the texture, making listeners more sensitive to its isochrony.

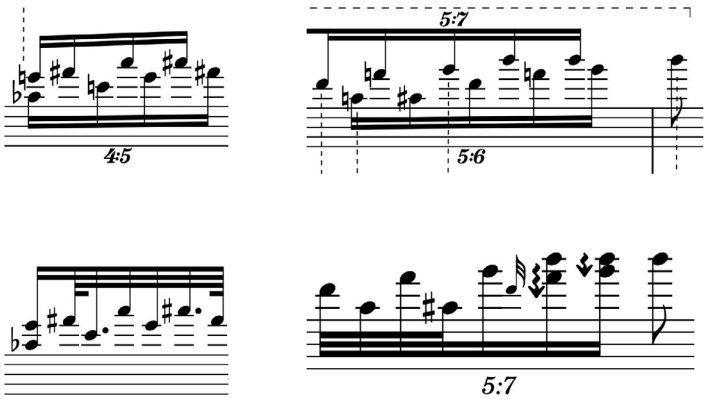

Fig. 19.9 Other strategies used. On the left side, the 4:5 polyrhythm is converted to a composite attack pattern using LCM-based respelling. On the right, a similar integration into a composite pattern in which a subdivision of the upper voice approximates the position of the third note in the lower voice. Reset in Dorico by author.

Two other strategies used here should be mentioned in passing: a) Some attack points can be rounded off to a subdivision of a polyrhythm in one of the metrical layers, as can be seen on the right, with the lower voice assimilated into the upper polyrhythm; b) Some polyrhythms can be translated into a composite attack pattern, as in the 4:5 in the left hand towards the end of the passage. In both cases, the principle is the integration of different rhythmic layers into a composite attack pattern.

Finally, the choice of renotation should make sure to preserve details in rhythmic layers that contribute to the macro identity. Looking again at Walk 3, we noted the abrupt bump in Voice D to a higher speed towards the end of the passage as a unique feature of this Walk. Accordingly, the renotation should preserve the metric identity of this voice to avoid obscuring this feature.

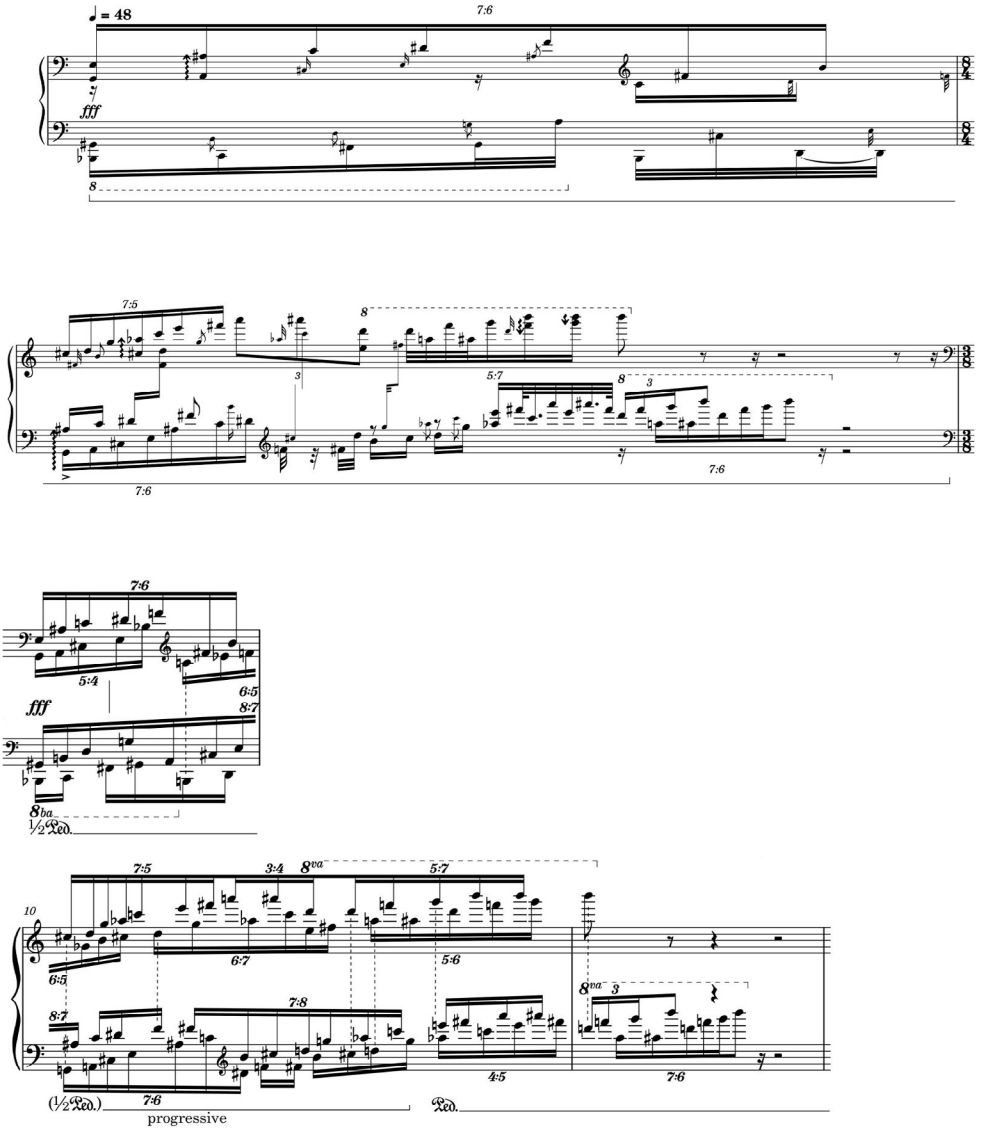

Fig. 19.10 Final renotation of Walk 1, *Mists*, measures 9–11. Renotation (above) followed by measures 10–11 in the original score (below). Reset in Dorico by author.

I think this renotation offers some immediate benefits compared to the original. The introduction of metric hierarchy facilitates learning and allows the performer to read the passage in more conventional way. It is also possible to read the approximate composite rhythm without being dependent on the extremely small differences in graphic spacing. In addition to conveying the composite rhythmic pattern more directly, the renotated score helps to divide the information in relation to physical actions (for example by highlighting points of synchronization between the hands).

In this way, one could see it as a graphic representation of the embodied navigation of the score, as described for example by Antoniadis.[9]

As a data-compression strategy, this renotation results in loss of information; only two of the four layers have preserved a precise definition, while the other two have become approximations and fail to convey their isochrony. However, we can see this as a practice and learning strategy rather than a replacement of the original score. While the renotated score loses some fine detail, it was the excess information in the original notation that led performers to informal approximations and unconscious normalization of rhythms. At the same time, the new score also adds useful information as a script for performance. In a sense, it spells out the mental process that performers would otherwise leave unarticulated.

A second problem is less obvious: the renotation can skew the dynamics by emphasizing the rhythmic layers. Attacks that fall on the beats tend to be emphasized, owing both to habits associated with traditional Western tonal music and to the connection between metric entrainment and sensorimotor performance.[10]

The loss of isochrony is less crucial than it seems, due to the fused nature of texture in this passage. The proximity in register and the uniform timbre between voices cause a destructive interference that prevents the perception of separate isochronous voices even in a perfectly timed computer performance. It is important to note that this is a highly contextual issue, and that in cases that allow entrainment to one of the layers, distorting the isochrony of each layer becomes much more problematic. For example, if each rhythmic layer articulated a single pitch or unique timbre, this could result in the perception of polyphony individual voices and improve our sensitivity to inaccurate performance. However, in this case both the decreased isochrony and dynamic skewing can be counteracted by conscious practice, or by switching back and forth between different versions of the score and choosing to focus on a previously neglected rhythmic layer.

The most significant issue with this renotation strategy is its time-consuming character when done by hand. The process could be automated using software that outputs symbolic notation, such as OpenMusic or Max/MSP's Bach package. This would offer the further advantage of having variable resolution for the quantization, from very crude approximations (which might be useful early in the learning process) to finer ones as goals for final performance.

9 Antoniadis, 2011.
10 See London, 2002.

Renotation of Stochastic Clouds

As Squibbs notes, *Mists* also contains two other types of textures in addition to the continuous random walks of the opening pages.[11] The second texture type to appear is arborescences, characterized by branching pitch structures, which first appear in measures 14–16 and then in two subsequent variants in measures 22–4 and 28–30. In contrast to the independent rates of each voice in the opening, this first group of arborescences "snaps" to a thirty-second-note rhythmic grid and presents no special rhythmic challenge for performers. Later arborescences, however, make use of the polyrhythmic writing of the opening and once again present extreme complexity, which can be addressed in the same way through renotation as the opening materials discussed above.

The last type of texture is discontinuous random walks, or stochastic clouds, which dominate the majority of the piece and give it its name. The random walks are discontinuous in both pitch and rhythm; unlike the previous figurations, they do not feature any isochronous attacks or metric organization, but only changes in rhythmic density and range of pitches in each cloud.[12] For the sake of clarity, Xenakis chose to notate these without metric values, with the notes placed spatially inside a sixteenth-note rhythmic grid for orientation instead.[13]

Interestingly, this notation presents performers with the opposite situation from the opening polyrhythms. While the former presents performers with too much information and requires some simplification and selective removal of rhythmic definition, the latter presents too little information, making it difficult for performers to learn and retain. In this case, it is advantageous to insert some rhythmic organization, particularly in higher density situations, where a notated rapid succession of slightly asynchronous attacks can be substituted with a (synchronous) rhythmic subdivision which approximates it closely. Although this strategy risks introducing more rhythmic regularity than the spatial notation suggests, it can help performers approximate the changes in density, which are perceived as an average that changes over longer time stretches of a few seconds.[14]

11 Squibbs, 2002.
12 Gibson, 2022.
13 Varga, 1996, p. 185.
14 This resembles the situation in asynchronous granular synthesis, which Xenakis first conceptualized in his articles on Microsound (Xenakis, 1992). In the same way that granular synthesis requires high level control (such as defining a deviation around a central duration value) instead of specifying every grain, performers can learn to perform these changes in density without specific metric subdivisions for each note.

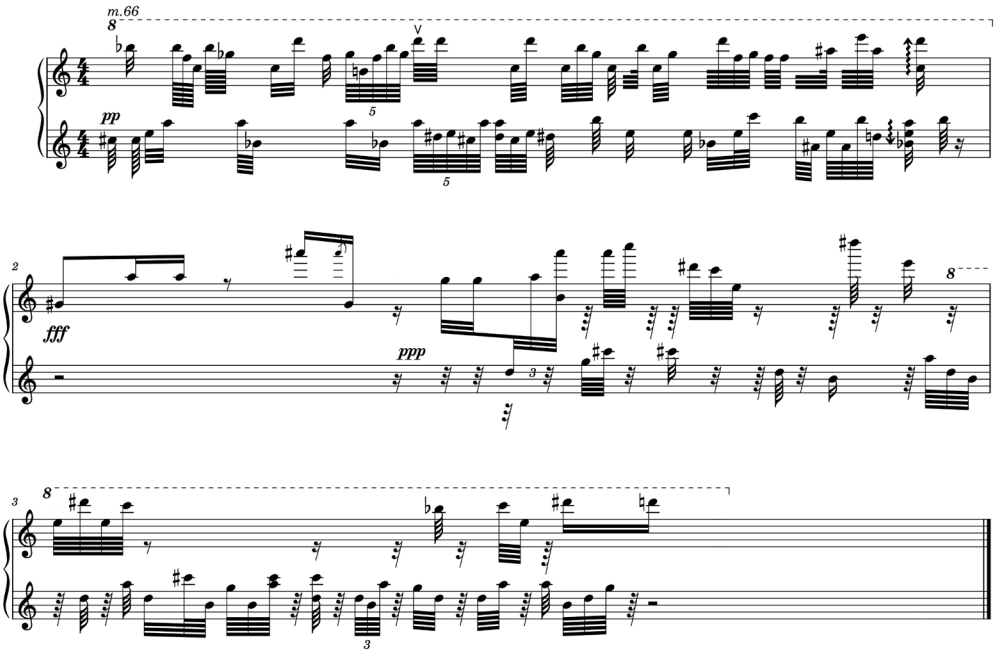

Fig. 19.11 Renotation stochastic cloud, *Mists*, measures 66–8. Reset in Dorico by author.

Once more, this strategy sacrifices some rhythmic detail by simplifying highly irregular, infinitesimally differentiated attack patterns in order to make it possible to convey the macro process of entire passages, such as changes in density and degree of irregularity between successive groups. In this particular case, the differences between an ideal asynchronous version and a live performance of the synchronous renotation are miniscule, especially considering the possibility that a human performer adds some small degree of randomness to the timing in a performance.

Conclusion

To review briefly the renotation methodology: the first step was to identify the source of difficulty, and then as a second step to define the perceptually salient characteristics that need to be conveyed. The third step was establishing limits to the precision and complexity that performance should aim for, based on both the performer's limitations as well as listeners' sensitivity threshold. With these perceptual considerations used to define the rhythmic grid, the rest of the renotation proceeds, based on practical considerations to choose which layers to define metrically and which to approximate.

The overwhelming amount of information in the original score of measures 9–11 leads performers to simplify it by normalizing some of the IOIs, resulting in more regularity than there should be. By contrast, in the renotated score, the deliberate loss of some information inserts a certain amount of noise into the rhythmic performance,

which guarantees irregularity. In other words, in this case it might be better to replace the noise generated by an approximate reading of a complex and precise score with a noiseless realization of a score that has some noise (or rhythmic approximation) already built into it. This can be seen as abandoning the high modernist ideal of performance as "noiseless" transmission[15] and replacing it with a model that recognizes the limitations of live performers and listeners alike. In the case of Xenakis, the introduction of some additional rhythmic noise seems well within the composer's aesthetics.

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15 Cox, 2002.

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20. An Approach to the Epistemic Potential of the UPIC

Mauricio Arturo Meza Ruiz

Introduction

The present chapter arises within the framework of a doctoral research project that investigates the role of artificial memory in the processes of musical creation mediated by digital technologies.[1] My research aims to contribute to the emergence of new categories of listening, specific to the process of musical creation, from a critical perspective that puts the digital trace to the test.[2] By digital trace I understand the retention in digital memory of the information input from a human agent into a computer system, in a context of interactivity.

I thus distinguish between two types of interactivity. The first is one in which computer formalism governs the whole process of creation, and in which bodily movement and aural perception have no relevant role in the output of the process. The second is a kind of interactivity in which a coupling between body movement and listening modulates the whole process, implying a richer and more dynamic exchange of information between the terms (entities, agents) that relate to each other, in the context established by the creative process itself.

Although the processes of music creation mediated by digital technologies involve at least some elementary level of interactivity, such processes do not always integrate a significant bodily engagement on the part of the composer.[3] In the current

1 This chapter presents elements of a previous publication, Meza, 2022, based on a presentation given by the author at the international conference Electroacoustic Music Studies Network, held at the Casa del Lago, Mexico, in 2019. I offer here a new version of the comparative analysis, putting it into an appropriate context in response to the celebration of the centenary of Iannis Xenakis.

2 For an appreciation of the state of progress of the music creation project linked to this research, see Meza, 2021a; 2021b.

3 It is convenient to distinguish between what I understand by interactivity and interaction. The latter term has a broad and generic application, referring to any interactive relationship between agents that inform each other in an analogical, digital, and/or hybrid context. Whereas, the term interactivity refers, in the framework of this research, on the one hand, to any interactive relationship in which at least one of the terms or agents that constitute such relationship is a digital agent, and on the

 https://doi.org/10.11647/OBP.0390.22

stage of development of my research, my purpose is to study those cases in which the projections of musical creativity are conveyed by a coupling between auditory perception and bodily movement; movement that is captured, inscribed, and indexed in digital memory. I focus on cases in which such projections arise from a close relationship between listening and imagination, and in which the captured information is converted into data, which in turn is transferred to the symbolic domain of music, that is, to graphic representations and notations of musical symbolic order.[4]

At the origin of the concerns that have shaped my research is my interest in a certain kind of musical artwork, including the work of Iannis Xenakis, particularly his technological proposal, the UPIC.[5] Among the potentialities of the UPIC is that of projecting and capturing an interactive creation process. Such a process of musical creation would imply, from my perspective, the possibility of building a dialogic relationship with sound, which in turn would give rise to the emergence of new procedures that require considering the advent of a new configuration of the relationship between technique, body movement, auditory and visual perception, and imaginary and creative intentionality, within the context of musical creation. Thus, it would be convenient to rescue the analogical and digital registers of the pieces that have been created with the UPIC system, in order to submit them to analysis and determine how, and to what extent, a digital enactive *poiesis* would have been emerging, at least as a potentiality, in the field of the creative use of the UPIC. By this I mean the fabrication or production of objects (works of art) from a corporeal foundation, situated in a digital technological environment. Paul Valéry (1875–1945) theorizes this in his account of *poiesis*, or poietics, that concerns "human action, from its psychic and physiological roots, to its undertakings on matter and on individuals, [...] invention [...] composition, [...] chance, reflection, imitation, culture and the medium [...] techniques, procedures, materials and supports of action [...] in the production of works of art."[6] On the other hand, the enactive approach "understands cognition as a way of regulating the relationship between the agent and his world, following rules that are based on the nature of the living body, which is considered as a precarious and self-constituted system, autonomous but in need of constant interaction with the environment."[7]

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other hand, to the situation of interaction in which the flow of information is mediated by digital technologies.

4 For an *état de l'art* on the subject of digital traces in musicology and music creation see Meza, 2020.

5 UPIC (Unité Polyagogique Informatique du CEMAMu). CEMAMu Centre d'Etudes de Mathématique et Automatique Musicales) Center for the Study of Musical Mathematics and Automatics.

6 Valéry, 1948, p. 260 [*une idée générale de l'action humaine complète, depuis ses racines psychiques et physiologiques, jusqu'à ses entreprises sur la matière ou sur les individus,* [...] *l'étude de l'invention et de la composition, le rôle du hasard, celui de la réflexion, celui de l'imitation ; celui de la culture et du milieu ; d'autre part, l'examen et l'analyse des techniques, procédés, instruments, matériaux, moyens et suppôts d'action*] (author's translation).

7 Thelma Garrison, "Jerome Bruner—Cognitive Learning" (May 15 2009), *Medium*, https://medium.com/interactive-designers-cookbook/jerome-bruner-cognitive-learning-abf4b3318c75

Among the drawings created with the UPIC device I single out the graphic records of *Mycènes Alpha* by Iannis Xenakis and *eua'on* by Julio Estrada (b. 1943), pieces created in 1978 and 1980, respectively.[8] I now offer a succinct presentation of the history and functioning of UPIC. In the following section, I present a comparative analysis of two excerpts from the graphic registers of both of these emblematic works created with this device.

The UPIC

In 1979, in an interview published in *Le Monde de la Musique*, in which he is questioned about his technological proposal, Xenakis offers an answer that begins by problematizing the use of computers in music:

> The computer should be used not only for sound synthesis but also for macro-structures, large-scale constructions. [...] The obstacle stood on the side of the computer: how to transmit to the machine a notation and concepts that the musician learns in the conservatories?[9]

Xenakis then reveals, in the course of the same interview, a solution that, to the great interest of my investigative project, places a particular emphasis on the integration of the body and, therefore, of its dynamic potential, in the dialogue with computers in the process of musical creation: "The solution was the hand: that the musician should give orders to the computer by means of drawings, and not by means of punch cards or programs."[10]

Although Xenakis had already been cultivating the vision of this tool since the 1950s, it was not until 1977 that he came to its implementation, with the support of his collaborators, within the CEMAMu, located in Paris (Figure 20.1).[11] Taking agogic as a reference—that is to say, the component of music that encompasses the elements that regulate the dynamics of musical expressiveness—Xenakis's intention, by proposing a *poly-agogic*, was to extend the spectrum of possibilities in the domain of musical creation by implementing such a project in a computerized system that takes *drawing*

8 Estrada is a music creator, researcher, and pedagogue. He maintained a close professional and friendly relationship with Xenakis. He was in charge of the research direction of CEMAMu between December 2000 and July 2001. He is a member of the National Institute of Aesthetic Research of the National Autonomous University of Mexico (UNAM) and professor of composition at the Faculty of Music of the same university.

9 Xenakis, 1979, p. 96 [*Il ne faut pas se servir de l'ordinateur uniquement pour la synthèse des sons, mais également pour les macrostructures, les constructions à grandes échelle.* [...] *L'obstacle se situait du côté de l'informatique : comment transmettre à la machine une notation et des concepts que le musicien apprend dans les conservatoires ? La solution, c'était la main : que le musicien donne ses ordres à l'ordinateur par l'intermédiaire de dessins, et non de cartes perforées ou de programmes*] (author's translation). See "Présentation de L'UPIC," *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/cix_upic_presentation?lang=fr

10 Ibid.

11 See "UPIC – Presentation," *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/cix_upic_presentation?lang=en

as the main vector of creativity. When working with the UPIC, the composer is faced with the possibility of designing all the formal and temporal aspects of the musical work, from the waveform to the macrostructure, passing through all the intermediate levels.[12]

Fig. 20.1 Alain Després during a UPIC demonstration in Delphi, 1985. Photographer unknown, courtesy of CIX Archives, Després collection.

For his part, Estrada (Figure 20.2) gives a brief description of the UPIC, of its characteristics and its functioning.[13] He underlines that one of the foundations of Xenakis's musical thought, namely the use of the Cartesian plane to represent sound graphically, takes shape in the poly-agogic computational device: "[…] the UPIC materialized a central aspect of Xenakian thought, the analogical representation of sounds by means of a two-dimensional graph."[14] On the other hand, Estrada highlights the challenges that any music creator must face when making use of the UPIC, and thus assumes the freedom that it offers to the creative process: "Whoever makes use of such a device must obtain all the results without having to be guided by preferences

12 See the video by uploaded by XenakisCollection, "Xenakis Documentary UPIC 2" (10 Mar 2019), *YouTube*, https://www.youtube.com/watch?v=lNPWub-MNxg

13 Estrada describes his relation with the UPIC: "*Usuario de la UPIC en obras y en proyectos de búsqueda, colaborador en la divulgación del sistema en festivales y cursos diversos,* […] *vinculado al desarrollo de dicho sistema a lo largo de las últimas dos décadas*" [I used the UPIC in works and projects of research, having been a partner in the spreading of the system in festivals and different courses […] linked up to its development over the last two decades]. See Estrada, 2000.

14 The "x" axis representing time; "y" axis for frequency. See Estrada, 2000.

coming from a foreign aesthetic. The UPIC is in this sense a table of free musical creation where each user can explore what suits his thinking and his imaginary."[15]

Indeed, the component that characterizes the UPIC device, and that gives it all its originality, is a drawing table, similar to a drawing board for architects, with the important difference that this table is electromagnetic, and its purpose is to mediate between the hand gesture of the *musical creator-composer-drawer-designer* and a synthesizer integrated to a computer. Thus, this design table is an interface that has among its functions to transfer to a computer the information generated by the drawings made by the composer. The data resulting from this transfer of information is then assigned to the dynamic control of the parameters of a synthesizer, finally giving the audition of the drawings through a pair of loudspeakers. The system allows various transformation algorithms (transposition, inversion, retrogradation, etc.) to be applied to the captured information.

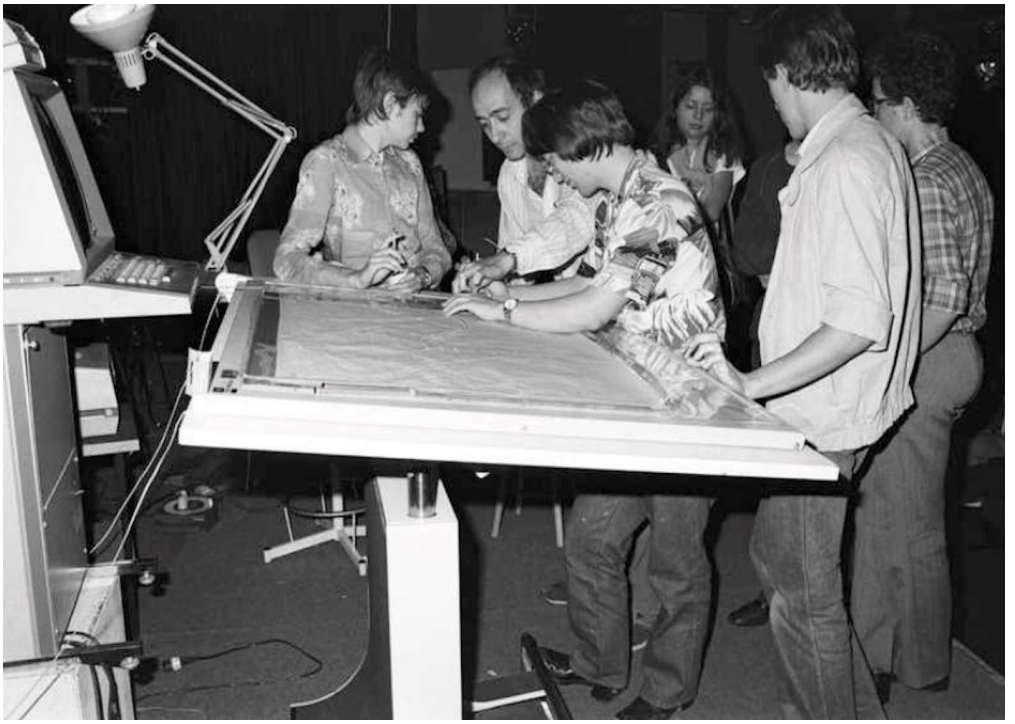

Fig. 20.2 Julio Estrada, in charge of a group of blind youths learning to use the UPIC, *Ateliers Portes Ouvertes UPIC, Forum des Halles*, Paris, 1981. Photo by Bruno Rastoin, CIX Archives, Rastoin collection.

15 Ibid., p. 1 [*Quien se sirve de dicho equipo debe obtener todos los resultados sin requerir ser orientado por selecciones previas provenientes de una estética ajena. La UPIC es en ese sentido una mesa de libre creación musical en la que cada usuario puede explorar aquello que conviene a su pensamiento y a su imaginario*] (translated by the author).

Three versions of the UPIC device were created.[16] With the first version, UPIC A, the one with which Xenakis composed *Mycènes Alpha* in 1978, it was necessary to draw on loose sheets of paper. In order to transfer these shapes to the computer, it was needed to place them on the electromagnetic table and highlight them with an electromagnetic pen. Then, after processing that could take a considerable time to produce its results, it was possible to listen to the resulting sounds.[17]

In addition to *Mycènes Alpha*, Xenakis composed two other solo tape pieces with the system: *Taurhiphanie*, created nearly ten years later in 1987, with a duration of eleven minutes; and *Voyage absolu des Unari vers Andromède*, which dates from 1989 and has a duration of sixteen minutes. It should be noted that Xenakis also composed a mixed work, *Pour la Paix*, in 1981, in which he integrated UPIC generated sounds.[18]

The UPIC was very widely used, resulting in an important production that testifies to the interest that a multiplicity of composers had in it and, at the same time, to the potential of this instrument to facilitate the emergence of a whole wealth of contemporary musical expressions. Among the creators and works composed with UPIC are, in a non-exhaustive enumeration, Nicola Cisternino (b. 1957), *Xöömij*, for bass voice and UPIC, 1997, 11'57; François-Bernard Mâche (b. 1935), *Tithon*, for magnetic tape, 10'10, 1989; Gerard Pape (b. 1955), *Le Fleuve du Désir III*, for string quartet and UPIC, 1994, 12'41; Jean-Claude Risset (1938–2016), *Saxatile*, for soprano saxophone and UPIC, 1992, 7'45; Curtis Roads (b. 1951), *Purity*, for tape, 1994, 7'13; Brigitte Robindoré (b. 1962), *L'Autel de la Perte et de la Transformation*, for UPIC, 1993, 8'33; Takehito Shimazu (b. 1949), *Illusions in Desolate Fields*, for voice, sangen, and UPIC, 1994, 13'27; and Daniel Teruggi (b. 1952), *Gestes de l'écrit*, UPIC, 1994, 11'00.[19]

16 The 1976 prototype, the UPIC A; the UPIC B, in 1982, with a higher sampling resolution rate, thanks to the 16-bit architecture of the IBM-8086 processor. The UPIC C version, implemented in 1986, introduced important advances, including a synthesizer with 64 oscillators, an analog-to-digital converter with a resolution rate of 44.1 KHz, the possibility of reading four pages simultaneously, a reading duration of up to one hour per page and, the most important of these, which distinguishes it from the two previous versions, the ability to reproduce in "real time" the sounds resulting from the drawings. A software version for the Windows system was implemented in 1990; since then, several applications based or inspired by the UPIC have been developed, including UPIX, in 2001 (Maroino, Fontalirant, Estrada), IanniX, 2001 (T. Coduys); HighC, 2007 (T. Baudel); Proba Painter (2008) implemented by R. Bourotte. In 2014, the development of UPISketch began at the Centre Iannis Xenakis, based at the University de Rouen Normandie, by a team of developers under the direction of R. Bourotte. The most recent version is 3.0, available as a free download for OSX and Windows: "UPISKETCH" (9 Mar 2022), *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/upisketch. See also "UPIC (UNITÉ POLYAGOGIQUE INFORMATIQUE DU CEMAMU)," Philharmonie de Paris, *Musée de la Musique*, https://collectionsdumusee.philharmoniedeparis.fr/0130439-upic-unite-polyagogique-informatique-du-cemamu-e992191-5.aspx?_lg=fr-FR

17 See the interactive timeline "CHRONOLOGIE INTERACTIVE," *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/exhibits/show/expo-upic/timeline

18 Four versions of this piece exist: mixed chorus, narrators, and tape; mixed chorus only; narrators only plus tape combining the UPIC sounds and prerecorded chorus; all parts (UPIC, mixed chorus, and narrators) on tape.

19 With the exception of *Tithon* by Mâche, the rest of the works mentioned are part of the collection published as CCMIX Paris Xenakis/UPIC/Continuum, *Œuvres électroacoustiques et instrumentales*, CD Mode 98/99, Paris, 2001 (henceforth CD Mode, 2001). A more

Fig. 20.3 A group of children playing with the UPIC, Les Ateliers UPIC in Orsay (France), 1983. Courtesy of CIX Archives, Alain Després collection.

For Xenakis, creativity is an attribute of every individual; society must make available tools that allow everyone to experiment and amplify their creativity (Figure 20.3). The UPIC project provides a model for a computerized system that, in addition to allowing the creator to integrate his listening and body movement to a process of creation that implies an immediate return of information by the computer, also allows the recording of this creative, corporeal, and perceptive activity. Thus, among the potentialities of the UPIC system, is one of projecting and capturing an interactive creation process. Indeed, the UPIC project makes it possible to consider the importance of recording the creative process, both analogically (graphic registers) and digitally (computer code or digital traces).

These aspects, memorial and corporeal, intrinsic to the implementation of a system such as UPIC, are of great interest for the purposes of my research. There would be macro-structures, inherent to the process of creation, that would exceed the temporal scope of the individual piece, or that would even surpass the totality of the corpus of a creator's work. What could then be inferred, from these *emerging dynamic forms* of a localized musical creation process, with respect to the process of creation, in a broad sense? A creative and investigative approach to a system such as that of UPIC, conducted and organized on a methodology that takes as its vector the capacity to

thoroughly detailed list can be consulted at "UPIC Composers," *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/upic_compositeurs?lang=en

capture information; its memorization and analysis should, by the same token, make such structures emerge.

To advance in the exploration of this line of research I propose, in the following section of this paper, a comparative analysis made from a *traceological* point of view, of two extracts of the graphic traces elaborated with the UPIC: one from *eua'on* by Estrada, and the other from *Mycènes Alpha* by Xenakis, an analysis that will illustrate the arguments that support my premises.

Comparative Analysis of *Mycènes Alpha* and *eua'on*

The analytical confrontation of two images extracted from the graphic records of *eua'on*, on the one hand, and of *Mycènes Alpha*, on the other, will reveal an ensemble of qualities of the creative processes that made them appear, at the same time as revealing the interest of the approach from a traceological perspective.[20] Thus, the comparative analysis that I present below will allow us to detect some characteristics regarding the activity that has taken place in each of these creative experiences. My intent is to demonstrate how, in this context of creation and research, a *traceological analysis*, that is, an analysis of the *traces of use* of the UPIC, can be conducive to the emergence of knowledge about the music creative process. But first, it is necessary to offer a brief presentation of the two musical works in question.[21]

Mycènes Alpha (1978)

Mycènes Alpha, for two-channel magnetic tape, composed in 1978, was created with the first version of the UPIC, being at the same time the first work of music created with the system. Xenakis composed it with the purpose of integrating it into the *Polytope de Mycènes*, a multimedia project premiered in September 1978 on the ruins of the Acropolis of Mycenae, Greece.[22] The French premiere took place the same year, within the framework of a concert program dedicated to Olivier Messiaen on his 70th birthday. The piece lasts nine minutes and thirty-six seconds, and its graphic register is composed of nine pages, one of which is repeated at the final section of the piece's sequence. Figure 20.4 shows an excerpt from one of Xenakis's original sketches, which corresponds to page one of the sequence.[23]

20 Which considers the object analyzed as traces of use of some tool, machine, or instrument.

21 "Traceology, or functional analysis, is a discipline linked to archaeology that aims to determine the function of tools through the study of traces of use." In "Tracéologie" (10 Mar 2024), *Wikipedia*, https://fr.wikipedia.org/wiki/Tracéologie (translated from French by the author).

22 A catalog dedicated to the polytopes, Xenakis's cycle of multimedia projects, established by Elsa Kiourtsoglou is at "Polytopes," *Les Amis de Xenakis*, https://www.iannis-xenakis.org/en/category/works/polytopes-en/. See also Xenakis, 2008, Part Four.

23 Xenakis's preliminary sketches for this work can be found at "Mycènes Alpha," *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/upic_mycenae?lang=en

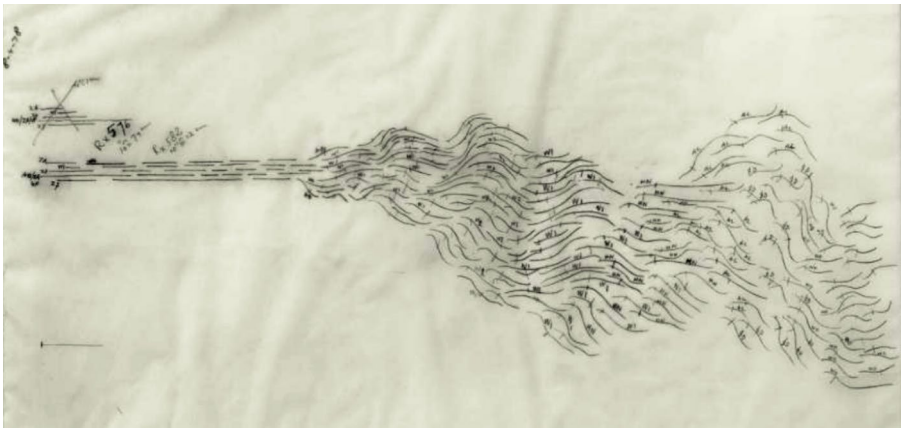

Fig. 20.4 Excerpt from one of Xenakis's original *Mycènes Alpha* sketches; page one of the sequence. Reproduced by permission of CIX Archives.

eua'on (1980)

Estrada wrote *eua'on* for UPIC in 1980. The process of creating this piece will serve as a catalyst for the composer in multiple ways, inspiring him to formulate novel concepts and ideas. A few examples of these include: the *continuous macro-timbre*, an original spatiotemporal conception of music, quite close to acoustical reality, expressed through the synthesis of the entire set of components (pitch, intensity, vibrato, etc.) of a sonic flow; the *method of chronoacoustic recording*, an idea for a musical creation process that uses the graphic register of imagination as a vector; and the *continuum*, an original project with profound aesthetic and philosophical resonances.

Furthermore, the experience of creating *eua'on* led the composer to progress in the acceptance of personal loss.[24] Hence the title, *eua'on*, which comes from the Nahuatl *eua*, to take flight; *on*, at a distance.[25] The sound that served as material for *eua'on* is a recorded sample of Estrada's voice.[26] The piece lasts seven minutes and fifty-six seconds and was integrated into the previously mentioned compilation published by Mode.[27] The first public performance took place on 19 June 1981, in Paris, as part of the Festival Estival du Théâtre du Petit Forum.[28] This is the only electronic music

24 The period of time devoted to creating *eua'on* fell within the period of the composer's grieving the death of his father. In the booklet of the compilation CD Mode, 2001, Estrada discusses the process of composing *eua'on*: "I refused to symbolize musically the loss of my father by a long silence of several months. Then I was able to access the creation of a music certainly brutal but perfectly analogous to the rage of my pain."

25 According to what the composer stated in his keynote at the international Electroacoustic Music Studies Network Conference, June 2019, Casa del Lago, UNAM, Mexico City.

26 CD Mode, 2001. In the accompanying booklet, Estrada explains that, having been dissatisfied with the sound of the UPIC, he decided to record his own voice and submit it to the transformations offered by the integrated synthesizer.

27 CD Mode, 2001.

28 "Julio Estrada (1943) *eua'on* (1981)," *IRCAM*, https://brahms.ircam.fr/fr/works/work/48877/

work in Estrada's catalog, and the only piece he created with the UPIC.[29] An extract of the sketched graphic register, whose dimensions span many meters, is shown in the figure that follows (Figure 20.5). The graphics for this musical composition were really created on twenty-five sheets, each of which was around forty-five cm long and thirty-five cm wide, or a length of nine to ten meters.[30]

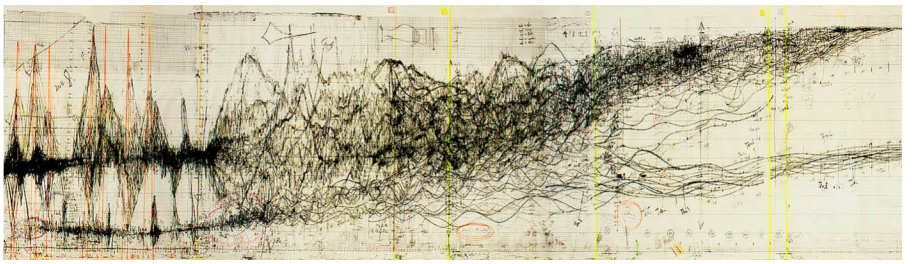

Fig. 20.5 Excerpt from the graphic register of *eua'on*. According to my observations, this passage is located between minutes three and four of the piece. Reproduced by permission of Julio Estrada.

Analysis

Below are presented, side by side, two extracts of the graphic registers made with the UPIC, on the left hand, *eua'on*, while on the right side, an excerpt of *Mycènes Alpha* (Figure 20.6).

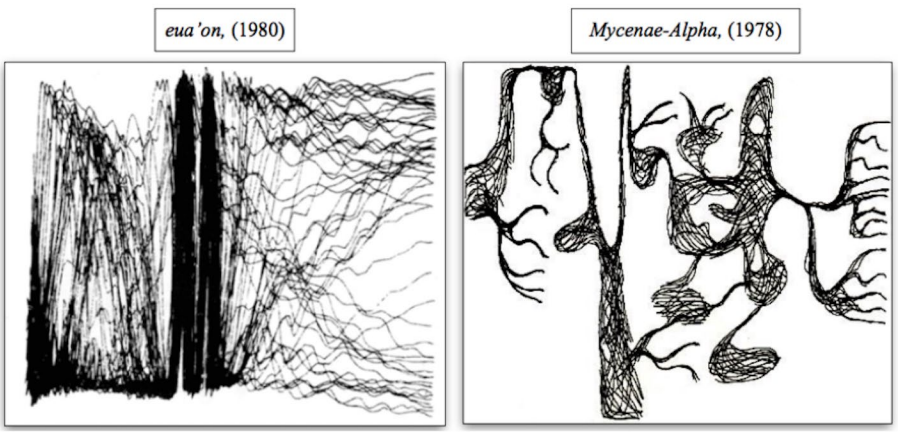

Fig. 20.6 An excerpt from the graphic register of *eua'on*, on the left, (reproduced by permission of Julio Estrada), located between 6′05″ and 6′25″. The *Mycènes Alpha* excerpt, on the right, corresponds to page six (reproduced by permission of CIX Archives) and is located between 4′17″ and 5′16″.

29 Estrada, 2024.

30 The author is grateful to Dr. Manuel Rocha Iturbide for scanning the graphic register of *eua'on* as well as for providing us with a copy of the document.

First of all, it can be observed, in the case of *eua'on*, an extremely intense gestural activity, which proceeds by the accumulation of the same long and continuous gesture (a characteristic both of this extract and of the graphic record on its whole integrity), which gives rise to a visual and sound texture of great plastic and organic density.[31] Meanwhile, in the *Mycènes Alpha* excerpt, it can be observed a gestural activity that in turn could be associated with a more reflexive attitude towards what should become a sound texture obtained through drawing. Indeed, Xenakis seems to proceed by *constructing the sound* from a precise and predetermined *idea of graphic forms* and designs, that is, from the projection of a mental image that gives primacy to the graphic form over the projection of a sonority. On the contrary, in the case of *eua'on*, the relation of analogy between gesture, graphics, and sound seems to be narrower. Futhermore, it is quite easy to discern a dramatic component in this fragment of the *graphic-analogical traces* of *eua'on's* creative experience. Indeed, the dense, blackened accumulation, vertically traversing with apparent violence the space of abscissae and ordinates, gives rise to the idea of an accumulation of energy made at a high-rate speed; located in the middle of the image, it dramatically divides the space of the "score" without, nonetheless, inducing a break in the flow of gestural energy. Arises here the idea of a mental and emotional state, or if one prefers, a particular *state of* (*un*)*consciousness*, which I dare to qualify as an "obsessive-compulsive-in-trance" kind of listening, that characterizes this particular moment of *eua'on's* experience of creation. At this point, I could say that we are in the presence of a process focused on the construction of a dialogical relationship with sound, and in which, the structural coupling of listening, as inner listening, with the dynamism of the body, informs in turn the construction of a dramaturgy, which would perhaps be that of a listening in *emergence*.[32] I conclude that, in the case of *eua'on*, it is rather a matter of a *performative listening*, that is, a listening in the process of creating itself, which transcends the graphic dimension of the experience and tends to establish a dialogue with sound. In the case of the excerpt from *Mycènes Alpha*, it would be a question of a more *speculative listening*, which focuses on constructing the sound from the projection of a graphic design.

Discussion

At this point, it is necessary to underline those aspects that seem to me of greater relevance for the clarification, both of my intentions in proposing this task of analysis, and of what appears as a perspective for my research from here on.

31 The piece can be heard to in its entirety at: "Julio Estrada: 'Eua-On,'" *Bandcamp*, https://moderecords.bandcamp.com/track/julio-estrada-eua-on

32 I use the term "emergence" in the sense of Varela and Maturana's theory of cognition, according to which knowledge emerges from the interaction between at least two autopoietic (autonomous, self-regulating) entities. Musicality and musical listening could be understood as emergent qualities of a context of interactivity. On the subject of embodied cognition and the theory of enaction, see Varela et al., 1991. See also Maturana and Varela, 1991.

First of all, regarding the nature of the analyzed objects, it is important to emphasize that, beyond graphic representations of sound, these are fragments of *graphic traces* of what was a creative, sensorial, and interactive experience, focused on sound. Indeed, these graphic objects are more *traces of the usage* of UPIC than graphic scores themselves; *graphic registers-traces* that stand as testimony of the presence of a body involved, both on a sensorial and on a perceptual level, as well as on a gestural level, all in a process of musical creation. These traces reveal the relationship between two domains of reality that converge or hybridize in interactive experiences with environments dedicated to music and sound creation, such as the UPIC: what we see are the graphic traces of a corporeal movement involved in the creation of a sonorous dynamism.

Another aspect that seems important to emphasize is that, by making it possible to create sound through drawing, the UPIC generates at the same time the traces of its use, and this on two interdependent levels: analog and digital. This interdependence of two heterogeneous information flows that unfold as manifestations of the same gesture of creation, in a context that implies creative actions committed from a full state of consciousness that assumes full responsibility for the creative act, a context induced by the very nature of the device, calls for a broader observation and an in-depth study that could reveal new aspects of the genesis of works of art, as well as of aesthetic cognition.

It should also be emphasized that what came to inform my descriptions of these creative experiences is a set of graphic registers that, being considered as traces of the use of a tool, retain for us a particular status, not only for the purposes of this analysis and my research, but perhaps also for what could be a broader description of what comes into play when working with a creative device such as the one proposed by Xenakis. The epistemic-generative dimension, inherent to this type of technological proposal, is still a territory yet to be explored.

The graphic traces that I compared are obviously analogical, however, the core of the device that has facilitated these creative acts, and that has captured and collected them, is a digital computer. This means that these traces have had a digital, symbolic correlate, which is the complementary part of the analog graphic register. This digital correlate has a specific double function: that of mediation between drawing, graphic design and sound projection, on the one hand, and on the other hand, to establish a structural coupling between gesture and listening, similar to that produced when playing a musical instrument. An analysis of this digital component could inform us in quantitative, and even qualitative, terms about the creative experience of both *eua'on* and *Mycènes Alpha*. Indeed, the temporality of the creation process is unknown to us, since it cannot be inferred from the graphical registers. Hence, what I have described, in the case of *eua'on*, as a state of "obsessive-compulsive trance-like" listening could only be corroborated by two methods that could complement each other: either by directly questioning the composer, or by *reconstructing the process* from the information captured in digital memory (it could inform us, for example, in terms of the speed of execution of the gestures, or the duration of the creation process of a specific passage, etc.).

Conclusion

The purpose of my analysis is to infer preliminary elements for the construction of technical-conceptual tools that can be used to describe the experience of musical creation. The traceological approach allowed us to undress the drawings made with the UPIC of the cultural charge that was in the way, not permitting for their deconstruction. The whole documentation of the creative experience with the UPIC should be analyzed. Unfortunately, it will never be possible to do so, since the magnetic tapes containing the digital part of the traces were destroyed.[33] I was unaware of this fact when I first proposed to analyze the creative process of the UPIC back in 2017. This opens-up the question: were Xenakis and Estrada so unaware of the memory of their own creative processes that they did not take care to at least preserve it? A response could have been given by Xenakis in the following remarks:

> The great idea is to be able to introduce randomness in order to break up the periodicity of mathematical functions, *but we're only at the beginning*. The hand, itself, stands between randomness and calculation. It is both an instrument of the mind [...] and an imperfect tool. The products of the intelligence are so complex that it is impossible to purify them in order to submit them totally to mathematical laws. Industrialization is a forced purification. But you can always recognize what has been made industrially and what has been made by hand. Industrial means are clean, functional, poor. The hand adds inner richness and charm.[34]

Hence, since I have no access to the digitalized registers of the drawings made with the UPIC, my demonstration cannot go further; nonetheless, other research perspectives are being opened by this exercise of analysis and approach to the UPIC. Indeed, a project in continuity with this one, and concerning *eua'on*, can be outlined here: Estrada revisited his experience with UPIC between 1994 and 1995 to create *eua'on'ome* for large orchestra, a large-scale work that, for the convenience of my research perspective, I consider, hypothetically, as a *transferential sequel* to *eua'on*. The systematic relationship between them situates these two works in a specific terrain of creative activity, which I must approach and investigate in order to elucidate and define the role of *eua'on's* traces in the creation process of *eua'on'ome*. The transfer of information gathered during the interactive creative experience to the instrumental realm sets an important precedent for what could be a musical composition practice that incorporates traceological analysis techniques. Beyond enriching my criteria for describing this type of creative, sensorial, and interactive experience, what would be the interest, in terms of musical creation, in an analysis of the analogue and digital traces produced by the type of creative and interactive sound experiences I have discussed here? This creates a twofold perspective, which I shall address in the subsequent stages of my study and

33 The memory supports (magnetic tape) were destroyed, according to what Estrada commented during a telematic meeting I had with him in 2021.

34 Xenakis et al, 1987, p. 23 (author's emphasis).

creative endeavor. On the one hand lies the ability to include the observation of the creative process into the process itself; on the other, the music work itself, conceived as a recorded, visible, audible, and *transferable* process... Here are a few creative and research opportunities that come to light when one considers Iannis Xenakis's magnanimous legacy from the perspective that time has allowed.

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XENAKIS AND ARCHITECTURE

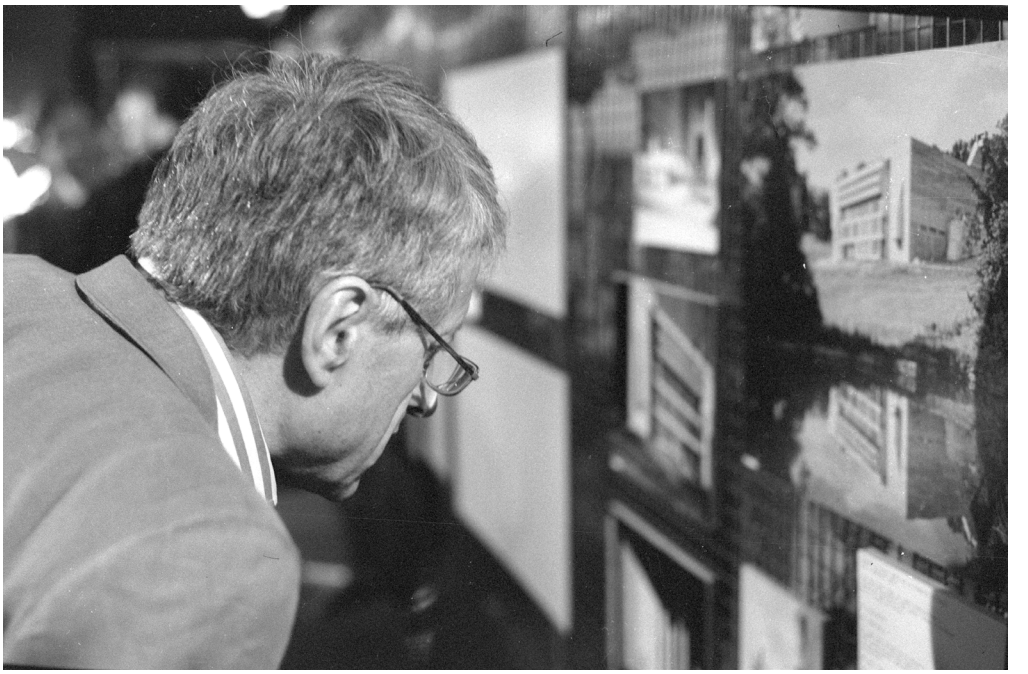

Plate 7 Iannis Xenakis viewing images of La Tourette Convent, for which he was Project Manager under Le Corbusier, in the exhibition at the Alliance Française de Glasgow on the occasion of Xenakis's 65th birthday celebrations, 1987. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

21. Seeing Music and Listening to Architecture: Iannis Xenakis and La Philharmonie de Paris

Brigitte Métra

Métra + Associés

(Architect and associate of Ateliers Jean Nouvel for the creation and realization of the concert hall of La Philharmonie de Paris)

Introduction

Iannis Xenakis has created architectural, musical, and visual works, and his architectures are true spatial transpositions of music. With Jean Nouvel (b. 1945), we conceived of an innovative type of concert hall in La Philharmonie de Paris (inaugurated in January 2015), offering a new musical experience, where both audience and musicians are immersed in a harmonious blend of space and sound. Xenakis's extraordinary way of linking space and music opened up new avenues for reflection and research. As an architect, I discovered, long after La Philharmonie de Paris concert hall was completed, some connections, filiations, and differences between Xenakis's approach to space and music, and our work on La Philharmonie de Paris.

Personal Thoughts and Experiences

Xenakis's artistic legacy is marked by an unprecedented relationship between architecture and music, evident in key works such as the Philips Pavilion (1958), the *Diatope* for Beaubourg (1978), and his project for the Cité de la Musique competition (1984).[1] A brief overview of some Xenakis's projects related to music and architecture,

1 Xenakis, 2008, Chapters 3.08–9.

https://doi.org/10.11647/OBP.0390.23

put in perspective with our work for La Philharmonie concert hall, highlights two different conceptual approaches yet interwoven threads of thought and imagination, as well as some parallel paths with similar goals in creating spaces for music: how to create an experience that is both musical and visual, allowing one to "see music" and to "hear architecture."

Xenakis knew how to transpose his innovative graphical implementation of hyperbolic paraboloids—initially used in engineering for calculating bridges—into his scores for music, and then into architectural forms, such as the Philips Pavilion and some of his Polytopes (1967–78).

After a long experience with the two current concert halls formats—Jean Nouvel's 1998 "shoe box" Concert Hall in Luzern[2] and the 2009 Copenhagen "vineyard" Concert Hall[3]—we wanted to invent a twenty-first century, new type of hall that would reflect the musical culture of our time. Our goal was to go beyond, add to, and blend the specific qualities of both the shoe box and the vineyard types of halls.

The Philips Pavilion at the 1958 Brussels World's Fair: "Volumetric Architecture"

The artistic director at Philips at the time, Louis Kalff, asked Le Corbusier (1887–1965) to create "A bold demonstration of sound and light effects where technical progress could lead towards the future." Le Corbusier answered, "I will not create a pavilion, but an electronic poem: with light, color, images, rhythm, sound, organic syntheses accessible to the audience."[4]

Le Corbusier created the "poem" and entrusted Xenakis to create his electronic poem's venue, which, for the former, could have no significant architectural existence as he saw his own creative work as being the core of the project.

Shortly before that, Xenakis was working on his score for *Metastasis* (1953–4), based on his drawings of hyperbolic paraboloids and conoids, much like those he had used as a student in engineering to calculate bridges.[5] He then used these types of surfaces for the Philips Pavilion, creating a freestanding structure without any supporting poles, and allowed this architectural revolution to be what he called "volumetric architecture,"[6] departing from conventional, two-dimensional architecture based on squares, rectangles, or circles… vertically translated.

Xenakis affirmed that parallel plane surfaces created detrimental reflections for sound, light, and color, and that curves with a variety of radii were excellent for sound.

2 See Conway Lloyd Morgan, "Lucerne Culture and Congress Centre (KKL)," *AJN*, http://www.jeannouvel.com/en/projects/centre-de-culture-et-des-congres/
3 See Jean Nouvel, "Danish Radio Concert House (DR Koncerthuset)," *AJN*, http://www.jeannouvel.com/en/projects/salle-symphonique-de-la-radio-danoise/
4 Xenakis, 2008, p. 105.
5 Ibid., p. 4.
6 Xenakis, 2008, p. 111.

Xenakis and Non-orthogonal Architecture

Xenakis wrote in 1958:

> [T]he referential system for the human body will no longer be the right angle and flat surfaces that are horizontal and vertical. Its sensibility will be shaped by curved surfaces. From the psycho-physiological point of view, this is a new and enormous enrichment, with yet unforeseeable consequences.[7]

Within the Philips Pavilion, one does not reason its geometry, one is subjected to the influence of its curvatures. The Pavilion's free and non-orthogonal approach marked a significant shift, inspiring future architectural developments, further aided by modern 3D software, that flourished decades later.

The *Diatope* for Beaubourg: "Music to Be Seen" in 1978[8]

Xenakis's *Diatope* (1978), for the inauguration of Beaubourg (aka Centre Georges-Pompidou) invited audiences to a multisensory journey, integrating the arts of sight and hearing. Xenakis wanted the arts and sciences to be treated as "alloys."[9] Through his pioneering "total art" works combining architecture, music, lights, and graphic arts, Xenakis invites us to experience unheard-of sound and light experiences.

The Cité de la Musique Project: "A Musical Jewel Box" (1984)[10]

Xenakis's proposal for the Cité de la Musique competition project carried forward his previous work on spaces for making music. He wanted that the music and the audience both be placed—absolutely—in all three dimensions. He proposed a flexible floor layout, allowing for various configurations with hills, islets, and valleys, where the audience could be face-to-face or back-to-back.

Xenakis on the Relationships between the Audience and Audio Sources [11]

Xenakis emphasized the importance of geometric architectural forms tailored to fit each particular audience-source relationship. For him, architecture had to be conceived of as a "jewel box" for music or light, like a high-quality instrument. Until then, except for ancient and Roman theaters, few new and valid forms, or musical instruments, had been created; parallelipedic or polygonal forms dominated. However, modern technologies, theories, and the quality of materials were far in advance, allowing for

7 Ibid., p. 118.
8 Ibid., Chapter 4.20.
9 Xenakis, 1985 (indeed, the title itself of his *Doctorat d'État* in 1976 at the Sorbonne).
10 Xenakis 2008, Chapters 3.08–9.
11 Ibid., Chapter 2.08.

the production of truly adaptable and interesting geometries; yet these were practically ignored at the time. Xenakis stated in this lecture nearly forty-five years ago(!):

> [...] shells and thin casements have been practically ignored. They are capable of being easily modeled in a vast variety of forms, allowing for new geometries that would be truly well-adapted to their use, in addition to being interesting. It is by the use of these membrane shells, and thanks to their free forms and curves, that a new palpable quality of acoustic space (or visual "jewel-box") can be created, comparable to the wooden forms of a Stradivarius. [...] Without excluding planes and right angles, curved surfaces could underline and increase the intimate characteristics of a receptacle or the mysterious characteristics of a cavern-hall with thousands of reflections. Sound would find itself naturally alive with warm resonances from the wall surfaces especially since there would be no acoustical corrections necessary, except under dire circumstances. This has been my experience and remains my profound conviction, demonstrated in the Philips Pavilion and the *Diatope*'s architecture.[12]

Noting the mediocrity of concert halls of the time, he remarked on the necessity to invent an architectural form that would eliminate the inconveniences of, and serve to liberate collective listening. La Philharmonie de Paris Concert Hall[13] seems, in fact, to be one answer to Xenakis's dreams, arrived at through different paths but with a common goal: to create a new 'architectural form' serving both music and collective listening.

La Philharmonie de Paris Concert Hall

As architects of La Philharmonie de Paris Concert Hall, and as music lovers, our vision was to create a musical instrument allowing musicians and audience to be immersed in space and music, echoing the spatialized contemporary music of the twentieth and twenty-first centuries, including Xenakis's.

The competition brief demanded an "enveloping" hall. In architectural and acoustical terms, that means a hall where the audience surrounds the musicians on stage, like in the Hans Scharoun Concert Hall in Berlin,[14] now called the "vineyard" type. This is to be compared with the more common, rectangular "shoe box" type of hall. We decided to go further and to "envelope" the audience with space—space being the medium for sound.

Acousticians generally impose, from the beginning, strict data to be followed: heights, widths, lengths, mass, and weights of materials for sound reflections. Architects, generally afraid of creating a hall that does not have a good sound, usually precisely follow their acousticians' briefs. For La Philharmonie de Paris, thanks to our

12 Ibid., p. 154–5.

13 See "La Philharmonie," *Philharmonie de Paris*, https://philharmoniedeparis.fr/fr/decouvrir/philharmonie

14 See Ralf Bock, "Building for Democracy," *Berliner Philharmoniker*, https://www.berliner-philharmoniker.de/en/stories/memory-of-hans-scharoun/

previous experience on the two mainstream types of halls cited above, we started on a reverse concept: our starting point was *music*; sound which travels through space and voids. Forms, shapes, and matter came later. We put the audience (seats on main floor and balconies) around the musicians (stage), enveloped the audience with space, and then, later, we put surfaces around and above for sound reflections. The flow of conceptual thoughts followed a fluid musical movement. Inspiration came from music itself. We wanted to create an "instrument," serving both musicians and audience, with eyes following a musical movement in space through architecture.

Every surface was thought of and designed in 3D. The angles of flat planes given by acousticians, imposed by necessary quality sound reflections, were blended into architectural 3D surfaces, put into space in a long, fluid, musical movement. After these conceptual intentions came the deep and long work with the two acousticians, Sir Harold Marshall[15] and Dr. Yasuhisa Toyota,[16] coming from the two different schools (the "shoe box" and "vineyard" schools) to ensure that our architectural innovation would fulfill the requisite acoustical qualities. Architectural innovation was accompanied by an acoustical one. Extra space around the balconies, as well as "clouds" and "ribbons," were used as sound reflection spaces or devices, participating in the creation of La Philharmonie de Paris as being a true "musical instrument." This very long and steady work allowed the very special visual and musical experience we can now experience in La Philharmonie de Paris Concert Hall.

In conclusion, Xenakis's profound exploration of the relationships between space and music has influenced further generations of musicians *and* architects. His influence, even though not directly, through our common culture, experiences, exchanges, can be seen in La Philharmonie de Paris Concert Hall, which stands as a new architectural form much like Xenakis dreamed of, and that serves both music and collective listening, allowing us to embark on a unique journey of "seeing music and listening to architecture."

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XENAKIS, Iannis (2008), *Music and Architecture: Architectural Projects, Texts, and Realizations*, compiled, translated, and commented by Sharon Kanach, Hillsdale, New York, Pendragon.

15 See "Sir Harold Marshall," *Marshall Day Acoustics*, https://fr.marshallday.com/people/sir-harold-marshall/

16 See "Dr. Yasuhisa Toyota," *Nagata Acoustics*, https://www.nagata-i.com/1977/01/01/dr-yasuhisa-toyota/

22. Iannis Xenakis/Le Corbusier: A Confrontation *en sol dur*

Guy Pimienta
(*translated by Sharon Kanach*)[1]

A work of art is good if it has arisen out of necessity.
That is the only way one can judge it.

Rainer Maria Rilke (1875–1926)[2]

Le Corbusier (1887–1965) always knew how to surround himself with extremely competent people. In this respect, Pierre Jeanneret (1896–1967), Charlotte Perriand 1903–99), and Pierre Faucheux (1924–99) were key in establishing his fame. What is not as well-known is how much Iannis Xenakis contributed to Le Corbusier's last projects. It is under the epigraph above by Rilke that this essay is positioned, as this citation is remarkably applicable to Xenakis. Yes, his music was born from a necessity, which we will call his "inner atelier." Something is transmuted there as Xenakis invented a non-perspective organization of listening; he listened to the world with a different ear.

The work of Xenakis is characterized by an internal tension, a horizon of expectation whose distinctive features between "fields of experience" and "horizon of expectation" are not yet fully grasped. His thinking is situated between Vitruvius and Aristotle, architecture and philosophy, where questions of place, void, and time are addressed.

> What makes architecture strong is proportions: the coherent relationship between the details and the overall work, and even when there are only ruins left, one still realizes perfectly well the power or not of proportions.[3]

Musician and architect; or rather, musician or architect? It is essential to address the question from both sides. It is in the relationship between these two aspects that Xenakis's approach is to be found. His originality lies therein, like his interest not in

1 This chapter was translated in May 2023.
2 Rilke, [1929] 2001, p. 6.
3 Xenakis quoted in Bridoux-Michel, 2022, p. 68.

 https://doi.org/10.11647/OBP.0390.24

numbers but in the relationship between them. It forms a kind of paradox that isn't one. His time with Le Corbusier structured him. Very early on, Le Corbusier recognized Xenakis's ability to shift the boundaries of his own architectural research. It is this "beyond" that Xenakis prepared during the twelve years he spent with Le Corbusier.

This chapter analyzes Xenakis's trajectory through an examination of the internal organization of Le Corbusier's studio and its evolution during the 1950s. What was the mutual influence between Le Corbusier and Xenakis, given the often-fractious relationship between engineers and architects? More specifically, I will examine the role played by Le Corbusier's assistants and the confrontation between music and architecture. On examination, I find that Xenakis brought to light the fact that there was not only a simple exchange between disciplines but that there was a true departure from all disciplinary thinking, and that his *œuvre* aligned his architectural projects, his musical compositions, and his writings.

Le Corbusier's Method: A Laboratory of Possibilities

It was Georges Candilis (1913–95)[4] who introduced Xenakis to Le Corbusier in 1947 when important commissions were pouring in. Le Corbusier entrusted this new young polytechnician with technical tasks: calculating structures. Le Corbusier's use of mathematics was rather literary: he resorted to it to legitimize his intuitions and make them acceptable. Xenakis quickly realized that Le Corbusier was a poor builder and that he left it to "his family" (the architects—and engineers—of his atelier) to sort out a certain number of constructive inconsistencies to accommodate his theories. Le Corbusier quickly recognized what Xenakis could do for him.

Something connected the two; they shared the capacity to be penetrated by emotional experiences. Their respective aesthetic stances were rooted in drawing and painting for Le Corbusier and in philosophy and mathematics for Xenakis. They both had a common way of exploring their respective research through the process of memory. The studio at 35 Rue de Sèvres where Xenakis arrived in 1947 was for him a laboratory of possibilities. Xenakis was confronted there with a very singular working method; nevertheless, he observed, he listened, he analyzed. Le Corbusier reminds us:

> My young people help me realize my ideas; I am their elder. If they came to me to contribute their work effort, it is because all in all they found these ideas valid. I get my ideas from their working drawings; I fight against their wrong paths; I try to uplift them.

4 Candilis was a Greek, born in Baku, Azerbaijan on 29 March 1913. Educated as an architect at the Athens Polytechnic (1931–6), Candilis met Le Corbusier during his studies, at Congrès Internationaux d'Architecture Moderne (CIAM) IV (1933) in Athens. Following their encounter, Le Corbusier assigned Candilis the leadership of Assemblée de constructeurs pour une rénovation architecturale (ASCORAL) in 1943. In 1945 he joined the office of Le Corbusier, where he became one of his main collaborators. He also became the project architect for the construction of the Unité d'Habitation in Marseille (1945–52), the first project on which Xenakis worked for Le Corbusier. Georges Candilis died in Paris on 10 May 1995.

> I endure the throes of childbirth with them, holding their pencil and eraser in my hand; they witness the birth of a work of architecture.[5]

In his manner of conceiving projects, Le Corbusier sought to articulate all this collective knowledge into new elements that had both form and meaning through a constant exchange with his employees.

Le Corbusier invited his employees to use their imagination as a complement to his own, to engage in a coerced exchange: he allowed them to make something *Le Corbusier* as long as the *Corbusian doxa* was not questioned; an enlightened despotism in which Xenakis never allowed himself to be trapped. Le Corbusier said of him: "Xenakis is of the race of the Greek tragedians, of the pre-Socratics; he is open to Greek art, to Byzantine music and, as an architect, he always has a global vision of things."[6]

Xenakis's command of modern music and mathematics literally fascinated Le Corbusier. During the twelve years he spent in the atelier, Xenakis forged his own tools. In his own way, Xenakis applied the rules of Auguste Dupin in Edgar Allan Poe's (1809–49) *The Purloined Letter* (1844): a time to see, a time to understand, a time to act. Architecture became the alloy that allowed him to create the fusion between the arts and sciences and became the theme of his *doctorat d'état* in 1976, comprised of his entire musical, architectural and theoretical output at that time: Arts/Sciences: Alloys.[7] This long process of cognitive development, *L'atelier de la recherche patiente* (Creation is a Patient Search)[8] as Le Corbusier called it, was a foundation for Xenakis's constant interest in music. He forged his musical destiny with the tools of architecture. Building, on the one hand, and composing on the other, are but the same aspects of the creative act; they both are preoccupied by the unresolved redefinition of space and time. Xenakis overturned tables in search of sound surfaces that would later translate into his polytopes, authentically enveloping spatial structures.

The Inner Atelier: A Vitruvian Dream

> It is imperative that an architect has a flair for writing, skill in drawing, knowledge of geometry… he must have a thorough understanding of arithmetic, be well versed in history, have carefully studied philosophy, know music, be familiar with medicine and jurisprudence, as well as the science of astronomy, which introduces us to the movements of the heavens.[9]

Without their mutual fascination with Greek antiquity, without such an understanding, one cannot address what brought Xenakis and Le Corbusier together: their formative years illuminate what each was to become.

5 Le Corbusier, 1941, p. 164.
6 Le Corbusier, quoted in Helffer, 1981, p. 203.
7 Xenakis, 1985.
8 Le Corbusier, [1960] 2015.
9 Vitruve, 1965, p. 30.

Le Corbusier

During his travels, Le Corbusier drew to capture the essence of what he discovered. His notebooks were his working tools: they served to record, in their raw state, his observations, the images that he would revisit later, or never. He constantly referred to his notebooks, spoke of them often, but rarely revealed them. Drawing for him was his means to understand things, a way to decipher the world. Between 1910 and 1911, Charles-Edouard Jeanneret (the future Le Corbusier) embarked on a journey to Constantinople, crossing all of Europe. His account of this journey was to become *Le Voyage d'Orient* (The Voyage to the East) and was supposed to be published in 1914. It was not. The manuscript was buried deep in Le Corbusier's archives. He rediscovered it fifty-four years later, and the account was finally published posthumously in 1966, the year after his death.[10] What emerges from this narrative is his fascination with the Acropolis. He was overwhelmed by the Parthenon. The nature of the relationships between the buildings is what interested Le Corbusier, as an enigma to be solved, without, however, being able to articulate it.

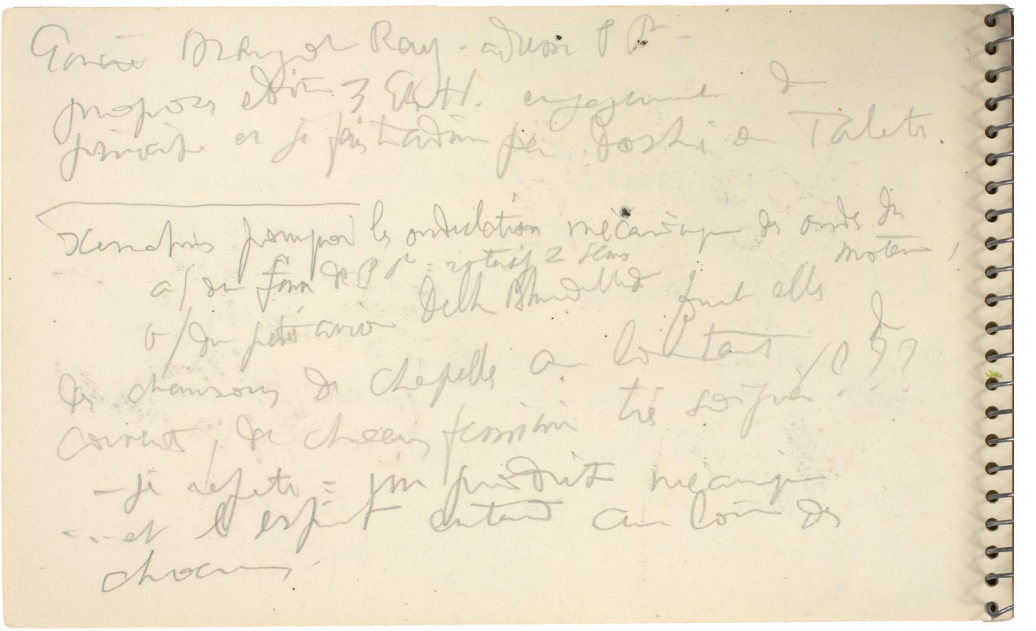

Fig. 22.1 Excerpt from Le Corbusier's Carnet III, no. 617 (courtesy of Fondation Le Corbusier).

Over the years, his notebooks (which he never abandoned), reflected his secret garden, the place from which his first ideas emerged. His drawings show a stenographic manner of working; they reveal a fundamental relationship between painting and

10 Le Corbusier, [1966] 1987.

architecture. His notebooks are a collection of analytical annotations, a veritable tool for appropriating and understanding what he sees. Seventy-three notebooks have been found and published in four volumes.[11] Quantities of images and notes can be found in these notebooks, which represent Le Corbusier's memory. They translate, day after day, his experience of the world and tell his own story: multiple sources of references, of jotted down thoughts, representing many layers of his invention. There are thirty instances where the name of Xenakis appears in these four volumes. It becomes very clear that Le Corbusier undeniably relies on him. Let us consider, for example, this one:

> [...] Xenakis, why mechanical waves of the engine // a) of PJ's[12] oven = rotating 2 directions // b) of the small airplane Delhi Ahmedabad // do they create songs of a chapel in the distance, of convents, of very refined female choirs?...- I repeat = a mechanical product...and the mind hears choirs in the distance.[13]

Xenakis

Xenakis's thought is fundamentally grounded in Greek antiquity. Xenakis was well-versed in the texts of Homer, the Greek philosophers, and Greek tragedy. Before joining Le Corbusier's studio, Xenakis always claimed to know nothing about modern architecture and asserted that nothing could surpass the Parthenon.

> In my youth, I intended to be an archaeologist, undoubtedly because I lived immersed in ancient literature, in the middle of statues and temples... I used to go to Marathon by bicycle. At the supposed place of the battle, there was a tomb with a bas-relief of Aristocles [Plato], and I would stay there for a long time to soak up the sounds of nature, the cicadas, the sea.[14]

Xenakis's invention and curiosity were constant, inseparable from who he was. While taking his first lessons in analysis, harmony, and counterpoint, at the age of fifteen, he transcribed a Bach fugue in graphical form in order to "find the structure, the architecture in a visible way."[15]

> I learned piano with a Swiss teacher, I sang Palestrina, and at the age of sixteen I decided to devote myself to composition. I was also very interested in philosophy and mathematics, but not at all in architecture, which, for me, had ceased to exist in the 5th century B.C.! It was somewhat by chance that I found work with Le Corbusier when I arrived in Paris in 1947. I understood what architecture was through his example, which corresponded to what I wanted to do in music.[16]

11 Le Corbusier, 1981.
12 "PJ" = Pierre Jeanneret, Le Corbusier's cousin and business partner.
13 Le Corbusier, 1981, Carnet III, number 617.
14 Xenakis, 2008, p. 17.
15 Xenakis, 1968, p. 7.
16 Jarry, 1992.

Xenakis engaged in "Le Corbusier's method" like a laboratory of forms and plastic ideas; he talked about "liturgy" where the master carried out a kind of "secret transmutation" with his disciples. This method became a "sounding board" for him.[17]

Concomitance of Music: Articulating Orient-Occident

Xenakis secretly composed music in Le Corbusier's studio whenever he had the opportunity; his manuscript would vanish as soon as the master appeared. Xenakis, while performing his role as an engineer, also composed at home and submitted his musical work to musicians whom he esteemed. This is how he met Olivier Messiaen (1908–92) in 1951 and followed his course at the Conservatoire. Later, Xenakis said of Messiaen: "For the very first time I saw a musician think in a wide and unconventional way. Especially the rhythms he introduced and the way he analyzed Stravinsky's *Rite of Spring*."[18] In the course of a few years, Xenakis managed to combine music, architecture, and mathematics in order to create a new music made up of sound masses. *Metastasis* (1953–4) is his most emblematic work of this kind. The role played by Messiaen was fundamental, he supported him unfailingly and encouraged him to continue his musical research:

> [...] Finally what he has done, he has used mathematics, he has used architecture, in order to compose and that has given something which is totally inspired, but is completely "outside." Which belongs only to him. Which no one else could have done! That has an impact, a force. That is a power.[19]

Messiaen's support was what made it possible for Xenakis to combine music and architecture. Such encouragement allowed the young Greek to define himself in relation to architecture while at the same time reinforcing his musical aspirations. He said:

> I found that problems in architecture were the same as in music. One thing I learned from architecture which is different from the way musicians work is to consider the overall shape of the composition, the way you see a building or a town. Instead of starting from a detail, like a theme, and building up the whole thing with rules, you have the whole in mind and think about the details and the elements and, of course, the proportions. That was a useful mode of thinking. I was young and I was not formed, so I thought that the best way to attack the problem was from both ends, detail and general.[20]

However, in his memory, the words of Messiaen from 1951 still resonated: "you are almost thirty, you have the good fortune of being Greek, of being an architect, and having studied special mathematics. Take advantage of these things. Do them in your music."[21]

17 Xenakis quoted in Matossian, [1981] 2005, p. 83.
18 Ibid., p. 60.
19 Ibid., p. 20.
20 Xenakis quoted in ibid., p. 81.
21 Messiaen quoted in ibid., p. 59.

Furthermore, Messiaen often brought Eastern and Asian music to his classes, to which he paid the same analytical attention as to Western music. It is undeniable that this had a determining influence on Xenakis:

> [I]n the 1950s, I discovered non-European music: from India, Laos, Vietnam, Java, China and Japan. Suddenly, I found myself in familiar waters. Concurrently, Greece appeared to me in a new light, at the intersection of relics from a very ancient musical heritage.[22]

And elsewhere:

> I was looking to see if studies had been done in older or more primitive societies than ours, such as with Australians, in Africa, or in the Amazon, to see if they conceived of time and space in the same way we do.[23]

Xenakis sought to transgress the duality of time and space categories by advocating their inseparable nature. The concept of in-between would later crystallize during his trip to Japan with his discovery of *ma*. The concept of *ma* is both what separates and what unites; in music, it is silence between two musical phrases. We even find its appearance in his piece *Hibiki-Hana-Ma* (1969–70)…[24]

Metastasis/La Tourette Convent: A Turning Point

One day, Xenakis asked Le Corbusier to entrust him with a project in its entirety. It was to be the convent of La Tourette, which illustrated Le Corbusier's talent for bringing Xenakis's qualities to the fore.

In 1953–4, while working for Le Corbusier, Xenakis created *Metastasis* for sixty-one instruments; it was his first music entirely derived from mathematical principles and procedures. For Xenakis, it was a question of implementing a direct relationship between music and architecture, an uncommon combination, but one that was self-evident for him.

We find here perhaps the Gordian knot of the composer/Xenakis corroborated by what he says about the similarities between architecture and music: "I discovered through contact with Le Corbusier that the problems of architecture, as he formulated them, were the same as those I faced in music."[25]

Indeed, Xenakis discovered a singular way of conceiving architecture with Le Corbusier, by crossing the borders between disciplines. He found and retained a way of thinking that he implemented in his musical practice. Xenakis only keeps the forms of the intention, in short, "matrices of ideas," a constant dialectic between analysis and bricolage.[26]

22 Xenakis quoted in Xenakis, 2008, p. 21.
23 Xenakis, 1968, p. 34.
24 See further Chapter 17 in this volume.
25 Xenakis quoted in Matossian, [1981] 2005, p. 64.
26 Cf. Xenakis, 1979, p. 95.

Le Corbusier is a complex figure in the history of architecture; his career was driven by a double ambition: to build at all costs and to leave his mark on the history of architecture. His architectural production becomes very heterogeneous after the war. Indeed, the projects were designed by architects from all over the world. Le Corbusier sensed what Xenakis could bring him when he offered him the opportunity to work on the La Tourette convent in 1954. With this project, Le Corbusier opened a loophole in his system where he foresaw the ability of Xenakis to put his theories into practice and even to go beyond them. With the convent of La Tourette, Xenakis applied the laws of the Modulor,[27] absolute credo at that time for Le Corbusier. He insisted on the fact that the Modulor was a way of regulating the logic of numbers, combinatorics, a way of getting out of the classical workings of academism. During his travels in Greece, Le Corbusier measured the components of buildings to note that the golden section appeared there in a recurrent way. Returning to the roots of ancient Greece legitimized the arrival of the young Greek polytechnician in his studio. The strategy of the Corbusian project is built around a double separation: separation between the formal and constructive project, and separation of the formal project between the sketches of Le Corbusier and the Xenakis's dimensions. The Modulor, deprived of any inherent logic, took its efficiency from a logic of conviction since the autonomy of the act of creation must be established together with the arbitrary. Xenakis takes the Modulor into his own hands and addresses the question of whether such a system of proportions can also serve as a basis for his musical compositions.

During the conception of the La Tourette convent, Xenakis developed the principle of undulating glass panes.[28] Thanks to an observation made by Le Corbusier in Chandigarh regarding a technique of inlaying glass in concrete, Xenakis applied and transposed the Indian glass panels from his musical experience. Le Corbusier coined the term "musical glass panes" because of Xenakis's rhythmic treatment of them. This invention bears witness to a turning point: Xenakis affirmed himself as an architect and, at the same time, confirmed his becoming a musician. In Le Corbusier's studio, he articulated the two registers concomitantly: music and architecture. He later admitted that it was through Le Corbusier that he had succeeded in considering architecture from a new angle, convinced that it could be treated in an abstract and not only in a formal way: "Graphics are indispensable; there are things that can be more easily manipulated through drawing. I acquired this experience during the twelve years I dealt with architecture with Le Corbusier."

One of his colleagues in Le Corbusier's studio, Fernand Gardien, recalled that Xenakis, when composing and decomposing his undulating glass panes, systematically beat the measure while singing![29]

Xenakis later mentioned the internal necessity that unites music and architecture while evoking the convent of La Tourette:

27 Cf. Le Corbusier, [1950] 1983.
28 Cf. Xenakis, 2008, Chapters 1.11–13, p. 41–8.
29 Ferro, Simonnet, and Prelorenzo (1994), p. 91, 94.

> Even if the concrete has aged, that "special something" has remained with the Monastery [sic]of La Tourette that instantaneously makes us under- stand that we are in front of a real work, an architectural work. By the way, it was conceived on the basis of a very classical schema: a simple rectangle. It holds together because, behind it all, there is that special something that creates the inner coherence, an internal necessity. In music as well, it is that inner necessity of sounds, their nature, how they are arranged, their transformations in or outside time, which constitute its "truth." This is towards what both the architect and the composer must aspire.[30]

The fact remained that Le Corbusier always wanted more. He would push to the limit all the tasks entrusted to Xenakis, demanding so much that he once wrote to him:

> It's time to move ahead! I have three urgent things to take care of at the same time. Don't complain! If you can't handle it, then you are neither an architect nor a leader. But I know you are capable.[31]

The Places of a Rupture: Denial Considered as one of the Fine Arts

In 1956, Le Corbusier asked Xenakis to design the Philips Pavilion for the 1958 Brussels World's Fair, a true contemporary expression of the synthesis of the arts. If with the La Tourette convent, Le Corbusier used Xenakis's talents to satisfy his aesthetic desires, with the Philips Pavilion, the situation was the opposite. Indeed, with its complex shapes derived from advanced mathematics and new construction techniques, this project evolved in a realm totally unknown to Le Corbusier. Xenakis's mastery was absolute, and such a situation was unbearable for his boss, who never fully delegated the control of a project. Le Corbusier was torn between his desire to be master of the situation and to be innovative. Le Corbusier's method was put to test; it turned against him. With the Philips Pavilion, Le Corbusier renounced the credo of his first hypotheses of the right angle. He saw an opportunity to make a 180-degree turnaround. Never had engineers and contractors had to deal with a construction composed exclusively of hyperbolic paraboloids, self-supporting ruled surfaces; Xenakis's project had no interior nor exterior support components. Xenakis pushed the limits of his favorite material, reinforced concrete, to the extreme. Moreover, he didn't have any modeling tools other than trial and error. In this respect, one of the first models made of piano strings is one of the most eloquent examples of Xenakis's experimental research.

30 Ibid., p. 5.
31 Xenakis, 2008, p. 84.

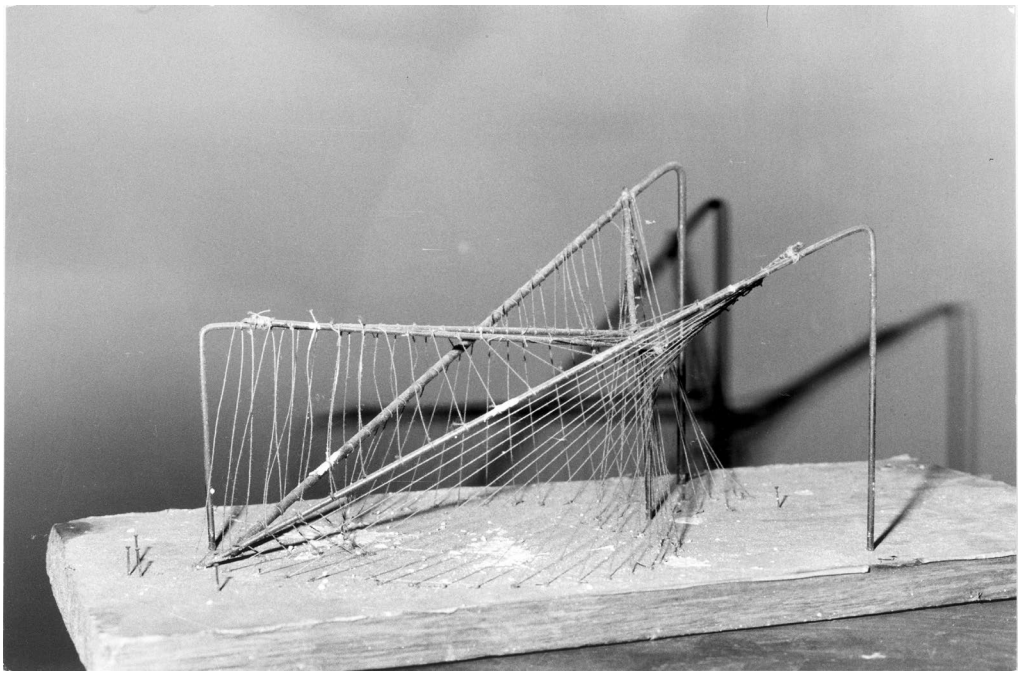

Fig. 22.2 Philips Pavilion first Scale model (courtesy of Fondation Le Corbusier).

The Philips Pavilion echoed Xenakis's musical preoccupations of the time, and mastering such complexity provided him with a solid foundation on which to build his future Polytopes.

> In the Philips Pavilion I realized the basic ideas of *Metastaseis*: as in the music, here too I was interested in the question of whether it is possible to get from one point to another without breaking the continuity. In *Metastaseis* this problem led to glissandos, while in the pavilion it resulted in the hyperbolic parabola shapes.[32]

While deeply involved in this project, Le Corbusier initially refused to acknowledge Xenakis's contribution, not wanting his name to be mentioned. It was a breaking point; their relationship deteriorated increasingly. Xenakis demonstrated with this project that he was much more than an engineer-draftsman, a simple subordinate to a demanding architect. The notes in Le Corbusier's notebooks prove the importance he placed on Xenakis. In 1957, Xenakis wrote to the director of Philips in disgust:

> I now demand, very firmly, that your press services mention my name in the architectural creation of the Pavilion, at the side of Le Corbusier [...] It is the least gesture of justice and truth which Philips owes me for the intellectual and moral qualities which I have placed at its disposal.[33]

32 Xenakis quoted in Varga, 1996, p. 24.
33 Xenakis quoted in Matossian, [1981] 2005, p. 129.

Le Corbusier's reaction was scathing: "Since 1922, I personally have not personally traced a single line on a drawing board. [...] It is a well-known fact that the studio is persuaded that it is he who drives the cart [...]"[34] How could one not be flabbergasted by such a formula! How can one not be shocked by such contempt? "What exactly do you think you have invented? All these shapes are well known!"[35]

The Philips Pavilion unleashed something unexpected and troubling in Xenakis. In this project, his mastery was total: he drew, he calculated, he composed, he built, he searched... Le Corbusier's reaction, writing to the head of Philips indicating that he was the sole creator of the Pavilion, left Xenakis dumbfounded. Even if the name of Xenakis appeared on the Philips Pavilion *in fine*, the damage was done. Le Corbusier's jealousy was at its peak; he took advantage of summer vacation to change the locks of the studio and to fire three of his pillars: Iannis Xenakis, Augusto Tobito (1921–2012), André Maisonnier (1923–2016). He called the three of them "date trees" because, according to him, they were enjoying the sun without producing fruit![36]

Later, Xenakis said he was deeply disappointed: "I continued to work until 1959 and the situation became absolutely untenable. He came less and less...and then he did something quite disgusting, he used summer vacation to kick me out!"[37]

When Le Corbusier asked him to return to his studio, Xenakis remained inflexible. He was dejected and offended: "When I decided to do only music, I was very distressed because architecture was very important to me. I did it because I had to make a choice."[38]

The Echo Chamber

In a possible anamnesis, we can resurrect how and why Xenakis ended up in Le Corbusier's studio: the young revolutionary fled Greece because he knew he would be sentenced to death there for his political activities (obviously). He therefore took the chance of receiving the same sentence, but in absentia, wherever he landed. He headed off, destined to the United States, where he had a brother awaiting him.[39] But, by the time he arrived in France, during a general strike, he ran out of money, but he was welcomed in Paris by other Greeks in exile and the Communist party. Very soon afterwards he met and was hired (as an engineer, at first, let us not forget) by Le Corbusier. However, he never forgot the demonstrations against the British in Athens in December 1944:

34 Le Corbusier's letter to Philips quoted in ibid., p. 130.
35 Le Corbusier quoted in Xenakis and Kanach, 2008, p. 101.
36 Quintana Guerrero, 2018, p. 11.
37 Xenakis quoted in Bridoux-Michel, 2022, p. 192.
38 Xenakis, 1985, p. 57.
39 Matossian, [1981] 2005, p. 40_1.

> then the fight against the British themselves, in December 44, who had transformed the icy city of Athens into a kind of fantastic polytope both of sound, and of light, with tracer bullets, explosions and all that. They were remarkable polytopes. And afterwards, to organize these masses of events: this is where I say that there is an emergence, because all this came out much later, sweeping away all the preoccupations that I had with polyphonic and harmonic writing, all that I was relearning at the time.[40]

Indeed, in December of 1944, the street was a vibratory space. This past, he would later transcend it, as he conceded in the same interview: "it comes closer to elsewhere, to the movements of celestial bodies, comets... shooting stars..."[41]

Xenakis had read Camille Flammarion (1842–1925) and Jules Verne (1828–1905), revealing his taste for the elements and tectonics. He was fascinated by chaos, catastrophes, storms; all those elements that emanate from the uncertain condition of man. How to speak of the earth and speak of mankind? How to make the relationship and the concerns of human beings on earth heard? It was a new consideration of the world, of the ground [*sol dur*][42] on which he stood.

What does Xenakis make us hear? A disembodied sound, the buzz of an insect, an indistinct sound that man struggles to hear? It is a sound *texture* that Xenakis offers us, plucked from the universe. Xenakis claimed this inner necessity and made of it a truly different music. To quote Messiaen, Xenakis is "a musician not like the others."[43]

What did Xenakis get rid of? Xenakis freed himself from any Western musical legacy. Milan Kundera (1929–2023) explained in his book, *Une rencontre*, how Xenakis's music extinguishes sentimentality resulting from the Romantic perception of the world: "And I think of the need, the deep sense of this necessity, which led Xenakis to take the side of the objective sonority of the world against that of the subjectivity of a soul."[44]

Xenakis was impregnated with both a method and a way of shaking the foundations of architecture in Le Corbusier's studio. Modern architecture swept away a repertoire cluttered by the fundamental elements of space: straight lines, plane, right angle. With the advent of the free plan of Le Corbusier, this progress could only serve as a "matrix of ideas" for Xenakis. A complicity united the two men, they unleashed elements of the past, architectural for the first, musical for the second. To establish a filiation between Le Corbusier and Xenakis makes sense only if one considers that the structure of expectation for Xenakis does not develop but unfolds. As sound unfolds in space; sound, that ultimate element that Xenakis appropriated. As Meister Eckhart (*ca*. 1260–1328) famously stated: "Only the hand that erases can write the true thing."

40 Delalande, 1997, p. 111–13.

41 Ibid.

42 The original title (in French) of this essay was "Xenakis/Le Corbusier: une confrontation en sol dur," which represents a clever play on words and language. *Sol* = ground, or the note G (or *gamma*), a fundamental pitch in the Ancient Greek system and which led to the term "gamme" in French (meaning "scale" in English); "*dur*" in German, means "major" (as in major or minor scales, intervals...) and in French, means "hard," like a hard surface. (trans. note).

43 Matossian, [1981] 2005, p. 17.

44 Kundera, 2009, p. 98.

Coda

Without Le Corbusier's firing of Xenakis in 1959, Iannis Xenakis, the musician, would never have revealed himself to the world. Metaphorically, Xenakis was wounded a second time, and he didn't forget the memory of earlier injuries such as those on his face, which one (and Xenakis shaving every day) could follow with a finger, as they evolved over time. He perfectly mastered the role history attributed to him and that was written on that indelible musical staff.

Le Corbusier's impulsive sidelining of Xenakis succeeded in bringing the composer to the fore, sidelining a figure the latter, in fact, had never feared. Xenakis's work momentarily distanced itself from architecture, but in no way did it erase it; rather, it solidified it. Xenakis's destiny had been, as it were, mortgaged. Its and his true vocation were elsewhere: in the necessity of which Rilke speaks in my epigraph. When Xenakis refused the master's last offer to reinstate him in his studio; he swept aside the Corbusian table and overturned a cumbersome figure with the certainty that in order to become, he had to open up a *topos*: the ground on which everything rests, no matter how solid (*dur*).

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23. *Polytropos*: Iannis Xenakis, Engineer in Music and Architecture

Panayotis Tournikiotis

Iannis Xenakis's contribution to architecture uniquely intertwines the work of Le Corbusier (1887–1965) with his own musical explorations. However, it has a special experimental dimension, combining morphogenesis with structural design and construction. His contributions are created, not born, and seek a cosmic relation with the earth. Starting from his civil engineering studies in Athens, he developed a mathematical thinking that fertilized the morphological search of Le Corbusier and gave an unprecedented material and spiritual dimension to buildings that are now landmarks and part of the world cultural heritage. He was equally creative in music and in the creation of spatial events that linked music and architecture. Xenakis was a *polytropos*: a "much-traveled" man, like Odysseus, resourceful and inventive, a traveler to unknown seas.

Fig. 23.1 Xenakis in front of the School of Civil Engineering, National Technical University of Athens, in 1945. National Technical University of Athens—School of Architecture, CC BY-NC-ND.

https://doi.org/10.11647/OBP.0390.25

Engineer

Xenakis studied at the School of Civil Engineering of the National Technical University of Athens (Polytechnic University) from 1940 to 1947.

This was a school that was very advanced in the studies of reinforced concrete. Not many documents from his studies have survived. However, there is one that he kept throughout his life, likely because it held great importance to him and to the computational shaping of his thinking. It is a graphic calculation of a productive reinforced concrete beam with a single connection, on the left side only.

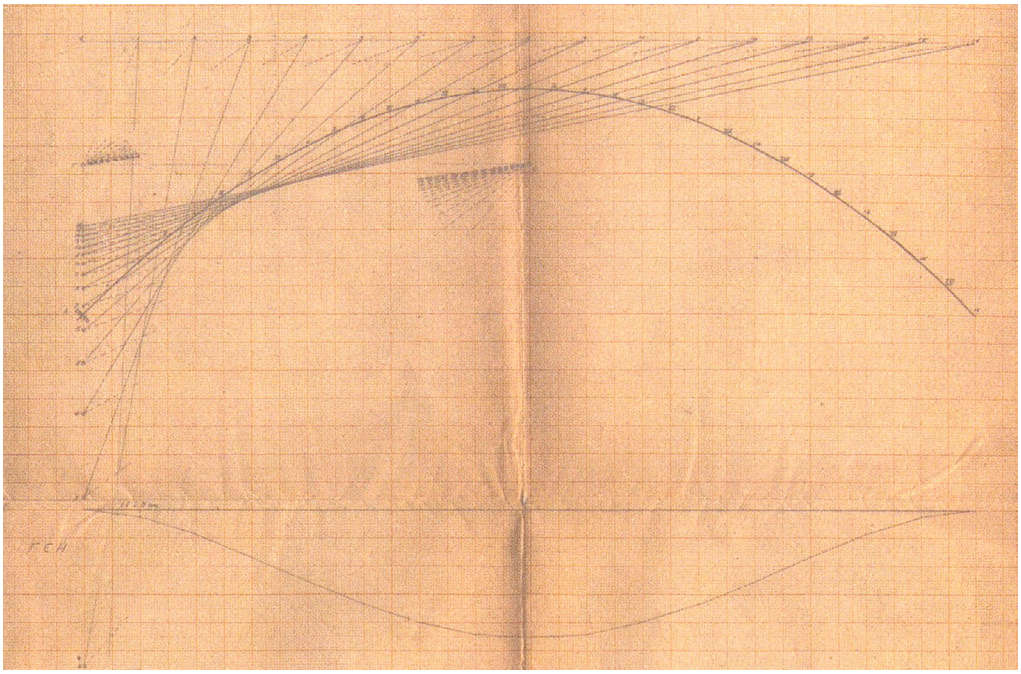

Fig. 23.2 Detail of a drawing of graphic calculation during Xenakis's studies at the School of Civil Engineering, Athens, signed 16 January 1947 (excerpt, Olivier Revault d'Allonnes, 1975, p. 44).

It is a parabolic arc, a graphical and not a mathematical solution of the calculation. Xenakis had a great love for mathematics, but here he solves his problem graphically and uses an approach on millimeter paper that is typical for the time. This is the approach of a civil engineer drawing with Cartesian coordinates on a piece of paper divided in millimeters. The architect's approach is inherently different because he is working on transparent paper with no reference points.[1]

1 See also Xenakis, 2008, p. 4, for another example of such a drawing.

The Atelier of Le Corbusier

Fig. 23.3 Xenakis and Le Corbusier at the Atelier, 35 Rue de Sevres, 1951. Courtesy of Fondation Le Corbusier.

Xenakis received his diploma in June 1947 and made sure that in July of the same year he obtained an official translation in French, clearly intending to leave immediately for France. He had to enlist in the army compulsorily in July, but he managed to escape to Paris and joined Le Corbusier's atelier at the end of 1947. Of course, he was convicted of desertion. Le Corbusier was famous among architects from the 1930s. Graduates of the School of Architecture of Athens had gone to work in his atelier immediately after their studies in 1930, and Le Corbusier came to Athens in 1933. He gave the lecture "Air, Sound Light" in front of the School of Architecture in the framework of the 4th International Congress of Modern Architecture. Several of the students who heard him then left civil war-torn Athens for Paris in 1945, and some of them joined Le Corbusier's atelier. George Candilis (1913–95) and Aris Provelengios (1914–99), for example, were both architects, but Stelios Moussiopoulos (1921–2003) and Nicholas Hatzidakis (1920–2004) were civil engineers. By 1945, Le Corbusier had begun to undertake major projects, and one of the first was the Marseille apartment block

(Unité d'habitation de Marseille), where civil engineers were needed for the complex reinforced concrete calculations.[2] Xenakis, who had just graduated, was immediately involved with the Marseille project, contributing to the construction as a civil engineer, and he was mainly employed this way, as part of the ATBAT (Atelier des Bâtisseurs or "Builders" Studio), a sort of subsidiary created by Le Corbusier for the housing project commissions he was receiving from the French Ministry of Reconstruction following World War II. Nevertheless, during his entire time in Le Corbusier's atelier, from 1948 to 1959, he worked systematically on various projects.

Le Corbusier kept a systematic record of what he commissioned, noting whom he assigned them to and when he received the results. For instance, Xenakis was commissioned by him on 28 February 1952, with sections for the Chandigarh High Court. Much later, in 1956, he was involved with drawings in the Chandigarh project, the Philips Pavilion, the Firminy Cultural Center, and the Baghdad Stadium. In a very interesting certificate, obtained in July 1958, Le Corbusier confirms that Xenakis has been employed at the Atelier since 1948:

> [...] in the capacity of architectural-engineer, head of studies. His attitude since then has been that of a perfect and indispensable collaborator, always very assiduous in his work, taking on ever-increasing responsibilities for which the direction [of the atelier] has long given him its full confidence, given his high professional abilities and scrupulous honesty.[3]

It was therefore a long collaboration in which architecture and the art of engineering were intertwined, while Xenakis was truly trusted by Le Corbusier.

Xenakis's first major contribution to Le Corbusier, however, was not in building but in theory. Xenakis's interest in mathematics, the golden ratio, and mathematical series, especially the Fibonacci sequence,[4] met Le Corbusier's interest in a global system of harmony in architecture based on man. Xenakis elaborated many of Le Corbusier's investigations contained in the *Modulor*,[5] but he does not sign them because he is just a collaborator in the atelier and, like all collaborators, he contributed to individual areas of an investigation that was a complex collective work. References to Pythagoras (*ca*. 570–500/490 BCE) and Plato (428/7–348/7 BCE) link music with architecture, seeking a harmony that transcends them, claiming a cosmic relationship. The Fibonacci sequence develops in the *Modulor* the relationship of the golden ratio to a spiral ascent following a red and a blue scale. Each step produces a dimension that is harmonious in relation to all the others, and at the same time different from all the others. That is,

2 See Xenakis, 2008, Chapter 1.04.

3 Solomos, 2022, p. 202.

4 The Fibonacci sequence is a sequence of numbers where each number is the sum of the two preceding numbers. The Fibonacci sequence, strongly related to the golden ratio, reflects various patterns in nature like the perfect spiral of a nautilus shell. The Italian mathematician Leonardo Bonacci da Pisa (*ca*. 1170–*ca*. 1242) who introduced the sequence to Western European mathematics in his 1202 book *Liber Abaci*, was nicknamed Fibonacci in the nineteenth century.

5 See Le Corbusier, 1950; 1955.

all elements differ from each other but are, at the same time, connected by a common rule. They harmonize following another kind of order. In Le Corbusier's mind, this starts with the average height of a human being, centered on the navel, and a series of data that harmonize and produce the overall work of art that is the Unité d'habitation of Marseille, and then other works in which dimensions are likewise harmonized. Of course, you cannot see this harmony. It is not obvious. It is something inherent that gives a reason to architecture, but is lost in mind and matter.

Chandigarh

During these twelve years, Xenakis worked on many projects, some more and some less important. I will mention three of them, to shed light on his participation in Le Corbusier's atelier, which I think was mutually important for both Xenakis and Le Corbusier. The first is the Parliament of Chandigarh. Le Corbusier undertook a gigantic project, an entire city with an administrative center, the Parliament, High Court and more, in the newly independent India. His aim was a symbolic work that could express the modernity that India was then striving for *vis-à-vis* the Western European world. The Parliament was built on almost deserted land, from which it emerges as a geometric form of sculptural reinforced concrete. A pyramid dominates the top of the roof, alongside a strange hyperboloid structure, which is inexplicable at first glance.

Fig. 23.4 The Parliament of Chandigarh (c. 1959). Courtesy of Fondation Le Corbusier.

Le Corbusier had told Xenakis that, while flying over Ahmedabad, India, to go to Chandigarh, he had seen a nuclear power station that was just being finished, with reinforced concrete towers, built to cool the decay of the atom.[6] From this was born

6 Xenakis, 2008, p. 22.

the idea that the great hall of democracy in the Parliament should receive the cosmic light through a hyperbolic release to the sky to illuminate the representatives of the people. Xenakis undertook to support this peculiar solid on a horizontal plate. It was not at all simple to define and calculate such forms at that time. Xenakis followed an experimental method that had been tested in civil engineering laboratories, constructing a scale model that accepts loadings and allows a proportional sizing of the real structure. Surviving photographs of this model show the young Xenakis clearly contented alongside the mature Le Corbusier.

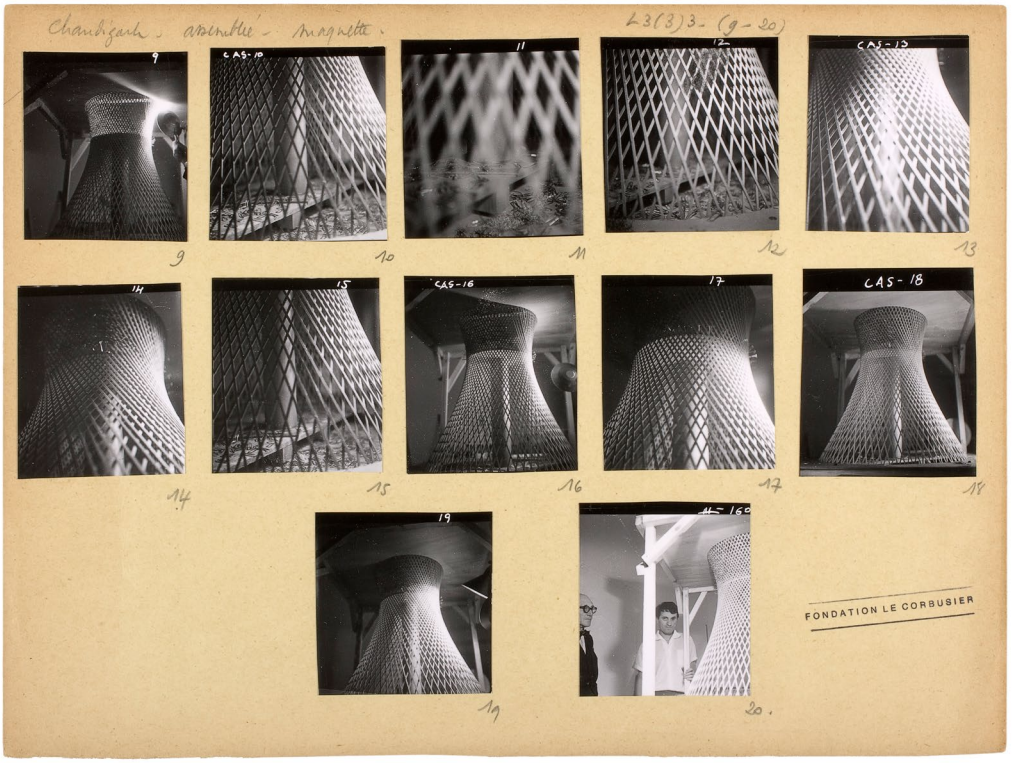

Fig. 23.5 The model of the hyperboloid on the roof of the Parliament of Chandigarh. The last picture in the series shows Le Corbusier with Xenakis (c. 1956). Courtesy of Fondation Le Corbusier.

Xenakis worked systematically to calculate, in geometric terms, the shape of this solid. He developed the model and made large drawings, which are signed "dessiné par Xenakis" (drawn by Xenakis).

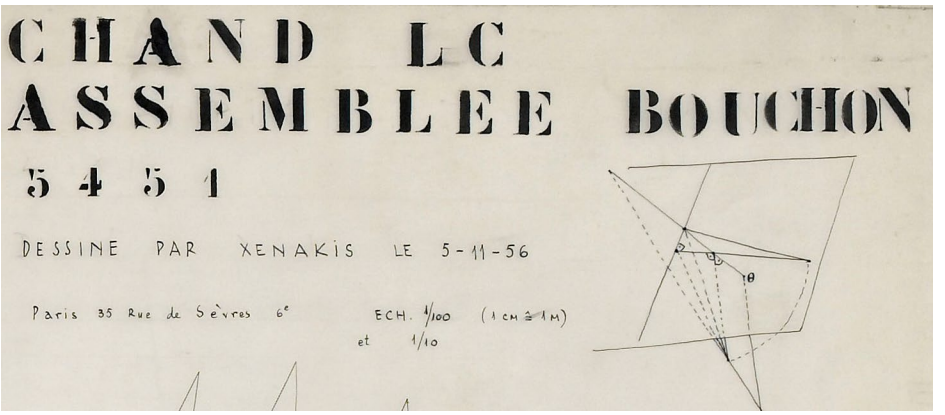

Fig. 23.6 Detail of the drawing 5451 for the Parliament of Chandigarh, "dessiné par Xenakis" 5-11-1956. Courtesy of Fondation Le Corbusier.

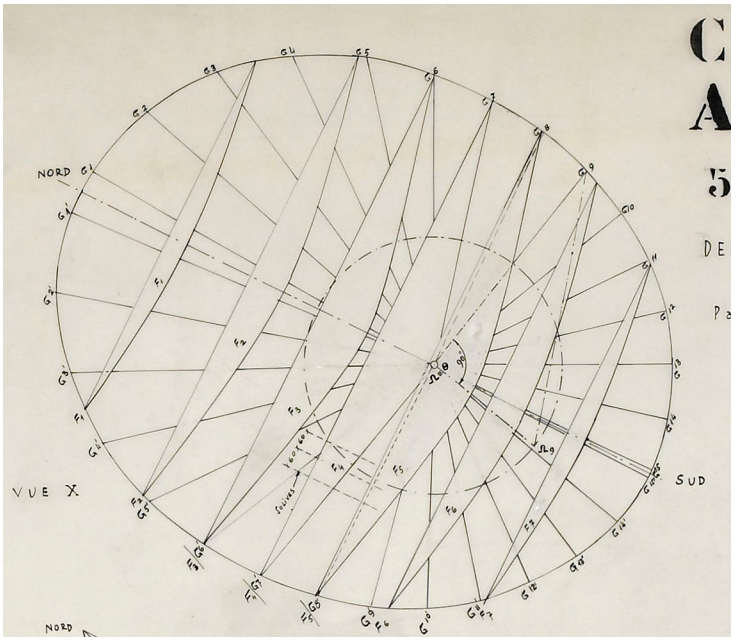

Fig. 23.7 Detail of the drawing 5451 for the Parliament of Chandigarh, 5-11-1956. Courtesy of Fondation Le Corbusier.

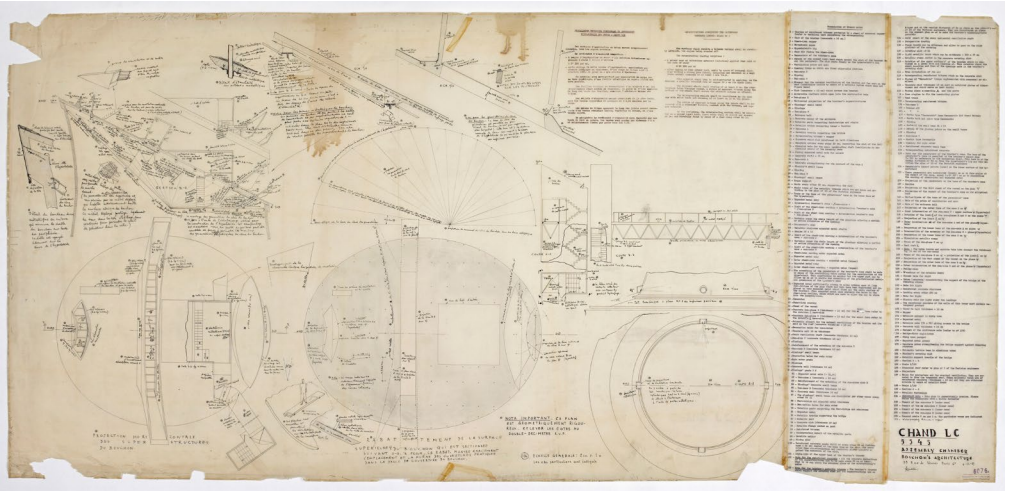

Fig. 23.8 The Parliament of Chandigarh, drawing 5545, signed Xenakis, 6-12-1957. Courtesy of Fondation Le Corbusier.

It was not easy to build the glass barrier on the roof of the hyperbola. Xenakis was also asked to design and calculate the metal trusses that were necessary to meet the technical problem. Looking at the details, we realize that there are dynamic proportions, which follow the square root of two or the golden ratio, and produce increasing spirals and ellipsoidal forms. The design includes the calculation of the structural reinforcement. That was Xenakis's job in the office. However, something else is particularly important: Xenakis does not simply consider how a particular concrete form will stand; he draws the form following the diagram of the static function and gives computational form to the building. Xenakis was deeply involved in the construction of these complex and innovative forms, which were unprecedented in large public buildings. While his signature is certainly on all the drawings he undertook, there is no doubt that these drawings, numbered Chand LC 5451 or 5545, relate to Le Corbusier's Chandigarh project. Though this was a collective work of Le Corbusier's atelier, these specific drawings can be attributed to Xenakis's contributions.

La Tourette

The second project is the Couvent Sainte-Marie de La Tourette, a Dominican monastery in which Xenakis played a leading role as "project manager."[7] In Chandigarh, he had not concerned himself with the overall work but mainly with one feature at a time, such as the hyperbolic roof. At the convent of La Tourette, Xenakis took pride in his approach to the work of the Dominican monks, a centuries-old lineage rooted in the Middle Ages and scholastic thought. This form of scholasticism has deep philosophical

7 Xenakis, 2008, Chap. 1.14

roots and differs from the contemporary understanding of the term. In its Dominican version, it links Christianity with ancient Greek philosophy, Aristotle (348–322 BCE) or Plato. Xenakis's contribution to the monastery is mainly known because he undertook the design of the glazing on the large horizontal glass panels on the façade of the building, called "pans de verre ondulatoires," i.e., undulating glass panes.[8]

Fig. 23.9 The Dominican monastery of Sainte-Marie de La Tourette (1954–60). On the right, undulating glass walls; to the left, the curved volume and the "light cannons" that bring light into the crypt. Photo by author (1999), CC BY-NC-ND.

In these glazing units there are vertical and horizontal dividers defining the dimensions of the rectangular windows without it being clear how. In fact, Xenakis applied Fibonacci's mathematical sequence, which is the basis of the *Modulor*. The distances between the separating elements are calculated so that there are no two panes with the same dimensions, but all dimensions are harmonized with each other, that is, well-tempered. This produces a chaos that is orderly and mathematically calculated as a whole. Xenakis also designed the internal routes, in which you move around within glass walls on the right or left, following the same principle. When you walk through the corridors you are struck by the complexity and variation of forms, and the changing dimensions of the vertical and horizontal elements, in which develops the geometry of the common harmonious rule. At this time, he also composed *Metastasis* (1953–4), which is in a way the musical expression of his architectural discourse.

Looking through the glass walls, into the courtyard, there is a cube of bare, reinforced concrete on which sits a pyramid. It is a chapel.

8 Xenakis, 2008, Chapters 1.11 and 1.12.

Fig. 23.10 The oratory in the courtyard of the monastery of Sainte-Marie de La Tourette. Photo by author (1999), CC BY-NC-ND.

At the edge of the cube there is a slit, like a black line, through which, alone, natural light enters the interior. Quite conversely, the inner edges that are blind are accentuated with thin bright lines of colored neon. It is worth keeping this illuminating intervention in the space of prayer in mind for the later discussion of polytopes and the relationships between space, time, and light in music and architecture.

The La Tourette project was a crucial turning point in Xenakis's career as an architect, for an additional reason. During construction, André Wogensky (1916–2004), the architect and manager of Le Corbusier's atelier, delegated responsibility for the project and communication with the Dominican monks to Xenakis. Consequently, in 1956, Xenakis became responsible for the entire project and supervised the construction on site. He thus became a decisive collaborator of Le Corbusier.

In the church of the monastery, one of the most impressive places I have entered in my life, there is a crypt to the left of the holy altar and a red sloping surface to the right. The crypt, one level below the holy altar, extends outside the rectangular prism of the building, defining a curved volume in the shape of a grand piano's tail, with three conical forms on its roof, the "light cannons," designed to bring natural light into the small chapels of the crypt where the monks go to worship. The interior of the conical forms is brightly colored in Le Corbusier's primary colors, which tint the natural light, giving a cosmic dimension to the sanctity of the monastery.

Fig. 23.11 The conical forms bringing colored light in the crypt of the monastery of La Tourette. Photo by author (1999), CC BY-NC-ND.

To the right of the altar, the sloping surface is red, while the rest of the church's surface, which is of bare concrete, is dark grey. Above the red surface there are seven light collectors, the 'machine guns', that bring in the sun and are tuned so that the sun completely covers the surface at the two equinoxes.

Fig. 23.12 The sloping surface in the church bringing red light to the holy altar. Photo by author (1999), CC BY-NC-ND.

The red then spreads and fills the whole area of the holy altar. The scene could refer to the Apocalypse. Remember that there is blood in this story, which has a deeper symbolic meaning.

Let's leave metaphysics inside the church and go to the roof. There is, of course, no reason to go to the roof, but if you get there you will find an extension of the staircase, a "stairway to heaven:" a rectangular prism, with openings that combine horizontal and vertical elements in an order that we cannot clearly define.

Fig. 23.13 Stairway to heaven: the neume of the window on the rectangular prism offering access to the roof of La Tourette. Photo by author (2003), CC BY-NC-ND.

It seems incomprehensible. For Xenakis it is a *neume* in French, from the Greek word *νεύμα*, which means "nod" or "sign." The neume refers to the harmony of Gregorian music, which predates classical harmony. The neumes, which are motions of the head, eyes, and eyebrows, become symbols of ascent and descent, which are written over the words to indicate the melodic curve and later evolve into notes of a four-line musical notation. Xenakis implies a melismatic relationship between the interior and the cosmic space, dependent on sunlight, which is subject to a *neume*. Turning our gaze to the other side of the terrace, we discover another symbolic geometry, a pyramid.

Fig. 23.14 A garden of symbolic geometry on roof of La Tourette. Photo by author (2003), CC BY-NC-ND.

One does not see it, nor the sculptural forms and the staircase that are organized in total harmony. Only God sees them. No one else.

Philips Pavilion

The third building I will refer to is the Philips Pavilion at the Brussels World's Fair in 1958, which was commissioned by Le Corbusier, who chose Xenakis as his main partner, and which ultimately became the apple of discord between them. The design is primarily due to Xenakis, who devised a parabolic hyperboloid to define thin, shelled, reinforced concrete surfaces. The graphic design of the form is the same as the graphic design of the static structure, so that the form and the static function form a single system. However, construction difficulties did not allow the implementation of the initial design, which was done conventionally with prefabricated slabs on a load-bearing metal frame.[9]

In order to refine his conception, Xenakis resorted to mathematical objects and sought an overall harmony. A platonic polyhedron is hung inside the pavilion as a dominant element of its architecture. Of great interest are the patterns of rotation of the planes to produce the curved surfaces of the parabolic hyperbola on the base of straight lines. Indeed, in each point of the composite curve rests a straight line. However, what is complex is at the same time as simple as its graphical representation.

9 See Revault d'Allonnes, p. 126–9.

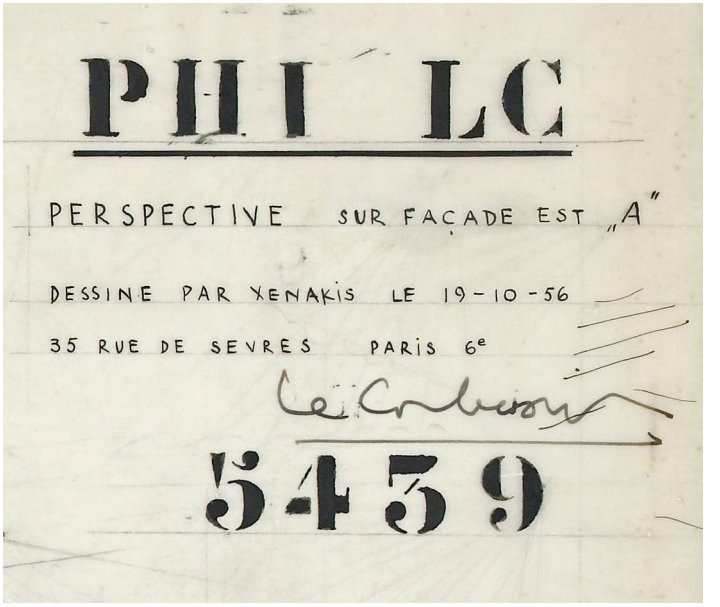

Fig. 23.15 The Philips Pavilion, detail of the drawing 5439, "dessiné par Xenakis," signed Le Corbusier, 19-10-1956. Courtesy of Fondation Le Corbusier.

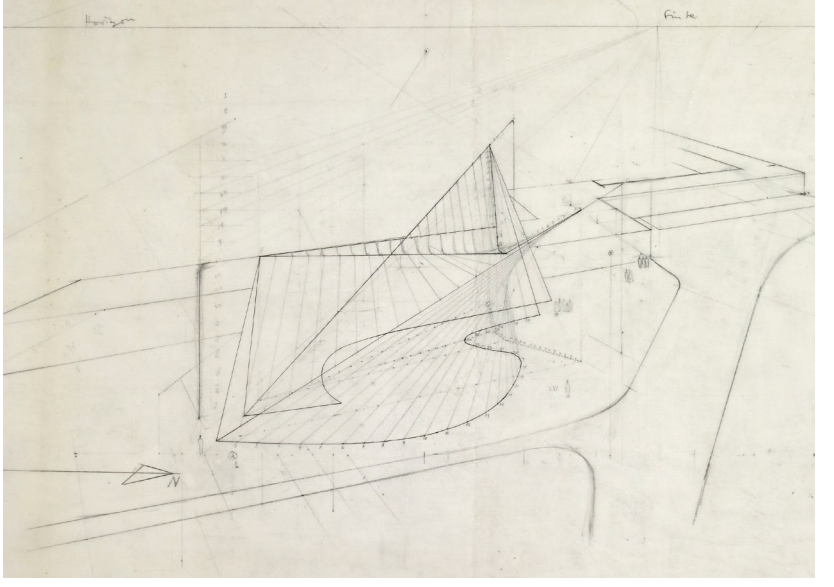

Fig. 23.16 The Philips Pavilion, detail of the drawing 5439, 19-10-1956. Courtesy of Fondation Le Corbusier.

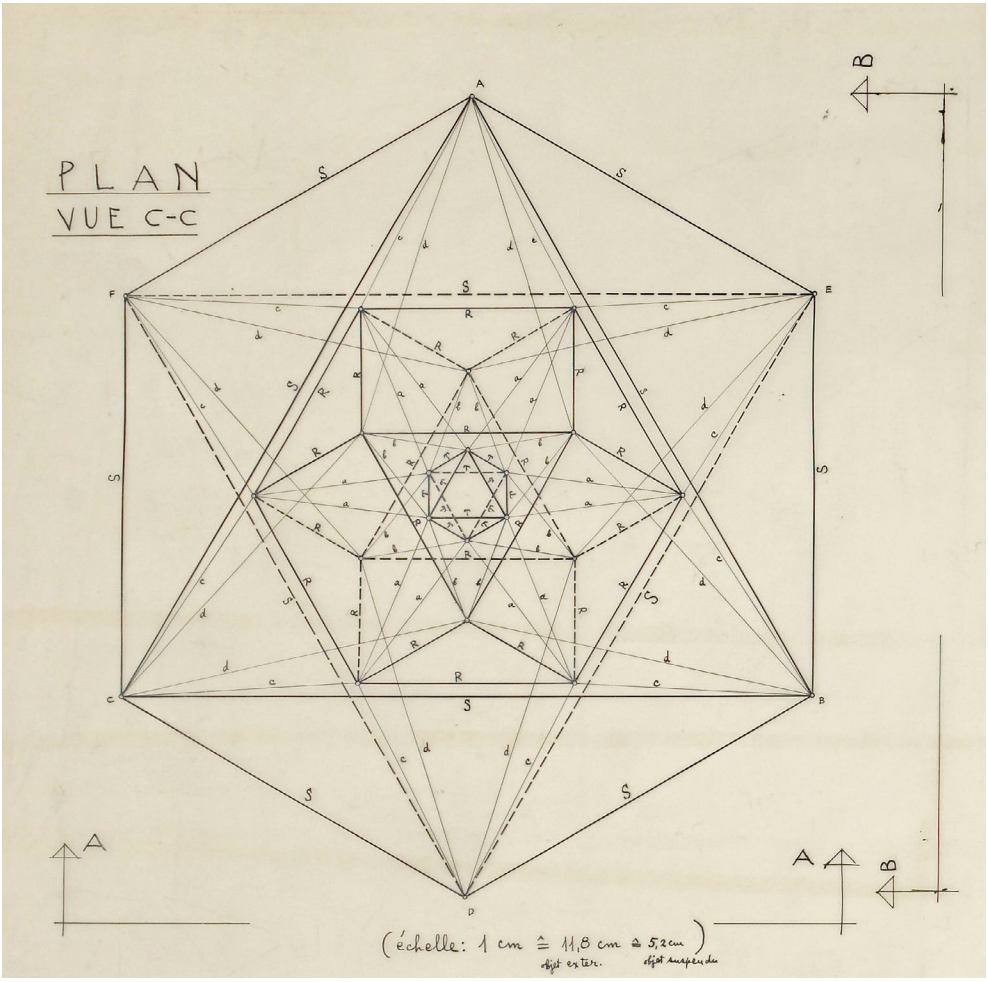

Fig. 23.17 The Philips Pavilion: mathematical object. Detail of the drawing 5547, 3-3-1958. Courtesy of Fondation Le Corbusier.

Inside the pavilion a multimedia event was organized, i.e., an early polytope, the *Poème électronique* (1957–8) (or Electronic Poem) to music by Edgard Varèse (1883–1965), but at the entrance and exit you could hear Xenakis's *Concret PH* (1958), developing "nuages de poussière de sons" (clouds of dust of sound). *PH* stands for [p]araboloid [h]yperboloids and for [Ph]ilips; *concret* for reinforced concrete and *musique concrète*. The cloud of Xenakis's *concret* sounds, the sound of smoldering coals, is a disorder that has another kind of order.

The Philips Pavilion period was, however, difficult for Le Corbusier's relations with Xenakis, as well as for Le Corbusier's relations with the other partners in the atelier. No doubt, Le Corbusier was growing up as well. In a very interesting, handwritten note entitled "Xenakis's personal expenses," that was sent by Xenakis to Le Corbusier on 11 February 1957, he writes to him:

[...] for rent, for food, for the maintenance of my father who is seventy-nine years old, for taxes, and for laundry, there is no money for more clothes, for books, for my wife and for my daughter. I am forty years old.

Le Corbusier replies to him in handwriting also just below:

[...] forty years old? What do you think I did when I was forty? I was trying to build the building of the League of Nations. Nobody was paying me. I had nothing to eat; I lived in a room with no bathroom and no running water. How do you think things are done?

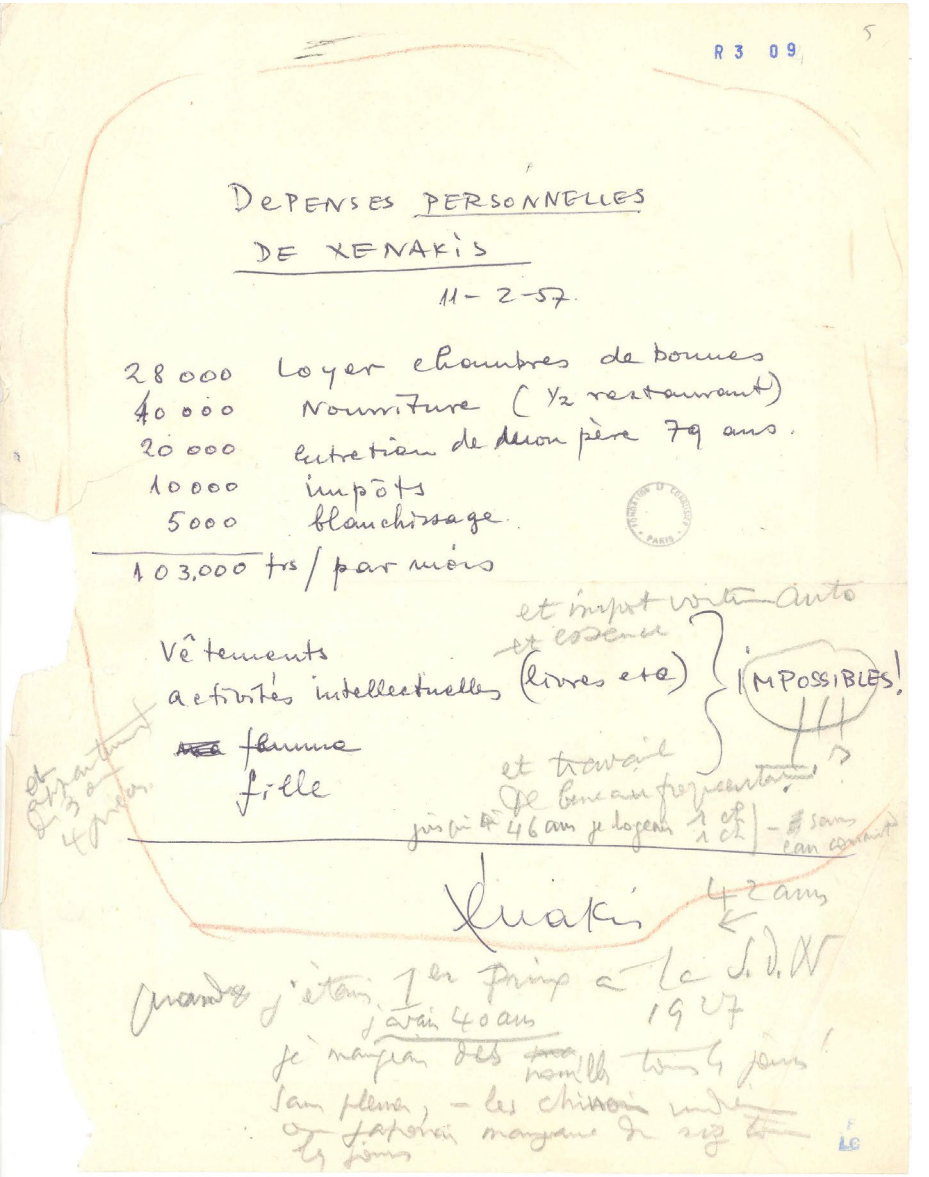

Fig. 23.18 An informal exchange of complaints between Xenakis and Le Corbusier, 11 February 1957. Courtesy of Fondation Le Corbusier.

Le Corbusier kept it, and that is how we can read it today, but we do not know if Xenakis ever got that answer. Nevertheless, this is a father-son fight, not an employer-employee dispute. Then, of course, things took a different turn, about which much has been written. Xenakis received on 31 August 1959, a letter from Le Corbusier, which for me is lovely because it expresses both sincerity and appreciation, with which Xenakis was fired. It is extremely interesting to read this letter, but it is equally noteworthy that a similar dismissal letter went to the entire office. Le Corbusier fired them all! He no longer wanted to have an atelier with associates. He had other things on his mind. He wrote:

> Dear Xenakis. Modern architecture in France has triumphed; it has finally been adopted. Now, it is possible for you to find new fields to apply what you have learned by yourselves, as well as what your work with me has brought you. I believe it behooves each of you to take advantage of any opportunity that arises or that you may induce. Therefore, I hereby render you free as of September 1, 1959.[10]

This letter has often been seen as an unfair rejection of Xenakis by Le Corbusier at a time when Xenakis was actually responsible for Le Corbusier's architecture. I would not see it that way. For Le Corbusier it is an end, and for Xenakis a new beginning. Xenakis was born in 1922 and Le Corbusier in 1887. When Xenakis arrived at Le Corbusier's atelier in 1947, he was twenty-five years old and Le Corbusier was sixty, world famous, and important. When Xenakis left the office in 1959, the age difference remained. Le Corbusier was seventy-two and Xenakis was thirty-seven. The difference was great, and was more akin to the distance between a father and a son than it that of a teacher and a student. Le Corbusier passed the baton and began the struggle to establish the Le Corbusier Foundation to protect his work, concerned with its future legacy. For Xenakis, this marked a pivotal moment as he shifted his focus towards music.

Music

I will not go into the depth of the relationship between music and architecture, as those deeply involved in music are likely more versed in this connection. Instead, I will revisit my starting point: the drawing of a parabolic arc on millimeter paper, a task essential in civil engineering but typically outside the architect's scope. Xenakis began to write music, starting with *Metastasis*, using graphics and parabolic arcs on millimeter paper, when he was working at La Tourette. In fact, the way in which he develops the drawings of his music on standard graph paper is analogous to the curves that define the calculation of reinforced concrete, and the form of the buildings he designed for Le Corbusier.[11]

He was an engineer in music. He reasonably had many doubts about these musical drawings, and so one day, he recounts, he took a pile of papers and went to Hermann

10 Xenakis, 2008, p. 5–6.

11 See "*Metastasis*, partition graphique sur papier calque, OM 1/4 p.28, Coll. Famille IX DR," *Les Amis de Xenakis*, https://www.iannis-xenakis.org/archives/

Scherchen (1891–1966), a famous French/German musician of the time, to show them to him and ask if they were worthwhile. He describes the scene in detail, but what is significant is that Scherchen tells him, "I'm interested in your music because it's made by someone who comes from outside of music."[12] Similarly, one could argue, substituting architecture for music, that the architecture Xenakis created "came from outside of architecture." He did not use the tools of an architect's education; he used other tools, with which he gave form to the materials. He was an engineer in architecture. Thus, Xenakis's music and architecture have a very important element in common. They develop beyond their field, and there they meet because they eventually develop in the same way, by the same mind, with the same approach, gradually escaping into a constant search for order in chaos, as clouds are organized. Of course, a cloud has a form. As do even sound and light.

Cosmos

The Cosmic City is the design of a utopian city. It is due to an initiative of Françoise Choay (b. 1925), who was compiling a book in the early 1960s about utopias and realities in urban planning, and commissioned Xenakis to design a utopia, i.e., to imagine how we could live in the distant future.[13] Xenakis called this city "la ville cosmique" (Cosmic City). The word *cosmique* refers to the philosophical concept of *cosmos*, which is the universe, and indirectly to the philosophical ideas of Kostas Axelos (1924–2010), another Greek who left Athens like Xenakis, and was linking the future of the cosmos to pre-Socratic philosophy.[14] Xenakis's Cosmic City consists of giant parabolic hyperboloid buildings in a meadow landscape that remains essentially intact. The buildings, like skyscrapers, were meant to disappear into the clouds, as he describes in the text accompanying the drawing. It is hard not to remember the utopia of the city of birds, that is Aristophanes's (450–388 BCE) city-in-the-sky, or literally 'cloud-cuckoo-land' (*Νεφελοκοκκυγία*). At the top right of a drawing by Xenakis of his Cosmic City is a black star.[15] I cannot say for sure if it is the moon or the sun, but we are up high, and underneath, grows a land that is a utopian return to nature, a meadow. I will revisit the meadow later on discussing the myth of Eer in Plato's *Republic*. In the meantime, let us keep in mind that Xenakis was not content with a text and drawing for Choay's book. He spent a lot of time calculating the giant towers of his Cosmic City, reminiscent of the hyperboloids of the nuclear towers he was inspired from in Chandigarh, the parabolic hyperboloids of the Philips Pavilion, the graph-based design of his music and architecture.

12 See Xenakis, 2022, p. 103; Matossian, 2005, p. 88–9.

13 Choay, 1965.

14 Axelos moved to Paris in 1945 together with about two hundred grantees of the French government, including most of the Greek architects and civil engineers whom Xenakis met in the atelier of Le Corbusier. His critical thinking has been reflected in many philosophical essays, with regard to pre-Socratic philosophy and planetary thinking; see Axelos 1962, 1964.

15 See The Outpost, "IANNIS XENAKIS AND THE NOTION OF A COSMIC UTOPIA" (21 February 2018), *Wilderutopia*, https://wilderutopia.com/sustainability/land/iannis-xenakis-and-the-notion-of-a-cosmic-utopia/

Polytopes

Around 1970, Xenakis, definitely free from Le Corbusier, becomes increasingly involved in something that is again beyond music. He designs sound, light, color, and space during live performances. The *Polytopes* are installations in Montreal (1967), Paris (Cluny 1971–2), Persepolis (1971), and Mycenae (1978), while the *Diatope* (1978), in Paris, is developed as an "offspring" of the Philips Pavilion event some twenty years earlier, with light and sound effects in special viewing conditions for spectators, who lie down and experience a cosmic event. The *Diatope* was an ephemeral tense form that followed the principles of the Philips Pavilion on flexible surfaces.[16]

Fig. 23.19 Xenakis, *A Gesture of Light and Sound*, the *Diatope*. Centre Georges-Pompidou, Paris, 1978. Scanned booklet from author's collection.

Inside the *Diatope*, an event was held: *La Légende d'Eer*. Eer is a mythical hero, in the last part of Plato's *Republic* (614–616), who has experienced what happens when you die. After death, there is a court: there are the righteous who go to the meadow, and the unjust who go to the Tartarus. Plato explains how all this happens; the most striking detail is that in the meadow, a grassy place like paradise, where souls are gladly encamped as at a festival, there are rays of light that connect the ground to the sky and other flares, giving, with their colored light interference, a lightning version of

16 Xenakis, 2008, Chapters 4.16–4.21.

paradise. In addition, eight Sirens stand in a rotating circle, emitting sounds to create the symphony of a single harmony. The use of lasers in Xenakis's polytopes is part of this modern yet metaphysical approach, with many flashes, flares, and sounds that rival the stars and the Sirens.

The *Polytope of Mycènes* in the summer of 1978 was a transgression of the myth of Eer in the world of the Atreides. Those who experienced it can recount the convergence of masses of spectators amid prehistory and myth, ruined antiquities, goats, and sheep in the midst of a hot summer landscape, full of laser lights, percussion, and computer sounds. It is impossible to reproduce this unique event. Xenakis introduced the electroacoustic sound of *Mycènes Alpha*, a composition that converts hand-generated graphics into music with the help of a computer. To make that happen, he invented a horizontal surface engraved with the Cartesian geometry of millimeter paper, on which a stylus or a hand moves to produce music. The music is produced by the movement of the hand on a drawing surface, such as an architectural drawing board, and this movement makes the gesture graphical and transcribes it into sounds.

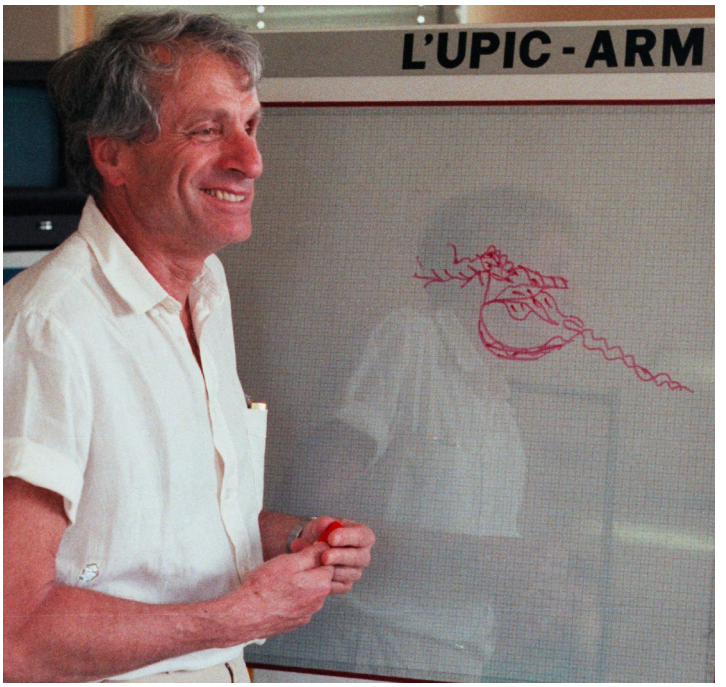

Fig. 23.20 Iannis Xenakis in Salzburg with UPIC (Centre Acanthes, 1985). Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

The machine is UPIC (Unité Polyagogique Informatique du CEMAMu, the Centre for Studies in Mathematical and Automated Music), which digitally converts graphics into sound. It marked a new era for Xenakis, but at the same time represented an impressive meeting of Mycenae with pioneering pursuits that literally go outside the field of music, outside the field of architecture; *outside*.

Amorgos

The house on Amorgos is one of Xenakis's most interesting works, his only building in Greece, also constructed in his absence during the Greek dictatorship. It is a holiday home for François-Bernard Mâche (b. 1935), friend and musician, in a deserted area of Amorgos, not at all like other houses. It is a series of curvilinear volumes, randomly twisted or arranged in excessive order, which develop in space like a dice roll or a skillful gesture and, at the same time, embrace vital functions within them. The relationship between inside and outside passes through the uncommon geometry of the openings similar to those we saw on La Tourette's terrace, with the *neume* coming back as an order of cosmic harmony, and indeed, a reinterpretation of the relations between inside and outside.

Fig. 23.21 Xenakis, holiday house in Amorgos, 1966–77. Photo by Elina Loukou (2005).

Fig. 23.22 Xenakis, holiday house in Amorgos, 1966–77. Photo by Elina Loukou (2005).

Fig. 23.23 Xenakis, holiday house in Amorgos, 1966–77. Photo by Elina Loukou (2005).

What is the opening, what is the wall, what is the window? The openings are designed with mathematical relationships and dimensions, revealed depending on how and where you sit, at what height, and how your eyes see horizontally, in and out, or how the sun and moon move. The house as a periscope or observatory creates an unfolding event of cosmic harmony in the prehistoric land of Amorgos.

Corsica

Xenakis lived with his wife Françoise and their daughter Mâkhi in various apartments in Paris. Describing her relationship with her father, Mâkhi writes that every time they entered an apartment, Xenakis would change it as much as he could. He was tearing down walls, changing colors, installing tense, textile surfaces, etc… that formed spatial structures. Most interesting in these domestic architectures, however, is the way he designed a holiday home for himself, his wife, and their daughter in Corsica. The two-story, tower-like structure rests on an ellipsoidal foundation, with a peripheral development of vertical openings arranged in a mathematical order reminiscent of the La Tourette monastery. The design allows for climbing to the roof, where one can sit in the evenings and look at the stars: to be in touch with the universality of a meadow, overlooking the sea, with a kayak on the beach as a measure of freedom and escape…

Fig. 23.24 Xenakis, holiday house in Corsica, 1996–7. Photo by D. Gainet (2005).

Back Home

Although a civil engineer, Xenakis was much more appreciated in the School of Architecture of the National Technical University of Athens. Students sought him out from the first time he returned to Greece, in November 1974, immediately after the dictatorship, demanding to learn about architecture, music, and his collaboration with Le Corbusier, and the school proclaimed him an honorary doctor *honoris causa* on 18 September 1992, in the large hall of the main neoclassical building. In front of the same building where Le Corbusier found himself in 1933 during the 4th CIAM (Congrès international d'architecture moderne), Xenakis stood in 1944, during the civil battle of Athens, amidst the rattling of bullets that left scars on both marble and people. Against the backdrop of bright anti-aircraft fire, the sky bore witness to the first flares of the composer's future polytopes. In awarding the doctorate to Xenakis, the President of the School, Professor Dionysis Zivas (1928–2018), proposed an interpretation of the decision, which concluded with this righteous statement:

> The honor is awarded to a graduate of the Institution who, first of all, as a civil engineer initially and with the dynamics that things themselves determine as an architect later, contributed to the conception of important and well-known architectural projects and to the solution of the corresponding problems with internationally recognized success. At the same time, this honor is given to the man who opened his own, new, and personal path in contemporary music, which has also received international recognition and acclaim. The synthesis of all these different in terms of expression, but perhaps not such different constituent parts, the synthesis in other words of science, art, and technology in such an original and creative way, determines the special dimension and uniqueness of the personality and the work of Iannis Xenakis. That is the reason behind our decision. This is what bridges Xenakis: a civil engineer with music and architecture. With the whole world.[17]

17 *Pyrforos* [n.a.], 1992, p. 114. *Pyrforos* means "torchbearer" and refers to Prometheus-as-torchbearer,

Polytropos

Polytropos is the very first adjective and main attribute Homer (*ca*. eighth century BCE) applies to Odysseus in his *Odyssey*. Literally it means "much-traveled" or "much-wandering," but it can be used metaphorically as "turning many ways," resourceful, inventive and complicated, militant, creative and adventurous, a traveler to unknown seas, armed with rationalism, and driven by cosmic geometry: that of constellations. Homer, of course, intended both senses of the word. Xenakis was as *polytropos* as Odysseus. He was first an engineer, but he was an engineer of music and architecture, a navigator without limits, certainly free, but with a constant return to his ideal Greek origin, his eternal homeland, along with his flight into the cosmos. *Polytropos* and *Polytopos*.

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which is the emblem of the National Technical University of Athens (NTUA). *Pyrforos* was the journal of the NTUA from 1992 to 2003.

LIVING TESTIMONY

Plate 8 Iannis Xenakis in conversation, Glasgow, May 1987. Photos by Henning Lohner, courtesy of CIX Archives, Lohner collection.

24. Liberated Music. A Loving Testimony

Nikos Kornilios

A shell explodes.
A young man, a young fighter, screams in pain.
The shrapnel has torn his face off.
He falls next to dead fighters, or some seriously wounded, and some survivors.

The young fighter with his wounded face is named Iannis.
Among the survivors, his friend, Manolis.
My father.

It was the last combat of the Lord Byron Company
from the People's Army of National Liberation,
which fought against the Nazis during the Occupation in Greece
and which continued to fight against the British invader
at the beginning of the Civil War.
An atrocious civil war broke out in December '44.
And there, on 1 January 1945, it was the last fight of the Lord Byron Company, against the English, and the Greek government that supported them.

The young fighters—they were about thirty or forty of them.
They had the courage to confront the English Army to the last squares of the fighting in Athens, by occupying a building on Didot Street—in the center of Athens.

https://doi.org/10.11647/OBP.0390.26

It represents the courage that these young people had—students from Polytechnic, like the young Iannis, or the Faculty of Political Science, like my father.
They were not soldiers; they had no weapons; and yet they had the courage to go into battle—a last battle.

After this shell burst, Vassilis, the commander, a young student too, he tried—with a group—to make his way out, but they were all killed or captured.

Years later, my father often told me this story, about this last battle of Didot Street,
and often referred to his friend, Iannis.

My father's description of this battle,
he always referred to his friend who had been mortally wounded.
He thought he was dead, Iannis, who fell next to him, his face torn off by the shrapnel.

He told this story often, with his friends, when they talked about the stories of the Resistance. He often talked about this battle of Didot Street.
It was a crucial moment for him.

Afterwards, deportations followed, really very difficult moments.
Their defeat.

These were moments that remained engraved in the memory of all these young people.
At the time, they deeply believed in—that a better world was possible—the ideal of the socialist revolution—that all these young revolutionaries, with deep faith—
all unaware that while they were fighting their battle the world was already divided—
and that Greece was going to belong to the West...

I believe that despite their very different paths, they kept the same emotion, the same quality of memory around these important events.

Then, time passed, the military dictatorship arrived in Greece
like from a chapter of this period impregnated by the Civil War.

I fled this country of dictatorship and colonels and moved to Paris when I was eighteen.
Of course, I didn't know anything about the story of Iannis Xenakis;
I did not know that it was the same Iannis my father talked about.
And who was a famous composer.

I arrived in Paris. I was eager for new worlds, new experiences, openness, everything that Greece—at that time—could not offer me.
I was interested in art, music…theater…
I dedicated myself to music.
I discovered the music of Xenakis—which was love upon first hearing—
an extraordinary breakthrough for a young man coming from Athens.

And then I decided to follow his courses at the Sorbonne.
I enrolled in his seminar.
There, I had the chance to meet Sharon Kanach—whom I thank for this invitation; Sharon, my lifelong friend.

And I followed his courses, trying to understand the mechanisms of his music.
Iannis was not Schönberg—he was not a man who wanted to create a school of his own.
On the contrary, he was a very solitary man, even from his students.
So he would turn his back on us; he would write mathematical equations on the blackboard—which nobody understood (or pretended to understand.)
And he would pretend to explain to us.
That's how his class was conducted.

At a certain point, I started to write my first scores.
I dared to present one of my first works in his class.
And then—little by little—a real master-pupil relationship began to develop in the sense that I wrote pieces and was lucky enough to have them performed.
Xenakis showed himself more and more receptive with regard to my scores, even on pieces that were in the process of being written.
And I also learned by chance that he supported, without telling me anything—
keeping the distance of master to student—the publication of my scores by Salabert.

These scores began to be played by important ensembles of the time and in festivals, like Musica.
And this relationship evolved but remained within the strict framework of his seminar at the Sorbonne.
We sometimes met a little before the course so that he had time to look at a new score.
He didn't give me advice; he just looked at it, and I don't think he even expressed an opinion on it. But I felt his moral support.

We used to talk about Greek poets for a long time, our preferences about contemporary poets when we walked out together at the end of the seminar.

Then, he was mounting his *Polytope de Mycènes* in Greece.
And so, thanks to things published in the press,
my father discovered that Iannis Xenakis was indeed *that* Iannis,
his companion from Didot Street
where he believed he was dead, wounded in the face.
He went to meet him in Mycenae

Me, I lent a hand to work a bit with the chorus which took part in the *Polytope*.
But I was not present at this meeting.
My father told me afterwards the emotion that he felt—enormous—when meeting Iannis Xenakis, who he saw between two rehearsals during the madness of the *Polytope of Mycènes*.
They talked about the details of that battle, they told each other things,
as though it happened yesterday.
And so, my father was very, very moved to have found Iannis
and to share with him things from that time.

I continued to attend his seminar in Paris
and to have the relationship with him that I have already described.
We never said a single word about this meeting:
I knew, he knew, but we never talked about it.
It concerned him and my father.
Of course, I was really surprised by this law of probability that Iannis Xenakis was indeed this Iannis my father knew.
He too, surely, was astonished, but he did not comment on it.
I felt that deep down another quality was beginning to take place between the two of us, but by doing things, as it were.

And… when I was about thirty years old, little by little I began to say to myself
that even if my music was played in festivals, like in Avignon, in Musica
and by Itinéraire, 2e2m, many European festivals, by IRCAM… I began to say to myself that it would always be sub-Xenakis. And I didn't like that.
It's something that put me in a kind of horizon that was drawn by Iannis Xenakis
and it's something that I couldn't accept, by my personality.
I decided to end everything, to stop writing music and move on to something else.
At that time, I already had a love for theater.
I wrote things for the theater:
Nuit des Suppliantes, a work of musical theater [at ARC], creations with the ATEM,
at Chaillot, on the invitation of Antoine Vitez … *The Seventh Door*.

Directing began to gain more and more ground, I decided to turn to the cinema.
I left Paris in my thirties and returned to Greece…
with a very deep nostalgia, to find my language, in my light…everything that I feel is my biosphere.

I wrote a letter to Iannis Xenakis telling him the news
that I had decided to give up composition and turn to cinema.
I had called him on the phone from Athens to talk to him and tell him that.
I felt, on his end, that he felt it a bit as a betrayal,
because I didn't talk to him about all that, about my different interests
that emanated from feeling a little bit in a dead end
by writing music that I characterized as "sub-Xenakis"…
which worked very well for several others
who imitated his style and succeeded in their careers,
all while doing 'sub-Xenakis.' But let's close this parenthesis.

I told him the news and we left each other, if I may say so, as friends.
And so, it was the moment of separation…
launching my new life,
the fact that the cinema interested me more and more, the fact of having returned to Greece.
That's it!

We lost touch, no contact. I always listened to his new works with admiration.
I remember the moment when one of my pieces, *Stehen*, was played in Strasbourg at the same time as Iannis,
with a performance of his *Jonchaies*. It was extraordinary, a masterpiece!
At the end of the concert, I told him.
"I'm not the one who's going to tell you that it's really a masterpiece."
"But no, but no, I need your opinion, how you found the work."

I also remember when he was listening to another piece of mine, a string trio, *Pros*,
where I had tried slower passages, or rather with less energy and more interiority.
When I played him this music I had the impression that he was getting a little impatient,
that he didn't appreciate it very much and I said to him:
"I tried to introduce a slower movement in this piece of music.
Your music, it's always full of energy and I tried to detach myself from this a little bit."
He answered me with a real: "But maybe it's not good
that there is always this energy in my music."
I told him: "No, no, no! I admire that but I tried to do something a little different."

Despite his influence on 20th century music and beyond, he was probably a man who was always
deep inside himself, questioning his art, his evolution, his place.

This energy that is in his music, this inherent violence in his music,
it was a response to this violence he received, this shrapnel that tore his face off
and that he transformed into a luminous violence, a violence of beauty, a sublime violence.

His violence, which I love so much in his music,
this energy that I love so much,
which is always…there is always this force, this energy behind it, vital.
Violence, of the cosmos, of the universe.
It is the violence of love—*Anaktoria*—
It is the violence of feelings, of passions. It is the violence of life…
which is opposed to the petty violence of war.

And…the more I listen to his music the more I appreciate this energy.
Jonchaies, for example, cosmic violence.
Phlegra…some examples…*Aïs*
But all of his music,
we understand at once that it is Xenakis
by this vital force, this energy.

And which is the the buzz of life, which is the explosion of organic cells of life.

I believe that all great art has the characteristic of sublimation of this part of ourselves:
black, violent, vital, something that takes shape, becomes an artistic gesture—catharsis—
that tells us that the catastrophe of life, inherent to life and death…
all of that is part of ourselves and we must face it.

Art is there to make of all this something beautiful,
something that gives us courage, to live, to continue to create, to love.

Iannis Xenakis was a human being deeply attached to his principles
which were the principles of his youth and which made him a young revolutionary,
courageous to go without hesitation with the last fighters
to this last battle of Didot Street that they knew in advance would be lost, but he was there.

All his life was this young revolutionary, this young man
who always questioned his art, music, and who always wanted to be ahead of the game,
who wanted to make a step forward,
who wanted to evolve by transgressing and by transforming the universe of sound, art
and the way of perceiving our universe.

I believe that his music is—if I dare say the word *truth*.
It comes from something lived that has, as with the great writers—
the great ones are strong when they manage to deposit their deep, intimate truth.
The same is true for music, even if the language is different.
I believe that Iannis Xenakis became a great composer,
because from one year to another, from one piece to another,
he deposited his deepest truth, his intimate being.
And this music shines by its inner truth, which is a truth born of love and amorous violence.

25. La Légende de Xenakis: Meta Xenakis

Curtis Roads

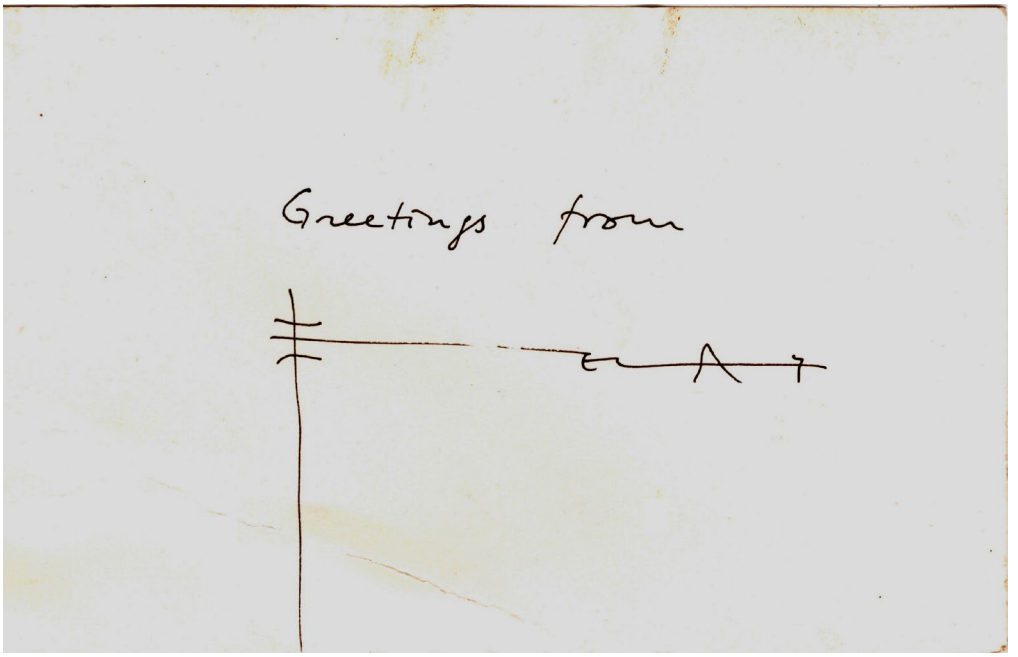


Fig. 25.1 Personal communication from Iannis Xenakis to the author (1985).

This is a personal account of the impact Iannis Xenakis had on my life over several decades.[1] To be clear, I am not an expert on Xenakis's life. These recollections view Xenakis through the narrow lens of my encounters with him. It has been wonderful to sift through my memories to reconstruct this narrative.

1 A version of this chapter also appears as Roads 2024. Sections are reprinted by permission of mdwPress. As a tribute to Iannis Xenakis, this text appears in a number of forms. This version was presented by Curtis Roads remotely as the closing keynote during the New York tranche of the Meta-Xenakis Global Symposium.

 https://doi.org/10.11647/OBP.0390.27

To begin, it is important to describe the historical milieu of my earliest encounter with Xenakis. In 1970 I was a nineteen-year-old professional musician living in a commune with twenty-four other people in Urbana-Champaign, Illinois—the home of the University of Illinois. I was learning about the music business and becoming less and less interested.

At the same time, my aesthetic perspective was rapidly evolving. I was going to concerts of classical music at the university but also concerts of new experimental music. On my own I was experimenting with sounds using available equipment.

In a lucky twist of fate, in this period the University of Illinois was a pioneering center for research in electronic and computer music. At the invitation of a graduate student friend, I started working in the University of Illinois Experimental Music Studio (EMS). The EMS was an excellent facility with a professional mixing console, four-track tape recorders, a large Moog synthesizer, and quadraphonic playback. My friend and I started making tape music pieces that we would play in various venues.

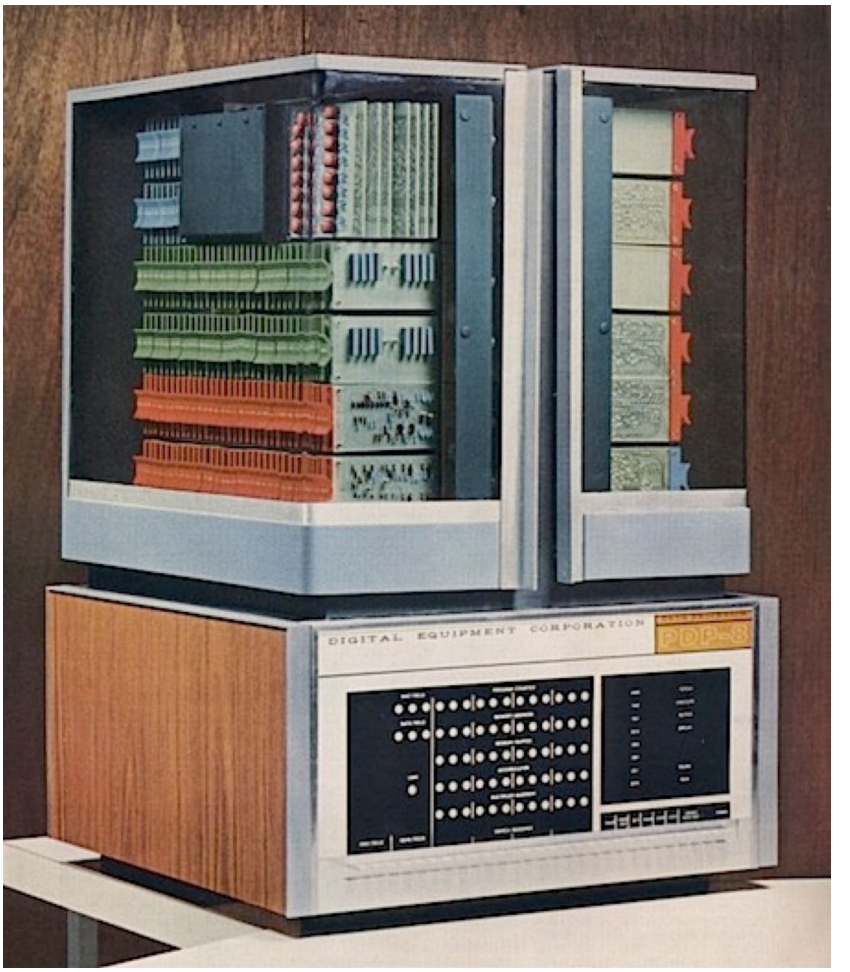


Fig. 25.2 DEC PDP-8 computer, author unknown.

The EMS also had a Digital Equipment Corporation (DEC) PDP-8 computer. It was the model with glass doors displaying the circuit boards. It was love at first sight for me. I saw the computer as a way to combine my intellectual and musical aspirations. I did not yet have a clear idea of exactly what this meant; I knew only that this direction seemed ripe with possibilities.

I met Professor Herbert Brün (1918–2000), a pioneer of algorithmic composition and experimental digital synthesis, Professor James Beauchamp (1937–2022), a pioneer of computer sound analysis and synthesis, and researcher Edward Kobrin, a pioneer of real-time interactive composition. They were all generous with their time. I was given a printout of Max Mathews's (1926–2011) MUSIC V program, written in Fortran, which I still have.

```
      264  J4=L1+J3-1                                                        00541000
           IN1=I(J4)                                                         00542000
      265  J5=L2+J3-1                                                        00543000
           I(J5)=IN1+I(J5)                                                   00544000
           IF(I21,EQ,0) GO TO 270                                            00545000
           ISAM=I(J5)                                                        00546000
           IF(ISAM,GT,ICHECK,OR,ISAM,LT,-ICHECK) GO TO 90                    00547000
      270  CONTINUE                                                          00548000
           IF(TIME(2),GE,I(28)) RETURN 1                                     00549000
           RETURN                                                            00550000
       90  CALL PAGE(1)                                                     00551000
           ISAM=ISAM*SFI                                                     00552000
           PRINT 69,ISAM,NSAM,T                                              00553000
       69  FORMAT(' SAMPLE OUT OF RANGE HAD VALUE',I8,' SAMPLE WAS IN BLOCK 000554000
          -F',I4,' SAMPLES PRECEDING ACTION TIME',F11.4)                     00555000
           GO TO 270                                                         00556000
      C    OSCILLATOR                                                        00557000
      C    THIS OSCILLATOR ACCEPTS NEGATIVE FREQUENCY INPUTS                 00558000
       102 SUM=FLOAT(I(L5))*SFI                                              00559000
           IF(M1)280,280,281                                                 00560000
       280 AMP=FLOAT(I(L1))*SFI                                              00561000
       281 IF(M2)282,282,283                                                 00562000
       282 FREQ=FLOAT(I(L2))*SFI                                             00563000
       283 CONTINUE                                                          00564000
           LIM=L4+511                                                        00565000
           DO293J3=1,NSAM                                                    00566000
           J4=INT(SUM+.5)+L4                                                 00567000
           IF(J4,LT,L4,OR,J4,GT,LIM) GO TO 295                               00568000
           F=FLOAT(I(J4))                                                    00569000
           IF(M2)285,285,286                                                 00570000
       285 SUM=SUM+FREQ                                                      00571000
           GOTO290                                                           00572000
       286 J4=L2+J3-1                                                        00573000
           SUM=SUM+FLOAT(I(J4))*SFI                                          00574000
       290 IF(SUM,LT,0,) SUM=SUM+XNFUN                                       00575000
           IF(SUM-XNFUN)288,287,287                                          00576000
       287 SUM=SUM-XNFUN                                                     00577000
       288 J5=L3+J3-1                                                        00578000
           IF(M1)291,291,292                                                 00579000
       291 I(J5)=IFIX(AMP*F*SFXX)                                            00580000
           GOTO293                                                           00581000
       292 J6=L1+J3-1                                                        00582000
           I(J5)=IFIX(FLOAT(I(J6))*F*SFF)                                    00583000
       293 CONTINUE                                                          00584000
           I(L5)=IFIX(SUM*SFID)                                              00585000
```

Fig. 25.3 A printout of the author's copy of MUSIC V, written in the FORTRAN IV language (1971).

At the same time, I was becoming familiar with the music of Xenakis through vinyl recordings, beginning with *Metastasis* (1953–4), *Pithoprakta* (1955–6), and *Eonta* (1963), the electronic works *Concret PH* (1958), *Diamorphoses* (1957), *Orient-Occident* (1960), and *Bohor* (1962), and the orchestra and tape piece *Kraanerg* (1968–9).


STEREO
Also Playable in Mono
VCS•10030
XENAKIS
METASTASIS
PITHOPRAKTA
EONTA
French National Radio Orchestra
MAURICE LE ROUX, conductor
Instrumental Ensemble for Contemporary Music of Paris
KONSTANTIN SIMONOVIC, conductor
YUJI TAKAHASHI, piano
CARDINAL
A DIVISION OF VANGUARD RECORDS
ART / ANDRE MASSON
GRAND PRIX
DU DISQUE
PARIS

Fig. 25.4 Xenakis on vinyl. (a) Vanguard Records, 1967 release; (b) Xenakis electroacoustic music on Nonesuch Records, 1970 release, artists unknown.

First Encounter with Xenakis

In 1972 I saw a poster for Xenakis's short course in Formalized Music at Indiana University (see Figure 25.5). I decided to enroll. Xenakis lectured at a blackboard, detailing his theories in mathematical terms. In between the lectures he played his pieces at considerable volume over four Altec-Lansing Voice of the Theater loudspeakers. Xenakis's computer programming assistant, Cornelia Colyer (1947–2003), took us to the campus computer center to show us large plots of waveforms produced by Dynamic Stochastic Synthesis.[2]

2 Xenakis, 1971, p. 247.

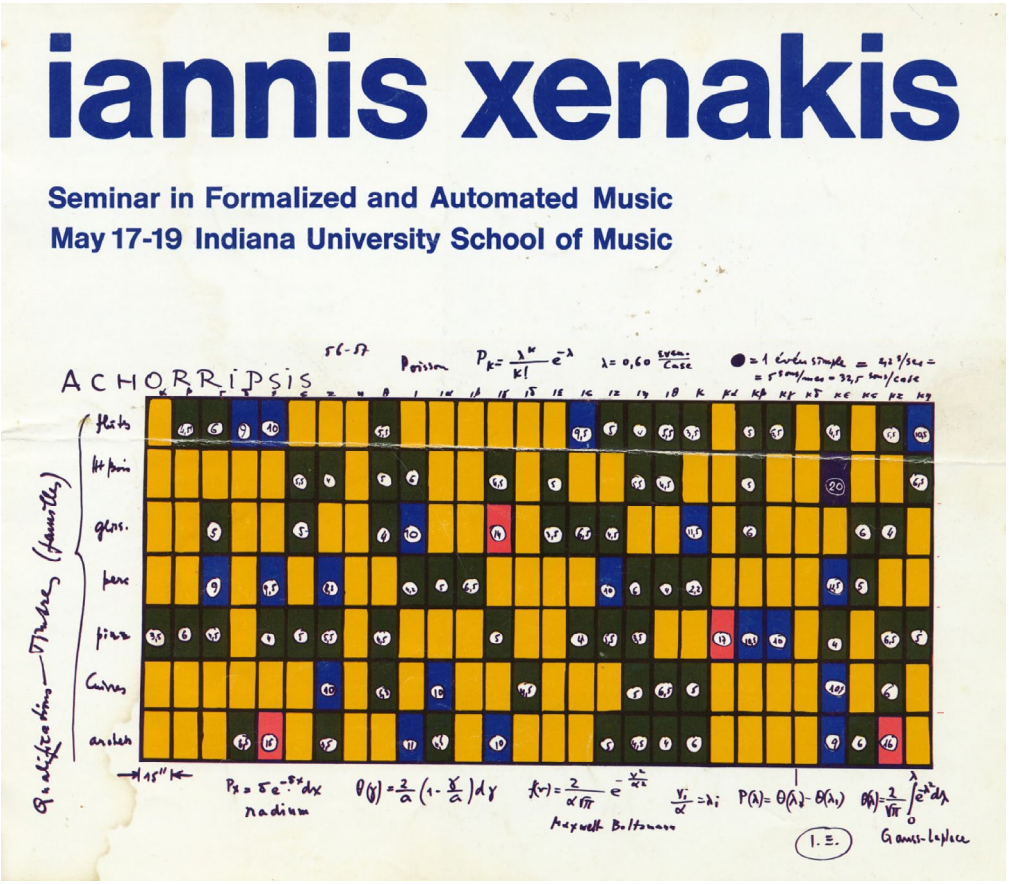


Fig. 25.5 Poster for the Seminar on Formalized and Automated Music, May 17–19, Indiana University School of Music (1972).

This encounter with Xenakis was life changing. It gave me a clear focus and direction. The idea of using algorithmic processes in music composition attracted me from an intellectual standpoint as a formidable design problem. I came away from Xenakis's course with two specific goals:

- First, I wanted to learn how to program computers to model stochastic processes for composition. For the design of new structures such as what Edgard Varèse (1883–1965) called *sound masses* and Xenakis called *clouds*, a stochastic model seemed an appropriate starting point.
- Second, I was intrigued by the concept of granular synthesis of sound. We heard no sound examples, but the theory fascinated me.

In the summer of 1972, I visited Stanford University in California. John Chowning (b. 1934) gave me a tour of the Stanford Artificial Intelligence Laboratory where the computer music center was housed. It was a revelation. I saw advanced technology that was ten years ahead of its time.

I began to learn computer programming languages. The first was FORTRAN IV, in order to analyze Xenakis's Free Stochastic Music program. I created a flow chart based on the analysis.[3]

In the fall of that same year, I enrolled as a student in music composition at California Institute of the Arts (CalArts) in Los Angeles. CalArts had just opened so everything was new and exciting. The faculty could not understand why I was interested in Xenakis's methods, but my fellow student composers did.

In that period, CalArts had a single computer: a Data General Nova 1200 with a Teletype keyboard, printer, and paper tape reader. I studied with the mathematician Leonard Cottrell. He taught us about assembly-language programming and digital circuit design. I began to write programs that implemented the formulas in *Formalized Music*.[4] Then I started writing my own composition algorithms.

Fig. 25.6 Poster for *Polytope de Cluny* (1972), from author's private collection.

3 Roads, 1973.
4 Xenakis, 1971.

In 1973, I flew to Paris to attend the Festival d'Automne. The main goal of my visit to Paris was to experience Xenakis's sound and light spectacle *Polytope de Cluny* (1972) in the medieval Musée de Cluny.

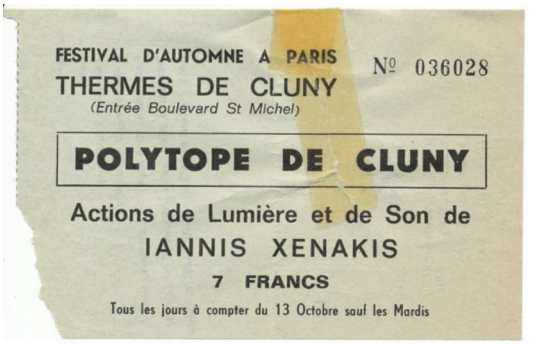


Fig. 25.7 Ticket for *Polytope de Cluny* (1972), from author's private collection.

Polytope de Cluny was experienced lying on one's back, looking up. A robotically-controlled laser projection system created moving geometric forms. A novel aspect of this movement was its stepped motion rather than smooth motion. This highlighted the quantized nature of robotic control, which was entirely new at the time. High on the ceiling was a metal grid with hundreds of flashbulbs also programmed by a digital script. Meanwhile the intense twenty-seven-minute octophonic tape of *Polytope de Cluny* filled the hall. I experienced the *Polytope* eight times. The design was extremely impressive both technically and aesthetically.[5]

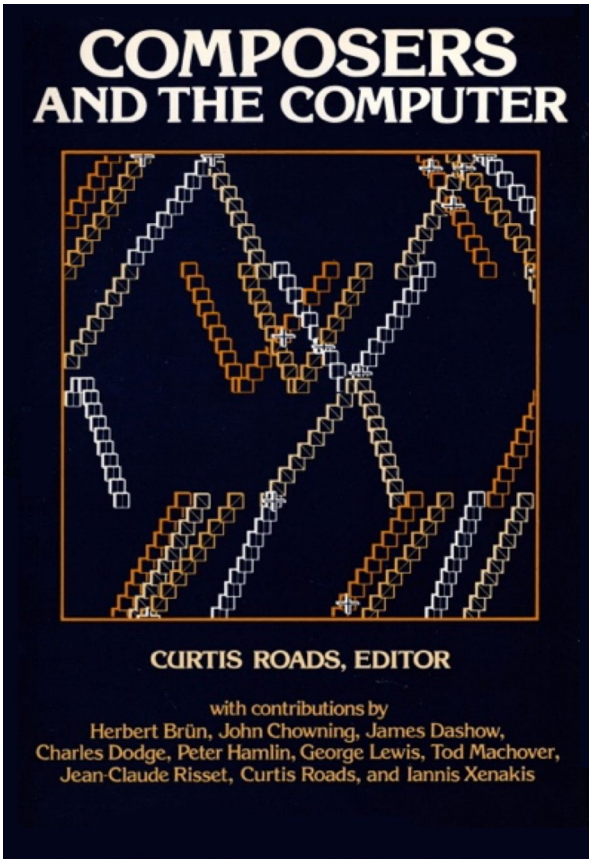
In Paris I also attended lectures and concerts featuring Karlheinz Stockhausen (1928–2007). This included his disappointing *Hymnen for Orchestra* (1966–7). The contrast between Xenakis's direction and Stockhausen's direction was starkly different, as time would tell.

Returning to California, I was determined to synthesize granular sound by computer. I left CalArts for the University of California, San Diego (UCSD) where they had a computer science department and a working computer sound synthesis system. Later I will talk about my involvement with granular synthesis by computer.

In 1980 I moved to Cambridge, Massachusetts to work at Massachusetts Institute of Technology (MIT). I was editor of the *Computer Music Journal* and a researcher at the MIT Experimental Music Studio (EMS). The technology of sampling had just become available. We had an exotic new analog-to-digital converter from the Santa Barbara-based Digital Sound Corporation and a primitive command line software tool for sampling written by a student. The studio's 300 Mbyte disc was shared by a dozen users, so space for storing samples was extremely limited. Nonetheless, I

5 For more information and some visuals of the *Polytope de Cluny*, see Xenakis, 2008, Chapter 4.1, p. 225–31.

managed to sample alto saxophone tones as well as percussion. I wrote a program in C to create granular clouds that moved around the four loudspeakers of the studio. The percussion clouds sounded like drum rolls. This was the first implementation of granular sampling.




IANNIS XENAKIS

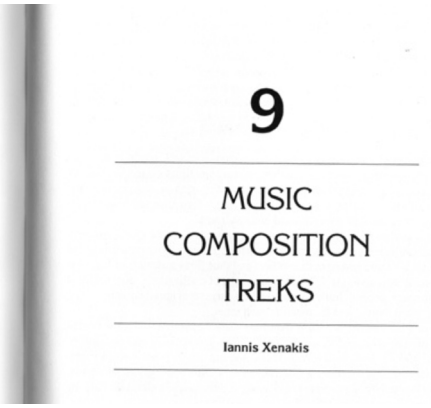


Fig. 25.8 (a) cover of *Composers and the Computer* (1985); (b) Xenakis's "Music Composition Treks" in *Composers and the Computer* (1985).

In 1981, the IRCAM (Institut de Recherche et Coordination Acoustique/Musique) center in Paris organized a conference on "The Composer and the Computer."[6] While there, I took a side trip to visit the CEMAMu (Centre d'Etudes de Mathématique et Automatique Musicales) center in Issy-les-Moulineaux. I witnessed a demonstration of the UPIC (Unité Polyagogique Informatique de CEMAMu) system by Xenakis and his assistant Colyer. Guy Médigue (b. 1935), the lead engineer of the UPIC, was also present.

Three years later the 1984 International Computer Music Conference was held in Paris. Once again, I visited CEMAMu. Following this visit, I asked Xenakis to contribute to my book *Composers and the Computer*, published in 1985. He wrote the excellent essay "Music Composition Treks" for this anthology.

In the summer of 1987, I had a residency as a visiting composer at the CEMAMu, working with the UPIC system. The 1987 version of the UPIC system allowed one to play not just synthetic waveforms, but also sampled sounds for the first time. I brought a tape of alto saxophone tones. My hand-drawn UPIC scores easily created saxophone *glissandi* that would be difficult to achieve using the MUSIC-N style programming languages of the time.

Of course, in this period, working with the UPIC was a slow, multi-step process. You had to draw a score using ink on a large roll of paper, then manually trace every line in order to enter it into the computer, a process called *digitizing*. Then you would give the command to start calculating the sound. The UPIC software ran on a Thomson Solar minicomputer, which had a clock speed of 7 MHz. Thus, rendering a complex page to sound took considerable time.

Fig. 25.9 Thomson Solar 16-40 minicomputer. Photo by Damien.b (2022), *Wikimedia Commons*, CC BY-SA, https://commons.wikimedia.org/wiki/File:Solar16-40-ACONIT.jpg

6 Roads, 1981.

Soon after this, I began my teaching career with a series of visiting faculty positions. In 1991 Pierre Boulez (1925–2016) stepped down from the leadership of IRCAM. As part of the regime change, I was invited to manage the software documentation service and teach in the pedagogy department.

In 1993 I departed IRCAM and was invited to teach at Les Ateliers UPIC by Gerard Pape (b. 1955). It was like a homecoming for me to return to the Xenakis fold. It was in this period that I came to know personally Xenakis and his circle. The people I met in his circle included his wife Françoise, his agent Radu Stan (1928–2021) (Editions Salabert), his editor Sharon Kanach, the arts patron René Schneider, the composers Michel Phillipot (1925–96), François-Bernard Mâche (b. 1935), and Jean-Claude Eloy (b. 1938), and the CEMAMu team including Jean-Michel Raczinski, Gérard Marino, and Marie-Hélène Serra.

Of course, Xenakis was the famous maestro, and I was an acolyte. I did not work directly for him but was rather a part of the team at Les Ateliers UPIC, working in parallel with the CEMAMu.

In my interactions with Xenakis, what struck me about him is that he was direct, unassuming, and without pretense. He exuded an aura of comradeship, rather than elitism. My impression was that the team at the CEMAMu was lucky to have such a benevolent boss.

As a composer, Xenakis was always more radical than me. In 1994 I was present at the Paris premiere of his electronic composition *S.709* (1994) at the auditorium of Radio France. This piece is the raw output of his experimental GENDYN stochastic synthesis algorithm. The sound is harsh and abrasive, and the structure is bizarre. It is not one of my favorites, but I must admit that it is completely original in both concept and result.

By contrast, I abandoned algorithmic composition in my youth because I found that I was more interested in beautiful sounds than in beautiful algorithms.

Today I use algorithms for sound synthesis but rely on handicraft in the editing and mixing processes to stitch all the parts into a cohesive whole. For example, my piece *Then* (2016) was the result of over five hundred submixes in the period from 2010 to 2016.

Granular Synthesis

The most direct connection between Xenakis and me is granular synthesis. It was, of course, Xenakis's concept. I found it in his book *Formalized Music* (1971). He cited Dennis Gabor (1900–79) (1946, 1947) as the source of the scientific theory. Years later in Paris, Xenakis gave me a copy of Hermann Scherchen's (1891–1966) journal *Gravesaner Blätter* with his 1960 article on granular synthesis. It is a prized possession.

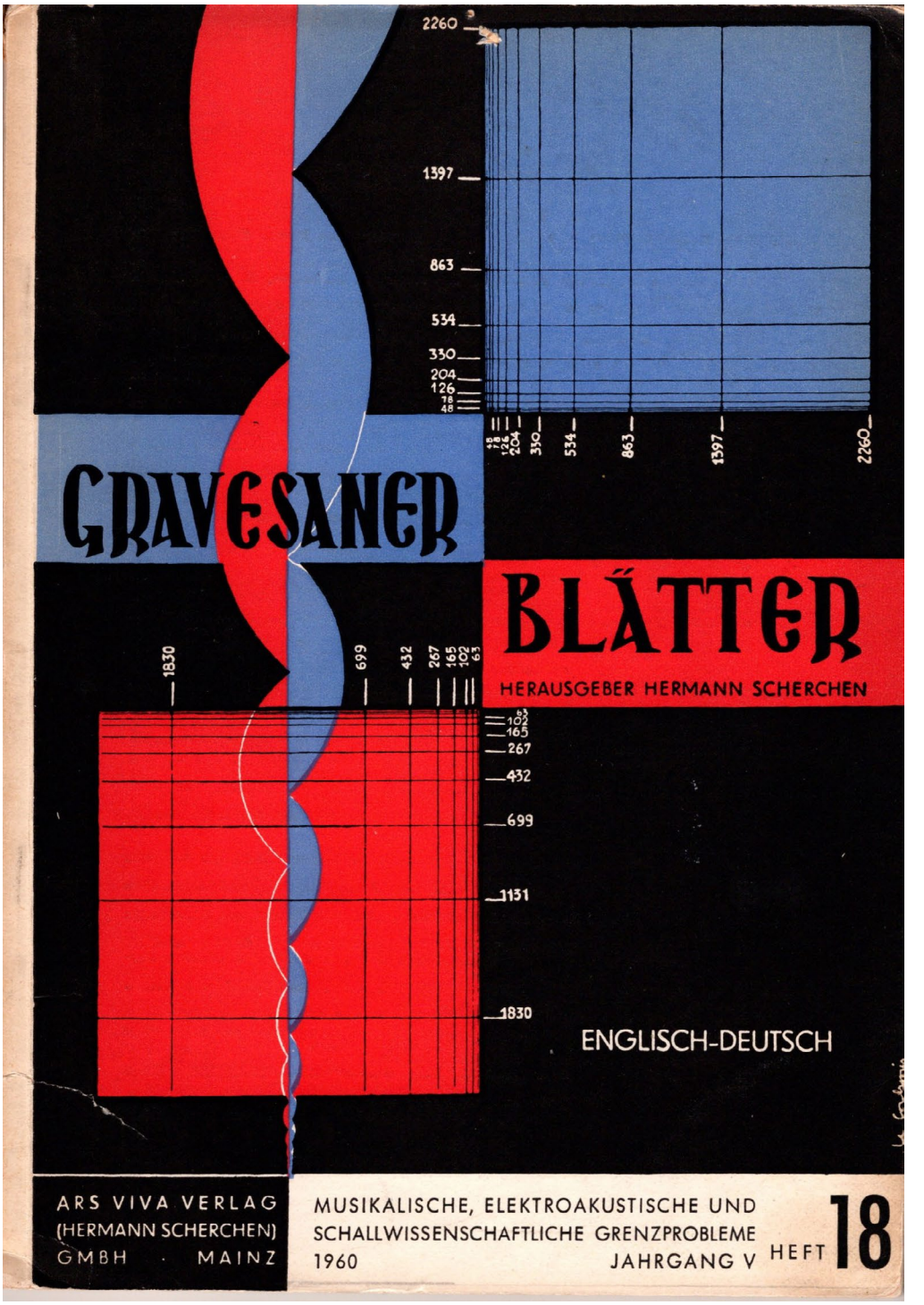


Fig. 25.10 *Gravesaner Blätter*, title page of issue 18 (1960).

In March 1974, I transferred to UCSD (University of California at San Diego) in order to use their facilities for computer sound synthesis. The researcher Bruce Leibig had recently installed the MUSIC V program on a mainframe computer housed in the UCSD Computer Center.[7] The dual-processor Burroughs B6700 was an advanced machine for its day, but sound synthesis was difficult, due to the state of input and output technology.[8]

I managed to test a first implementation of digital granular synthesis in December 1974. For this experiment, called *Klang-1*, I typed each grain specification (frequency, amplitude, duration) on a separate punched card. A stack of about eight hundred punched cards corresponded to the instrument and score for thirty seconds of granular sound. Following this laborious experience, I wrote a program in the Algol language to generate thousands of grain specifications from compact, high-level descriptions of clouds. Using this program, I realized a six-minute study called *Prototype* (1975). These were the earliest manifestations of granular synthesis by computer.

Les Ateliers UPIC

Next, we skip to another point of encounter with Xenakis. The story of Les Ateliers UPIC is told in the book *From Xenakis's UPIC to Graphic Notation Today*, which is a free download from ZKM Karlsruhe.[9]

Fig. 25.11 Les Ateliers UPIC (1995). Music historian Harry Halbreich (1931–2016), Curtis Roads, Brigitte Robindoré, Iannis Xenakis, Gerard Pape. Photographer unknown.

7 Mathews, 1969.
8 Roads, 2001.
9 Weibel, Brümmer, and Kanach, 2020.

As previously mentioned, in 1993 Gerard Pape asked me to teach at Les Ateliers UPIC. I already knew the UPIC system, but this was a new version that ran on a Windows computer with a dedicated hardware synthesizer, enabling it to synthesize sound in real-time.

Les Ateliers UPIC was a small organization supported by the French Ministry of Culture and the city of Massy, outside Paris. I became the director of pedagogy and led a year-long course. The course was a general introduction to computer music, based on my textbook *The Computer Music Tutorial*, which was in production at MIT Press.[10]

I also managed to conduct research, in particular the development of the first standalone app for granular synthesis: Cloud Generator (1995). It was written by me with John Alexander, a student at Les Ateliers UPIC. Cloud Generator was developed specifically for teaching granular synthesis. It has a simple user interface that enables a musician to generate a single cloud of sound at a time, which was saved to a file. These sound files could later be assembled into a piece using a digital audio workstation like Pro Tools.

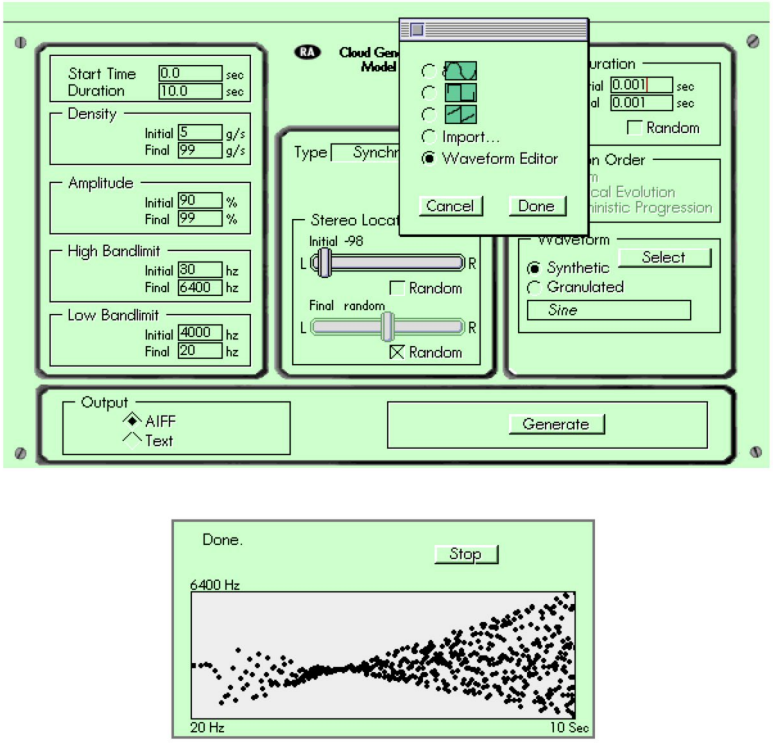


Fig. 25.12 Cloud Generator (1995) by Curtis Roads and John Alexander.

10 Roads, 2023.

I demonstrated Cloud Generator to Maestro Xenakis. He said it was "not terrible." Knowing him, I took this as a compliment.

After I showed Cloud Generator to Xenakis's publishing agent, Radu Stan of Editions Salabert, Stan slipped me a cassette of *Analogique A & B* (1959), which was Xenakis's first attempt to realize pure sinusoidal granular synthesis using analog sine wave generators and tape. I had never heard it before. So, twenty-one years after my first experiments, I finally heard the original granular synthesis!

Fig. 25.13 Analog cassette of *Analogique A & B* (1959). Photo by author.

One of the highlights of my experience at Les Ateliers UPIC was a concert organized by Gerard Pape at the Salle Olivier Messiaen of Radio France in Paris in 1994. This included the full Acousmonium setup of forty-eight loudspeakers. Upmixing my music on the Acousmonium made an indelible impression.

After I became a professor at UCSB in 1996 I returned to Paris annually to teach at the UPIC center (renamed the Centre de Création Musicale "Iannis Xenakis" or CCMIX) until 2007. It was through CCMIX that I met Luc Ferrari (1929–2005) and Bernard Parmegiani (1927–2013), among others. Indeed, Les Ateliers UPIC/CCMIX was an open door to many artists.

Continuing the Granular Model at UCSB

In Santa Barbara I have continued to advance the granular model. My 1997 constant-Q granulator, written in SuperCollider, was the first program to apply an individual bandpass filter to each grain. This is what I call *per-grain processing*, where each grain has its own envelope, waveform, amplitude, frequency, spatial position, filter center frequency, and resonance. Per-grain processing is essential to create heterogeneous and multidimensional textures. The constant-Q granulator was the core tool used to

make my album *POINT LINE CLOUD* (2005, reissued 2019).

In 2005, my graduate student David Thall coded the EmissionControl granulator, which implemented my concept of per-grain processing but also added a modulation matrix for automatic low-frequency oscillator (LFO) control of certain parameters over meso-time scales. A ramp function, for example, might modulate grain density over a period of a minute, while the user adjusted other parameters manually on shorter time scales.

Another important research direction has been the creation of an analytical counterpart to granular synthesis, called *atomic composition*.[11]

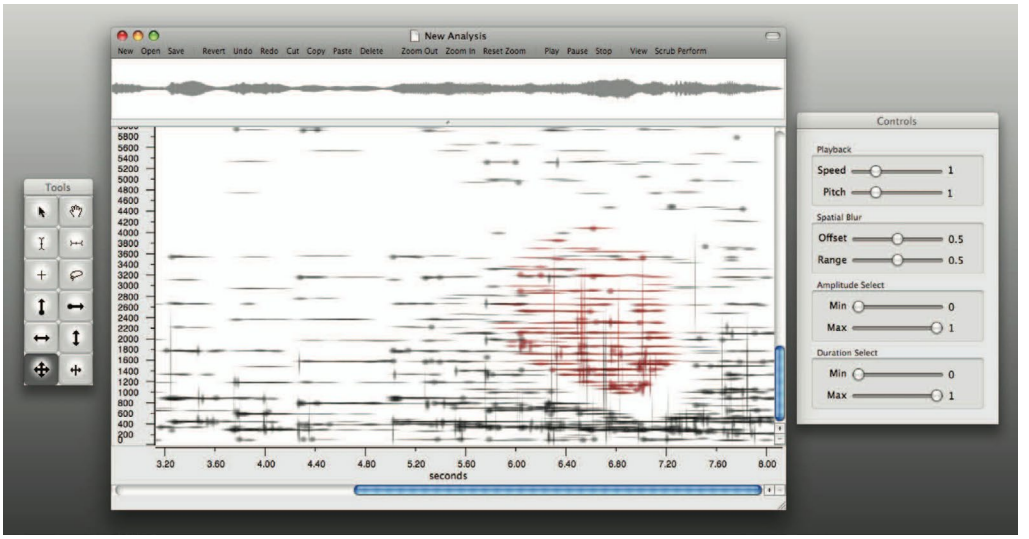


Fig. 25.14 Screenshot of SCATTER. Figure created by author (2009).

We built a prototype time-frequency editor called SCATTER, but such a model could be taken much further.

Meanwhile, the original EmissionControl granulator ran only on old Apple G5 computers, so it was time to create a new version. The original goal was simply to recreate EmissionControl for modern computers. As we proceeded however, it became clear that EmissionControl2 went far beyond the earlier program.

In October 2020, we released the new EmissionControl2 or EC2. EC2 is designed as a laboratory instrument for research in granular synthesis. As a laboratory instrument, EC2 enables detailed control over the vast parameter space of granular synthesis for the composition of extreme granular textures and gestures. In the summer of 2022, we published a second version, which adds Open Sound Control (OSC) functionality.

11 Sturm et al., 2009.

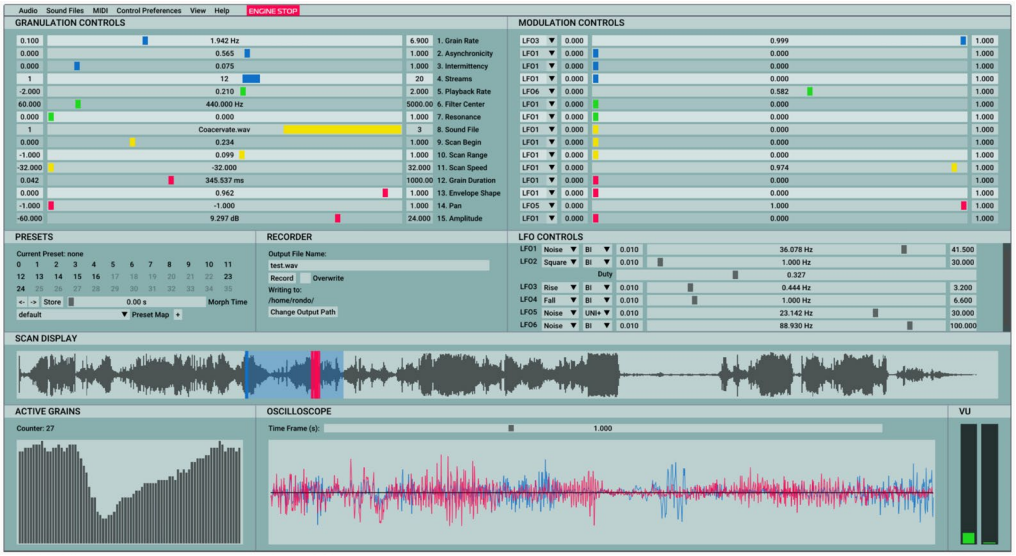


Fig. 25.15 Screenshot of EmissionControl2. Figure created by author (2021).

The main features of EC2 are:

- Per-grain signal processing.
- Granulation of *N* sound files simultaneously.
- Up to 2048 simultaneous grains.
- Synchronous and asynchronous grain emission.
- Intermittency control.
- Modulation control of all parameters by six LFOs with extreme ranges.
- Real-time display of peak amplitude, active grains, waveform, scan range, scanner, and grain emission.
- Scalable graphical user interface (GUI) and font size.
- Easy mapping of parameters to any MIDI or OSC continuous controller.
- Algorithmic control of granulation via OSC scripts.
- Unique filter design optimized for per-grain synthesis.
- Unlimited user presets with smooth interpolation over time for gestural design.
- Open-source code and free to download.

Since its release, EmissionControl2 has been downloaded by over 7300 musicians around the globe.

Finally, I should mention my recent book *The Computer Music Tutorial, Second Edition*, which presents Xenakis's Free Stochastic Music program and devotes chapters to granular synthesis and atomic decomposition of sound.[12]

Conclusion

Xenakis said that he composed in order to feel less miserable.[13] This is an excellent reason. But the effect of music goes beyond oneself. Composition is a service to humanity. Through music, a composer can make other people feel less miserable.

Fig. 25.16 Plaque outside Xenakis's Paris residence. "Member of the resistance, political refugee, composer." Photo by Mu (2010), *Wikimedia Commons*, CC BY-SA 3.0, https://commons.wikimedia.org/wiki/File:Plaque_Iannis_Xenakis,_9_rue_Chaptal,_Paris_9.jpg#/media/File:Plaque_Iannis_Xenakis,_9_rue_Chaptal,_Paris_9.jpg

12 Roads, 2023.
13 Lohner, 1986, p. 54.

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26. Creating and Learning with UPIC

Takehito Shimazu

"The reason why we need to study pedagogy is
because we have forgotten our childhood."

I remember these words. They are the words once spoken by a professor during a lecture on music education in a university class. I remembered these words, and after that, through my life, they became very important and significant for me.

This chapter presents what I experienced through the process of creation of my first piece for UPIC (Unité Polyagogique et Informatique de CEMAMu (Centre d'Études de Mathématique et Automatique Musicales)), *Monodie IV*. In the summer of 1990, I attended the seminar at Les Ateliers UPIC, in Paris, and there I produced this piece. Figure 26.1 shows a part of the score.

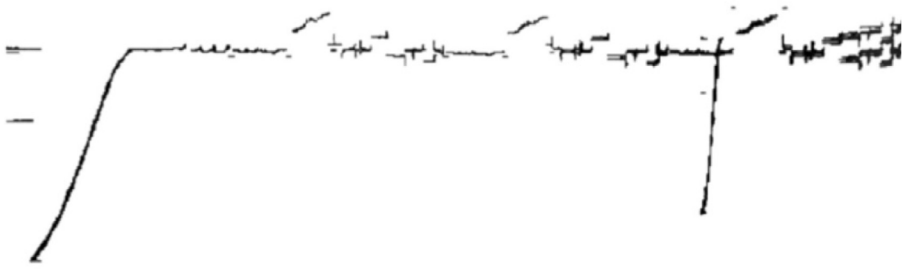

Fig. 26.1 Score: *Monodie IV* (1990). Figure created by author.

https://doi.org/10.11647/OBP.0390.28

Originally, the purpose of this short seminar in 1990 was not to create works, but I managed to spend four days there for my own creative work. The reason why I could realize my composition in this time, I think, is that one could easily and speedily realize ideas and create works by means of this system. It could truly be called a "dream" device.

Around this time, I was trying to make a series of musical works for various instruments in "monophony," each of which I titled *Monodie*. In order to put together a work in such a short period, I decided to apply the same idea as one possibility, using UPIC as a solo instrument. And then, as the source of this piece, I chose a sampled sound I had, rather than using resources within the UPIC System. I had not prepared any materials in particular to produce my piece using this system, as it was a sudden idea. At the time, I had a CD of my own works with me, so I chose one sound from a very short piece I made for the opening of a Cable TV program that was then becoming popular in Japan. Cable TV then was like YouTube today, and it was one of the communication systems that, at the time, we expected to be widely used in the near future. This piece for cable TV, titled *Artistic Vision*, is a two-minute, fifteen-second work in which the first phrase of a Japanese work is sung by a baritone singer, and during the piece his voice is electronically deformed, attaining a mechanical, electronic sound, and finally returns to the original voice.

Media 26.1 Title music for the television program *Artistic Vision* (1989).
https://hdl.handle.net/20.500.12434/a5ced890

I sampled the long (circa one-minute) tone of just the beginning of this piece as the sound source for my piece for UPIC. The singer was Yoshiaki Takezawa, a friend of mine who taught vocal music at the same university as me.

Media 26.2 Vocal sample from title music for the television program *Artistic Vision* (1989).
https://hdl.handle.net/20.500.12434/dc1764f3

His rich and deep voice was enough to inspire creativity on its own, but I picked up only one cycle (that is, one Hz) of his voice, and the sound was resynthesized from the one cycle of waveform using FFT (fast Fourier transform), one of the excellent functions of the UPIC System that had been demonstrated during the workshop. It

was like creating a "clone" of a voice, artificially proliferating from a single sound cell. That's why I named the sound source material of this work "voice cells."

I do not have a UPIC at hand now, so I have used a sound editing app to simulate the process.

Media 26.3 First part of the sound source of *Monodie IV*.
https://hdl.handle.net/20.500.12434/af011db7

Here is a transcript of the voice-over:

> This is a clip of the first part of the sound source of this piece.
> Then, enlarge it and set it so that you can see the smallest waveform.
> Choose one cycle from this waveform. In this case, you can see that the two peaks are periodic.
> Cut it, copy it to a new file, and copy it over the new file.
> You will repeat this process.
> It will sound like this. This way you get a new sound source.
> The UPIC System could automatically make this to the required length.

Each of the various sound editing techniques on UPIC presented in the workshop was a fascinating way to stimulate creativity. I believe it was inevitable that the charm of this system would lead me toward "creation" rather than "learning." That being said, I think I was the only one of the ten or so participants in the workshop who managed to create music at the time. I always think that such positiveness or audacity is one of the necessary qualities as a composer.

Around the time of this seminar, I also participated in workshops at IRCAM and at GRM (Groupe de Recherches Musicales) in Paris. Therefore, I understood the differences between those facilities well. I wrote a report about this in an article "Computer Music in Paris" for the music magazine *Ongaku Geijutsu*[1] which was widely read by Japanese composers at the time. Of these three facilities, Les Ateliers UPIC, and GRM were the ones in which a composer was able to create works, or create materials that led to future works. IRCAM was the most specialized of the three and housed comprehensive electronic technology with many facilities and multi-talented assistants right next to the Centre Georges-Pompidou (aka Beaubourg), a comprehensive contemporary art facility that looks like something out of a James Bond movie. However, workshop participants were not allowed to go any further than participating in learning experiences. I did not have enough skills and knowledge to make works using such high-level facilities. In that respect, the other two facilities

1 Shimazu, 1990.

were "small" by comparison, with several rooms mainly for music production, and it could be said that they both offered a high degree of creative freedom.

I always feel that creation is a very "luxurious" and "selfish" act. For me, Les Ateliers UPIC was a unique facility in terms of being able to answer my selfish questions. As for the INA-GRM, the music production method there was analog-based and easy to engage with, but it seemed like an extension of the tape music I was able to accomplish at home; I felt it was lacking a certain freshness for me. Since I like to focus on the act of composing music, I could say that UPIC's studio was just the right amount of fun for me to learn advanced information processing knowledge and sound editing techniques.

For the musical construction of *Monodie IV*, I deliberately tried to avoid what many people may have done when faced with an input device like UPIC's large "drafting table" of the time. In other words, I was able to imagine many people drawing various figures, one after another, with straight lines and free lines on this "table." In particular, a score that would combine straight lines in various angles made me imagine Xenakis's own work. I certainly sensed his personality in the system he developed. So what came to my mind was the experience of the composer Yoriaki Matsudaira (1931–2023), who participated in the first UPIC workshop in Yokohama, Japan. He said that he tried drawing a bunch of lines on the top corner of the table, but it did not sound as interesting as he thought it should be. The idea of seeking this "corner edge" would not make it look like Xenakis's work gave me a great hint.

I thought that I could "return the favor" to Les Ateliers UPIC, which had given me such a great opportunity, by expanding the possibilities that could be used on UPIC for composing works. So, I focused on giving the lines a new depth. For the outside scenery, I tried to create a world with a lot of open space using a brush, like a Japanese painting that uses calligraphy techniques. The sound material used was a method that gradually deforms the musical outline by assigning a sound which had been created from one cycle to each line segment, called an "arc," adding depth and thickness, changes in timbre, etc.

As one sound grew, it passed through a "Shakkyo" melody of Noh theater music, and finally developed into a sound with violent and sudden inflections like a "Gidayu," which is also from Japanese traditional music. The "Shakkyo" (which in English means "stone bridge") song from Noh theater was a theme I had been researching extensively for the work I wrote for a Japanese musical instrument just previously.[2]

In terms of how the sound develops, I made extensive use of the process that I was accustomed to using on a computer, the so-called "copy and paste," gradually adding thickness to a single line, and heading towards polyphonic music, like tracing the history of music. Of course, in order to deal with the "poverty" of such sounds

2 In 1988, my composition of the same name, *Shakkyo* for seventeen-string koto had been awarded the Agency for Cultural Affairs' Creative Encouragement Special Award.

produced with such a simple method, I also created percussive waveforms with sound sources called "vocal cells" and added low notes with spaced accents used in Gagaku, Japanese traditional court music, to give the sound a wider range.

Thus, at first, I composed it as music for UPIC solo, but in the following year, I also composed a version *Monodie IVa*, with percussion parts, and performances of this form of the piece have been increasingly popular. A new concept was added to the version with live instruments. Using percussion instruments played by humans, UPIC-sourced sounds resonate throughout the venue creating a special environment, enveloping the musicians and the audience. In other words, I composed the piece with the image of a percussion solo accompanied by a (virtual) vocal chorus. Here is the schema of this work's setup:

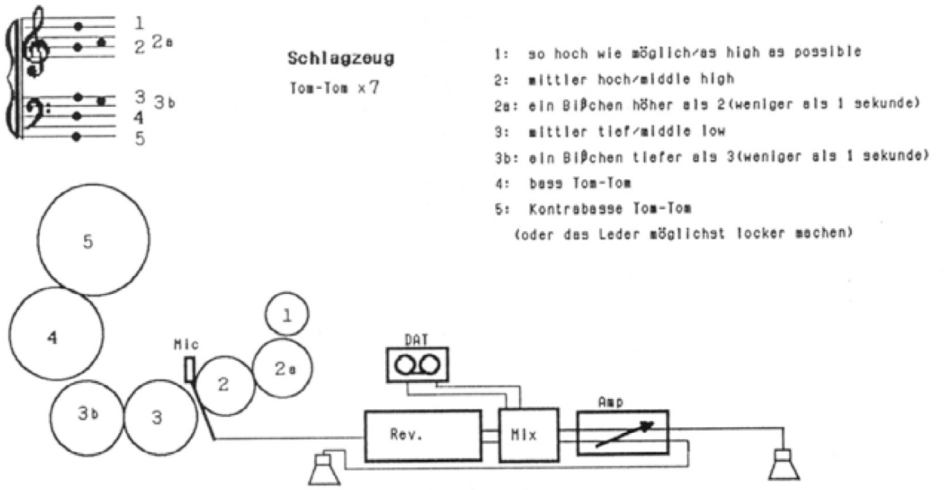

Fig. 26.2 *Monodie IVa* setup. Figure created by author.

I used only seven tom-toms as percussion instruments. A microphone was also set to capture the voice of the performer. The UPIC sounds were played from a DAT player, and it was a simple to mix those with the percussionist's voice having passed through the reverberator, and the mixed sounds were output from the speakers. Here is a composite score (UPIC and percussion) and live recording of the first few minutes of this piece.

Media 26.4 *Monodie IVa* (1990), performance by Shin-ichi Ueno (percussion) on 7 June 1992 at the Asian Composers League Festival, Sendai Japan.
https://hdl.handle.net/20.500.12434/5ef909fd

The appreciation of this work was delightfully and surprisingly high, and, in 1993, I was commissioned to create a new work by Les Ateliers UPIC. The second piece, *Illusion in Desolate Fields* for UPIC solo was completed in their studio. This work was originally created for live performance of UPIC solo. But like the previous *Monodie IV*, by combining it with live instruments, it became an instrumental piece accompanied by electronic sound. Including live performers also provides a realism and visual appeal, which are lacking in the plain "reproduction" of pre-recorded music. So, in 1994, I made the production into a work with shamisen, simply titled *Illusion*. In this work, the music from the shamisen might represent a traveler, and the UPIC sound is intended to represent the natural environment surrounding him. This work is based on the last haiku of Matsuo Basho, a Japanese haiku poet from the Edo period. The poem reads:

> On a journey, ailing—
> My dreams roam about
> Over a withered moor. [3]

Kazuko Takada, a very talented shamisen player, performed for the recording of this work. Although she was a soloist of a traditional musical instrument, it was a valuable experience for me that she could participate in such new music. Sadly, she passed away six years after this 2001 CCMIX[4] Paris Xenakis|UPIC|Continuum CD was released by Mode Records.

Fig. 26.3 CD cover of the two-disc CCMIX album. Reproduced with kind permission from Mode Records. © Mode Records (2009).

3 Ueda, 1982.

4 Les Ateliers UPIC were renamed the Centre de Création Musicale Iannis Xenakis (CCMIX) in 2000.

Here is an excerpt of this piece with its score.

Media 26.5 Excerpt of *Illusion*, recorded 1994, for UPIC and shamisen, with corresponding score; Kazuko Takada (shamisen).
https://hdl.handle.net/20.500.12434/3a801aed

I stated above that the original piece for *Illusion* was made for "live UPIC performance," so let me explain what that means. The UPIC System could also be used as a live playing instrument. I was therefore able to perform improvisationally by tracing on the time axis of the UPIC's table some figures I had created in advance. In fact, in the recording above, the sound of the UPIC solo, onto which the shamisen was later added, uses a fixed (recorded) version of such a "live performance."

I would also like to take this opportunity to point out a few things about the educational value of the UPIC System. The attractiveness and visual depiction that the UPIC System offers create acoustic phenomena as they are seen, lowering the "wall" of composing and allowing even children to "compose" as if they were painting. Xenakis had thought of it as a "dream device" not only for composers but also for children. As I remembered before, "The reason why we need to study pedagogy is because we have forgotten our childhood."

UPIC was and remains different than today's keyboards and other computer digital input methods. Handwritten figures could be traced and thereby input into the system, and it was a combination of digital and analogical methods. For those who used it, it was a system that could convert visual sensations directly into auditory sensations in a very natural and fluid manner.

This system could also be defined as something that enables children to be "released" from heavy and difficult technology and allowed to touch directly and concentrate on creation itself. Having majored in education at a Japanese university, maintaining an educational perspective has always been essential to my musical activities. UPIC's appearance was also very effective in arousing the interest of children. The table was similar to a so-called "drawing board" used for sketching paintings and was extremely easy to start using. However, it was never incorporated into popular teaching methods in Japan. It may have been the peculiarity of this system, and versions of the device up to the 1990s seem to have had especially complicated structures. I remember that UPIC required two computer systems to function until that time.

Fig. 26.4 Self-timed photo of the author at Les Ateliers UPIC in 1993.

This photo was taken during the production of *Illusion* in 1993. One can see that there are two computer monitors. At the time of this photo, I was still in my early forties. In 2008, I had the opportunity to work at CCMIX's studio in Romainville, Paris. What I could see there was that the "drawing table" was gone and the new version of UPIC was only a computer software application. I remember feeling like I had lost the most important element of something.

But let us return to the question of education. In order to use this system for educational purposes effectively, I think it became necessary to develop it in terms of software rather than hardware, so that it could be installed in more compact computer systems. In the 2000s, as software, we see that IanniX,[5] and in recent years UPISketch[6] are being distributed free of charge. This makes me feel the potential inherent in this concept, and that it is a movement that suggests the "future" of music education. However, in Japan, I am afraid there is a bigger problem in introducing this system into the music education curriculum: the lack of interest in new music among educators in the field. However, there could be teachers who, if they had enough time, could incorporate creative education, or even composition, into their classes; unfortunately, in many cases, new music is only approached from the "appreciation of music"

5 *Iannix*, https://www.iannix.org/en/
6 "UPISKETCH," *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/upisketch

perspective in schools. Music classes are generally concerned with singing, and there are a few lessons offered to learn to "play an instrument" and even fewer offered to learn to "play instruments with others." But the main problem in introducing such technology is that the people most ignorant of science in elementary and junior high school are the so-called "music teachers"; and often, there are many such teachers who are less skilled even in music history and theory.

Finally, I would like to address what I think Xenakis might have dreamed of for the future of UPIC. Although I have already mentioned the educational potential of UPIC and that descendants of the system today already exist as software or free applications, we are likely to be in a situation where even more people can become engaged. I do not know if Xenakis himself expected this kind of expansion, but since he always had a strong interest in creative education for children, I imagine that he dreamt that it could go beyond the world of electroacoustics and be used widely in children's creative activities, becoming a tool that can be used by anyone.[7] Furthermore, as even the historic UPIC system demonstrated, it is conceivable that collaborations with the visual world accompanied by graphics would further expand its possibilities. Personally, I would cherish the opportunity to participate in real-time in such an endeavor.

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7 Indeed this has been confirmed by Xenakis in a promotional (albeit unpublished) video where he states, "[W]e want to develop this system in such a way as to put the UPIC within the reach of the entire population of the globe so that man can manifest his supreme capacity for abstraction because that is his most interesting power" [xenakis.org/items/show/674 (especially from 0:48)].

27. Music, Science, Architecture: Two Conversations with Iannis Xenakis

Julio Estrada[1]

Introduction

In 1994, I had a couple of meetings with Iannis Xenakis, the first in April and the second in December. I proposed to record both of them as informal conversations, and he willingly accepted. Originally, I did not think of publishing them. My intention was to better understand the imagination of someone I had met around 1967 during my studies in France and with whom I shared a frank communication. Over time, this straightforwardness developed into a long-standing and pleasant friendship. Whenever I could, I would chat with him one-to-one about the link between his ideas and his music, because he was the most different and boundary-pushing musician I have ever met. From this last perspective I understood that our bond was not one of formal discussion about his theories, aesthetics, or music; with that approach it was impossible to maintain the openness necessary to address such issues. These talks were spontaneous, closer to those we had on our train trips during the eighties or, as almost every month in the early nineties, at his dining room table or, rather, his kitchen table. As the years went by, I came to understand him better, despite his permanent tendency to take refuge in an abstract discourse in order to avoid musical dialogue. In the field of music, his training was purposely incomplete, to the point of opting for ignorance instead of traditional knowledge. Paradoxically, thanks to this evasion and an original imagination, he achieved accomplishments that distinguish and honor him. Works like *Metastasis* (1953–4) were among the very few that managed to reveal a new and direct perception, something capable of producing fascination and intrigue at the same time. Almost three decades after this pair of dialogues, sometimes interspersed with jokes or laughter, I share them for the first time with readers so that their freshness may contribute to celebrations for the centenary of the great Xenakis's

1 Translation, from the French, of the two conversations with Xenakis, by Sharon Kanach and Julio Estrada.

 https://doi.org/10.11647/OBP.0390.29

birth, demonstrating that he was far more accessible than the distant image that he and the snobbish musical milieu tended to project.

Conversation with Iannis Xenakis: Part 1

April 1994, Xenakis's Studio, Paris

JE: How do you imagine music; that is, the internal relationships in the process of creating it?

IX: I can't tell you that, I don't know. Do you think I can imagine exactly how a whole piece is going to unfold before I start writing it? No, I do that while I'm working. I make sketches, and try to figure out how it will work, how it should work, and that's that!

JE: How do you go about sketching: with drawings or sometimes with equations?

IX: There are different kinds of sketches. Sometimes they're drawings, sometimes with notes, writings.

JE: Texts?

IX: Yes, texts.

JE: And sometimes also by trying out certain musical passages once you've memorized certain aspects of it?

IX: Yes.

JE: Do you take this aspect of music from your memory and reintegrate it into the writing process, for example?

IX: Eventually, yes. But that's normal practice; it's nothing special. Everyone works like that, in every field. Elsewhere, it's the same, whether you're a scientist or an artist or even a banker [...] but I don't know how a banker works!

JE: You said a long time ago that you imagine things in the dark.

IX: In the dark?

JE: In the dark, yes, that you imagine in the dark; that there aren't any images.

IX: There are no images. No, no, there are no images. I don't know what there is.

JE: Is there a sense of movement within?

IX: Yes, of course, but they're not images; they're not cars, or stars, or snails.

JE: Nor even pigs!

IX: No, not pigs! (Laughs)

JE: Is it a nebulous environment in the dark?

IX: No. They're ideas, abstract ideas. You don't need any images for that.

JE: At the same time, are they audible?

IX: Heard.

JE: Heard?

IX: Yes, but in a certain way.

JE: Sometimes yes, sometimes, no?

IX: Sometimes, yes. That's right because it also depends on how you dress these ideas or thoughts.

JE: Clothing, garments?

IX: Garments, yes. If it's clarinets, if it's an orchestra, if it's music [...].

JE: What I'd like to talk about—and I think you're very close to it—is music in which there is no language; that is, there is no conditioning, in particular, of eminently abstract music.[2] [...]

IX: You mean for music based on a text? If so, for example, I'm working on a commission for the BBC, and I've composed the music. Now I'm in the process of applying words to it, and I thought of a text by Shakespeare that came back to me because I've known it by heart for seventy years.[3] So now I'm trying to apply it, but not in a regular way, but in a fragmented way, you see? I take the phonemes and place them anywhere on the music. And because when one sings, one uses phonemes, whether one likes it or not. In *Nuits*[4] (1967), I used phonemes from all sorts of languages.[5]

JE: But here, for example, with this text by Shakespeare, how do you disperse it? Is it your memory of the text over time?

IX: Yes, but I use the text from Shakespeare's *The Tempest* in which I acted—I was Ariel at the time—and I cut the syllables, the phonemes, and then I mix them up and put them anywhere on the music.

JE: Like a combinatorial or random process?

IX: Yes, yes.

JE: But there's now a strong connection with your memory of the text, that is, you put this text in time.

IX: That's precisely what I do. I take the text and break it up. It's as though I have a text, and in this case, I split it up into phonemes, mix it all up, and then toss them.

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2 I really wanted to get Xenakis to focus here on music without any references to language, but he insisted on exploring other means of using literature when writing music.

3 Here, Xenakis is referring to his work *Sea Nymphs* (1994) for mixed choir. See Ryan Power, "Iannis Xenakis—Sea Nymphs (Audio + Full Score)" (31 Mar 2022), *YouTube*, https://www.youtube.com/watch?v=z3SCoWVjOZs

4 *Nuits* (1967), for 12 mixed solo voices or mixed choir. Based on Sumerian, Assyrian, Achaean, and other phonemes.

5 "Iannis Xenakis - Nuits (w/ score) (for 12 voices) (1967/68)" (12 Oct 2015), *YouTube*, https://www.youtube.com/watch?v=jESS3gP1GGE

JE: Like confetti?

IX: Yes, like confetti, that's it, do you find that funny? (Laughs)

JE: A lot of your music or pieces are related to physical space; that is, virtual movements produced by the instruments, especially, for example, in *Terretektorh*.[6] This aspect is particularly linked to your imagination because it's unique. I think you have a very precise commitment to the idea of space in your own music.

IX: Listen, I have spent my life, during my holidays, on a kayak with Françoise—who doesn't like that; she's already written about it, by the way.[7] Well, what's kayaking? It's being in the sea, and sometimes there are storms. There's either silence, or waves, or just the feel of things. But there's a sound environment everywhere, and that didn't exist before in music, because we were always frontally oriented, unfortunately or fortunately. So I asked myself: how did Beethoven[8] listen to his symphonies? From within the orchestra or as a listener? And where should the listener be placed: in the front row, the tenth row or at the very back?

JE: Or in the middle of the orchestra…

IX: Or in the middle of the orchestra. Or above the orchestra or behind the orchestra. The German architect who designed the Berlin Philharmonic, Sharoun, created a concert hall with people behind the orchestra.[9] But from behind, you can't hear! I was in Berlin when he was finishing that, and I was even there with the physics professor from the Technical University of Berlin. He had a phonometer in his pocket, measuring the echoes in the hall, which wasn't yet open to the public—to see if he had made a mistake, because he was the acoustic consultant. Well, it doesn't work having the audience behind, because all the musicians are watching or all the instruments are turned towards the conductor; in other words, the audience in front of them. But I thought it would be interesting to try something different. That's why, in Strasbourg, we removed the chairs, and the conductor, who was German, and the orchestra too, were in the middle of the hall, and once that was done, there was not much room for the audience but a little balcony for them which is fine. The program included Mozart[10], Stockhausen[11], who was on stage, *Terretektorh*, and then Wagner.[12] You see, in

6 *Terretektorh* (1965–66), for 88 musicians scattered throughout the audience. Hessischer Rundfunk, "Iannis Xenakis—'Terretektorh' für Orchester - Cresc... Biennale für Moderne Musik" (28 Nov, 2011), *YouTube*, https://www.youtube.com/watch?v=37ajOyhcl_c

7 Xenakis, 1994.

8 Ludwig van Beethoven (1770–1827), German composer and pianist.

9 Hans Sharoun (1893–1972).

10 Wolfgang Amadeus Mozart (1756–1791), Austrian composer.

11 Karlheinz Stockhausen (1928–2007), German composer.

12 Richard Wagner (1813–1883), German composer. This concert took place as part of the Musica Festival on 20 September 1984, with the Philharmonique Orchester Freiburg (see "Programme," *Festivalmusica*, https://festivalmusica.fr/documentation/editions/1984).

order to put all the musicians back on stage and put the chairs back for the audience… What a bloody mess! So I said, "Why don't you leave the musicians where they are? We'll listen to Wagner like that."

JE: Of course!

IX: And we did. It was wonderful, and I don't think Wagner ever heard his music like that.

JE: No, but you had imagined it for *Terretektorh*, didn't you? Did you decide on and follow a, let's say, serpentine form, one that circled around?

IX: Yes, yes, of course. But I had lots of strings, for example, and they had to make a continuous ring of sound; then the other instruments were also dispersed.

JE: This was also done at in the lobby of Radio-France, with Charles Munch[13] conducting, right? Only the strings were placed in a circle…

IX: Charles Munch? What are you talking about? No, no, it wasn't Charles Munch, no, no, no. It was […] You generally have an extraordinary memory, but now yours is worse than mine, eh?

JE: It was in '68, yes, this circular room with a […]

IX: Yes, but it wasn't Charles Munch, no, no, no, no, no. It was Bruck!

JE: Charles Bruck[14], okay. I'm sorry.

IX: Well, it's a good thing I'm here! Yes, that's right, that was it, *Terretektorh*.

JE: Yes, the way you had conceived the piece…

IX: Yes, yes, that's how I conceived it. There was a ring of strings and then the others were scattered too…

JE: In other words, you created an architecture of musical space?

IX: Yes, there was an architecture of sound…

JE: […] that you temporalized within the music based on this architecture of musicians distributed throughout the room. You let it unfold in time.

IX: Yes, sir.

JE: There you go. But there are two things: the first is the architectural organization, which ultimately determines the whole score; and the other is to imagine with a certain conviction how the sounds will move in space? How will they circulate? Why do they move from left to right and not […]?

IX: I even chose their speed, you know?

JE: You mean, of course, the kinetic trajectory?

IX: And it followed an Archimedean function. There are several logarithmic Archimedean functions, for example of the speed of motion of sound that slows

13 Charles Munch (1891–1968), French conductor and violinist.
14 Charles Bruck (1911–95), French-American conductor.

down, or accelerates, etcetera, and of several forms. I wanted to try it out and see if it worked. Well, you have to be in the middle to hear these things, or you can hear who's far away, which is also quite nice. So, I was thinking that in these cases, there's also another problem, which is when there's sound or even for moving light, there's the—what do you call it—effect?

JE: Doppler?

IX: Doppler, yes. *Merci*, sir! The Doppler effect. That is, you have (he hums…).

JE: The passing ambulance…

IX: …yes, I'm the ambulance! It was quite difficult, but I did it, or I tried to do it. You have the sensation of something moving, because otherwise you only have the impression of the sound getting closer or being softer because it's further away.

JE: Yes, yes. It's a virtualization through dynamics.

IX: Yes […] but no, through the interstice, you mean, right?

JE: Yes.

IX: But there's no movement in the true sense of the word; that is, when you're used to hearing sound. But then it becomes physical with the Doppler-Fizeau effect.[15]

JE: So, do you imagine some kind of wave moving away, or approaching; in the same way as you did in your kayak?

IX: Absolutely, of course […]

JE: […] and that comes from 360 degrees? If someone asks you how you listen to music, it seems like there's an imaginary scuba helmet over your head!

IX: In that case, yes, because in other cases, no, it's remains frontal. Left and right. And that's it.

JE: Yes, like in *Retours-Windungen*,[16] for example, where the twelve cellos are placed in a semicircle.[17]

IX: Yes, that's right; it's a plane.

JE: But one where there's an integration of sound movements that you hear in physical space—those that will occur as well as those that you hear after that given moment. They're distributed in space and cut into little fragments so they can be articulated as they move. They don't fit into a completely continuous composition.

IX: Yes.

JE: There are segments of sound which, through a certain kinetic density, accumulate

15 "Doppler-Fizeau Principle," *Photonics*, https://www.photonics.com/EDU/Doppler-Fizeau_principle/d3641

16 *Retours-Windungen* (1976), for twelve cellos.

17 12 Cellists of the Berlin Philharmonic, "Windungen für 12 Violoncellisten" (6 January 2015), *YouTube*, https://www.youtube.com/watch?v=MX9s4Of9c8g

and give the impression of a sound or noise moving away or approaching in space. For example, each musician who plays a sound must receive that sound and make it *crescendo*. Like a spider.

IX: Huh? No. But the one who receives the sound has to make a *crescendo* and the other, the one who gives the sound, has to make a diminuendo. But that's very difficult to achieve. You must have the sensation that the sound crosses and moves, and it's not just that the sound moves in dots. That's it. It's the most difficult thing and you have to work on it a lot. I did that with percussion in *Pléiades*[18] too, I think.[19]

JE: Rather, in *Persephassa*.[20]

IX: Yes, in *Persephassa*, thanks! (laughs).[21]

JE: Yes, there you play with the hexagon...

IX: ...Yes, that's right.

JE: ...in an abstract and at the same time in an extraordinarily eventful way.

IX: Yes, it's necessary for each player to pass on a diminishing sound, all while listening to what the others are doing.

JE: Of course.

IX: *Voilà*! But that's not the case. It's very rare when that works.

JE: Have you ever thought of musicians actually walking around in space?

IX: Yes, I did it, in *Eonta*.[22]

JE: Ah, yes, because the brass instruments approach the piano and play inside it.

IX: And they also have some fun walking around, etcetera.

JE: And all this is part of the particular conviction of the way you want the music to be heard, isn't it?

IX: Yes, of course, they're experiments to see how it can...

JE: ...you can't just experiment, it's something that makes...

IX: ...no, it's part of...

JE: ...of imaginary time.

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18 *Pléiades* (1978), for six percussionists.

19 Tracotel, "Iannis Xenakis, *Pléiades* (1979)" (5 February 2013), *YouTube*, https://www.youtube.com/watch?v=dqtFGaHcWRk

20 *Persephassa* (1969), for six percussionists. Alxarq Percussió, "Persephassa (1969)—Iannis Xenakis" (15 October 2022), *YouTube*, https://www.youtube.com/watch?v=cLUss2hPVD4

21 In the "Performance Notes" in the score of *Pléïades*, Xenakis specifies, "The players should be placed either on an elevated platform in the middle of the audience which would thus surround them, or else, on a stage in a row in front', showing that spatialization was equally one of the composer's preoccupations in this work." (Xenakis, 1978, n.p.)

22 *Eonta* (1963), for piano and five brass instruments. Ensemble Linea, "ENSEMBLE LINEA—IANNIS XENAKIS—EONTA" (13 September 2011), *YouTube*, https://www.youtube.com/watch?v=IzUPAMY2A8k

IX: Yes.

JE: That's right, there's a kind of faith that…

IX: …yes…

JE: …no! It's an inner conviction…

IX: …no: that's your imagination. When you want to do something, you imagine it and then you realize it, little by little.

JE: But are you confident you can achieve a certain result?

IX: No, that's working on paper, trying to imagine things. It's not like that: bingo!, like some sort of divine illumination.

JE: No. But there's something that makes the thing imagined […].

IX: That's it. There's always a starting point […]. Often, we don't pay attention to it. Sometimes there are lots of things like that that you can think of but that don't really have anything to say—"No, that's not what I mean, I'm not interested in that, I'll do something else." And then, after a while, you may say—"But that was pretty good, it could work. It could be the seed for other great things, perhaps?" And you start working. That's how I work, and that's how the spirit of man—who is a poor fellow, by the way—lives. Man is a poor fellow.

JE: …who stays…

IX: …um…yes.

JE: One day I asked you—because of your inclination to space and spatialization—if you were left-handed and you told me—"No, I'm not left-handed!", but then we found out that you were a left-handed contrarian.

IX: Yes, contrarian […], that's what I was told. Maybe I was a left-handed contrarian.[23]

JE: Maybe? Why perhaps?

IX: Because you know, in those days when I was a kid, I lost everything. There was nothing left… I didn't live in a house, in a town: it was all completely turned upside down. So I don't know what I was like back then.

JE: But who told you that you were left-handed?

IX: Just a rumor from my childhood. I was in Romania at the time and […]

JE: And you don't remember?

IX: No.

JE: Or […] don't you remember the teacher who bugged you, who annoyed you and told you "Don't write with your left hand"?

IX: I don't remember, I have no memory of that time. But what do you expect? I do

23 "This question refers to research I've been pursuing for nearly half a century, based on the observation of my students: right-handed people tend to imagine focally, as if wearing a mask, while left-handed people imagine environmentally, as if wearing a scuba helmet." Estrada, 2024, n.p.

what I can. Besides, it's a bad thing to have a sharp memory, because afterwards you can't imagine new things. Be careful, you have to forget! (Laughs)

JE: This is something I'd like to talk to you about. When you hear music, it's happening in time, but where is your memory then? It's somewhere else. Not all music creates sounds in a specific ambit that retains the events that have just occurred: one doesn't get attached to them but creates them. These events are actually created in a living way, to support this constant, conscious life at every moment. In this way, you can't lose yourself in the past.

IX: In the past, no. No! Listen, the past, that is, the repetition of something, exists in architecture too, in sculpture. I don't know about painting. It's also a legacy of past centuries: architectural motifs, for example, that repeat themselves. You can't invent new forms all the time. That's the point. The ideal, in architecture for example, is to build something that doesn't repeat itself: a house wouldn't have to be made of squares, for example, or rectangles, or straight walls, because that's repetitive—and that can give you something that's […]. In fact, no, you can't have, you can't invent something that doesn't repeat itself. It doesn't exist, be it for terrestrial life, on Earth, or for the movement of the Earth, the sun, the stars, the universe. There are things that repeat themselves in a terrible, dreadful way as they are, but with small differences that we don't perceive, but which exist and make things change, little by little. And that's that. So, in music and art, this is very important. In the old days, you had a theme that you repeated at will, with polyphony and so on. That's how it used to work, and not only that, but you could do *da capo*, for example, exactly as it was, *da capo*, without changing a thing. With great musicians like Beethoven, we began not to write *da capo* but to change constantly. Instead of *da capo*, Beethoven created variations. Brahms's[24] variations on Haydn are extraordinary, because in the variation there's exactly this problem.[25] Variation means not having an identity as such, or having an identity, but not quite the same one: it has to change. Then we can go very far: the identity has to change in such a way that we no longer understand anything. That's all there is to it. That's what I've always done as a musician. I didn't want to have repetitions of this or that, but maybe I'm wrong...

JE: That reminds me of Julián Orbón.[26] He used to say that there are two kinds of compositional thought: on the one hand, there are musicians who think in terms of variations of models, with constant manipulations of the same things

24 Johannes Brahms (1833–97), German composer, conductor, pianist.

25 黃紹綱, "Brahms Variations on a Theme by Haydn op.56a" (30 April 2015), *YouTube*, https://www.youtube.com/watch?v=CcOEumzkaTQ

26 Julián Orbón (1925–91) was a Spanish born Cuban composer, who sometimes also lived in Mexico and the United States. I studied with him at the Mexico National Conservatory between 1961–3 and privately with him in New York in 1962 and 1963.

and always attached to memory. And on the other hand, was symphonic development, like that of Beethoven, for example, who didn't want to endorse this notion of variation, in the same way as the others.

IX: And then...

JE: ...so, you identify with this second trend?

IX: Hmmm [...] Maybe, I think. Wait, what? Did you just insult me? Of course not!

JE: (Laughs) No!

IX: Let's go! What's next?

JE: That is to say, you would rather be identified with this kind of conception of a continuous development of music without arriving at variation? Meaning without memory, but in the sense of continuous time?

IX: Yes, but memory is there all the same.

JE: In the sense of certain ideas that are maintained, that "snake" through the form?

IX: Yes, yes, that's the most interesting thing. When you have an identity, that is a being you have in your head, that you've worked on and made, but if you make this being... for example, a chord, as simple as that: a chord. This chord can last three hours even, (hums), if you have instruments that can handle it...

JE: (also hums). (Laughs)

IX: ...but, you get tired after a while and say—"I've had enough of this, next; what's next?", well, then it's after that that it might become another different chord, etcetera. That's the way things are, because [...] we're bored, we're used to development, to change.

JE: You have to let people perceive...

IX: ...yes...

JE: ...that's it. And then?

IX: Yes, yes, what's next, because you can make a chord and then give the guy who's listening a shotgun blast and then [...] (Laughs)

JE: So, it's again a spider, it's the same spider; that is to say, it has six legs, it moves one, then another, and the other, and the other...

IX: Why always a spider? It could be another insect...

JE: Spiders are in continuous transition.

IX: But [...] it could be another insect; it could be a salamander...

JE: A salamander is an insect? Now you're a zoologist! (Laughs)

IX: It could be a [...] a, what's it called? [...]

JE: A worm?

IX: Yes, it could be an earthworm, which never sees the sun [...] and can be very big—you know, earthworms used to be huge, in prehistoric times.

JE: [...] But I mean, in the face of this continuous transition, which certainly retains a good deal of previous information and moves little by little, until it becomes a new one, as in the transition in space [...].

IX: Yes, it can change slowly, but it can also change abruptly, rapidly. That's how it works in music; it has always worked that way. A carbon copy by repeating it as is, or modifying it. Why do we say—"yes, that's what represents the composer's identity"? Why do we say "Yes, it's a work by Mozart because we recognize..."

JE: ...that it's a good piece? (Laughs)

IX: No, because it's similar to what we know of Mozart, and the same goes for Beethoven. Sometimes they get confused. Is it Mozart or Beethoven, because they don't sound alike. But that means that someone's personality is also something where there are repetitions of a certain type.

JE: It's his way of communicating certain information, it's a way of conveying...

IX: ...yes, not only to communicate, but also to invent them beforehand. That's what happens at certain points in history because traditions change too. Each generation takes what has been said before and tries to do something different with it. If they don't try, it gets tiresome everywhere and they do something else. And so, in the end, sometimes there are major differences between eras. So, there you go. In other words, what you're doing is the same as what musical culture has been doing for thousands of years. That's what I mean. We don't produce anything else and that's a shame, but that's the way it is. It's man's destiny; he can't do anything. He's a poor guy, very stubborn in the end. Yes, indeed!

JE: "I'm the great memory [...] because it's genetic too," as another fellow would say.

IX: As well, of course. For example, genetics is a perfect example of that, because each couple makes a being where there are mixtures of what they are, but also other things that aren't them. And then, little by little, they drift apart. For example, the grandchildren of the original couple may be very different from their grandparents. But they're still human. They're not monsters or maggots! They are because it's the force of genetics that gives them an identity—which is translated into form. Shape is the shape of the human body, which makes us all human. For example, the skull of a contemporary of Lucy was found, with a very strong chin and thick eyebrows, and it was a male. Lucy's head is lost, so unfortunately, we don't know what she looked like.[27] But we're like that bloke, for example, there's not a lot of difference. It's been three million years, all the same, but that's not much. Then there are other permanent features or similarities:

27 "Lucy (*Australopithecus*)" (19 March 2024), *Wikipedia*, https://en.wikipedia.org/wiki/Lucy_(Australopithecus)

we can see [...] we have two eyes, two ears, etc., this binary symmetry of the body. But it's been around for two hundred million years, or even four hundred million years. That's fantastic! But why? We don't know the causes of these things, but there is a permanence to them. So that's why a poor composer also has permanence; it's because he's learned these things, it's because he's also inventing from known things.

JE: In your case, for example, and your penchant for architecture [...] your particular organization of space, is combined with a way of constantly experiencing time. In your architecture, there's a characteristic tendency to organize structures in space in an abstract way. As in *Terretektorh*, there's an architecture of the distribution of musicians that defines what's going to happen through the evolution of time. There's a moment when you can combine or move from your architectural imagination to the temporal imagination of music. Maybe that was at the beginning. You had some musical training since you were a child, and you also had this interest in architecture. At some point you put them together.

IX: Yes.

JE: One day, when we were in Mexico, you told me about the origin of all this. You listened to sounds after your injury and wanted to translate them; that it was very important for you to transmit these sounds you heard in your ear, something that was bothering you.

IX: And still does!

JE: Still?

IX: Yes, of course.

JE: I didn't know! How is it that you've integrated your two vocations? You're sometimes compared to Da Vinci[28], aren't you?

IX: Ah, Da Vinci! Yes!

JE: Who had a lot of interests.

IX: But it's natural for humans, because we have eyes, we have ears, and we address [...] and touch [...].

JE: Yes, and smell! Taste and bad taste. (Laughs)

IX: Yes, bad taste. (Laughs) Right. But, then, the most important things are the eyes and the ears. Because the sense of smell is only used in cooking, it's only used when we're making love... The sense of touch is also important, but we don't use touch so much.

JE: (Inhales deeply) Not when making love?

IX: In love or elsewhere; you don't make love all the time, or do you? Whereas with

28 Leonardo Da Vinci (1452–1519), Italian polymath (painter, sculptor, architect, engineer, scientist, theorist...).

your eyes and ears, you make love all the time. You live with these two things, they're constant, and you're aware of space, of encounters; you recognize enemies or friends by their voice.

JE: Yes.

IX: Still, there are things that create an interference between the two; and another thing is to discover connections, identities, for example [...].[29]

Conversation with Iannis Xenakis: Part 2

7 December 1994, Xenakis's Studio, Paris

JE: Last time, we talked about the imaginary world, and we got a bit carried away. But there are certain questions I'd still like to ask you. And the first starts with a parable: I want to ask you about your relationship with Beethoven's music. I remember that one day, looking at the huge quantity of your scores you have in this corner [...], and you immediately said to me: "Is it too much?" and you said immediately, after: 'Beethoven, he'd done more than that!'.

IX: Yes, I don't know how much he'd made. Do you?

JE: No, no, (IX laughs) [...] but, is there a connection between what you're doing and Beethoven? It was he who demystified the relationship between music and religion; he distanced himself from the religious side of music. He was much more secular; he was a revolutionary, someone with political ideas. He was also committed and broke with all the norms of his time. In a way, it all coincides, doesn't it? Tell me about it!

IX : What?

JE: Not "what"! (laughter)

IX: What do you want me to say? Something about Beethoven?

JE: Yes.

IX: It's very difficult for me because I used to love Beethoven. I often listened to him when I was young, and then I stopped listening to music a long time ago. And that's because on the one hand I don't have the time, and then it bores me. (Laughter). It's true! I don't even listen to my music. I have tapes that I haven't listened to, for example.

JE: Was there anything in Beethoven that attracted you in particular? A certain connection with his side of being a committed person?

IX: No, not the committed revolutionary side, no, no, no; that's not what attracted me. It was for his music. I know he had met the German philosopher...

29 This conversation was interrupted by a phone call Xenakis was expecting and received at this point.

JE: Goethe?[30]

IX: Goethe, yes. I believe he loved Beethoven, didn't he?

JE: *Si*.

IX: *Voilà*!

JE: And Mozart.

IX: And Mozart too, yes. But... *Nein, Nein*. I've been trying to think for a long time about these things because I think that, even if you have political ideas or whatever, when you make music, really music that's not imitative, it results in music that imposes itself, that leads or that un-leads. Do you understand?

JE: Mmm...

IX: So, it's not program music; that's what I mean. It was in his character to make the music he did. With his intelligence. Character and intelligence. He had these two things that go together. And that's it.

JE: I remember the way you explore this freedom, this attitude that doesn't cling to the past, nor to certain laws or norms that have already been established. That's what I saw as the identity shared with Beethoven.

IX: Ah, yes. A self-respecting composer has no right to imitate or imitate himself, because otherwise there's no point. It's been said by others in an extraordinary way, so if a composer imitates himself, he's screwed. Do you understand?

JE: Yes.

IX: There you go. So that's the difficulty of invention, the difficulty of being ... different; that is, of being different first of all from others, well, of being yourself, because unfortunately, we're human [...] and we have internal resources, and these internal resources impose what you think.

JE: And in a way, you were going to spend this abundance of internal resources in a logistical way; that's to say by developing theories, ideas, methods, techniques during certain periods. And today we can see how there has been a relative distancing from all these resources that were your strengths—it was also a bit your carapace, in a way that you got rid of, in my opinion.

IX: Yes.

JE: As with other composers. And now you abandon that part, all those extraordinary powers of the time, of your resources, and you start doing something much more spontaneous.

IX: Eh...

JE: There's something like that going on with Beethoven too, in Beethoven's last period...

30 Johann Wolfgang von Goethe (1749–1832), German author and polymath.

IX: Yes...

JE: ...He did the same. He became much more humble, with an attitude much more confident in other resources, in his intuitions.

IX: I don't know. Why are you comparing me to Beethoven in the first place? [...] Do you think it's important?

JE: I think it's a good way of not addressing me too directly yet being more...

IX: Ah, *gut, gut*! (Laughs)

JE: ...and things you wouldn't want to say about yourself..., you'll say:—"ah, yes, Beethoven did [that], but I didn't." (Laughs)

IX: No, I think that someone who works hard, who makes efforts—I make efforts—that doesn't mean they're "stable" every time, one tries on the one hand to cultivate oneself, like a peasant—you know, in the fields... that's to say to bring forth what's inside. And to do this, he has to forget his contingencies, his education, his experiences... he has to be as new as possible. When I say new, I mean something not yet done by anyone, not by himself, not by others; and that's the hardest thing there is, because we're limited. We've got a brain that dates back, let's say, three million years, and we're limited because we've got a small skull, right? (Laughs) So, I notice that in all the sciences and among all the scientists, there's, suddenly, an interesting theory coming out. A lot of people get involved—and then there are others who [...] even contradict it. And then it goes on like that, and the only way of knowing whether it's interesting or not is the so-called "technological" result—not theories, because there are lots of theories that contradict each other too. A technological result is proof that it's scientifically valid, or at least an indication that it's more valid than something else. Since we always live in the clouds, and whatever we do, we stay in the clouds. But sometimes these clouds have material spin-offs that justify—up to a point—these images. For example, there are theories today that say there are infinite universes, and that time, that the finite thing, is something from the past. I'm reading this book that talks about infinity as an element that is fundamental and exists even if we try to eliminate it, and that nevertheless exists in everything, it's very interesting, by a guy called Luminet, a Frenchman, an astrophysicist.[31] So, that's what happens with composition, in exactly the same way. You have ideas, but these ideas have impulses, or instincts, but that doesn't mean that they are valid. So you criticize what you do—in principle, because I don't know what *you* do—but you criticize when you can. (Laughs) But that doesn't mean that criticism solves all problems because there are some

31 The book in question is actually co-authored: Jean-Pierre Luminet (b. 1951) and Marc Lachièze-Rey (b. 1950), 1994. See also the two authors more recently: DunodVideos, "Un voyage passionnant dans l'infini grâce à Jean-Pierre Luminet et Marc Lachièze-Rey" (24 June 2016), *YouTube*, https://www.youtube.com/watch?v=Gy5rAF_NHmU

things you can't do anything about. You say, "yes, I like that," or, "I want it to be like that," and not, "I like that, but I want it to be like this"—because liking something means that...

JE: It's also about making choices. For example, I think that in the last ten years you've made the choice to go..., that you've taken on a pattern in which you allow yourself things that before weren't so possible?

IX: I didn't think [...] in recent times...

JE: You've given yourself permission...

IX: ...to...

JE: ... to be spontaneous?

IX: Eh well ... yes and no. Yes and no!

JE: For example, in one year you compose, say, six different works; whereas before, it was more like one work per year.

IX: Ah, yes.

JE: It's not just a question of quantity, but that access to music...

IX: Oh yes. But I'll give you an example: the calculation of probabilities was very important to me sixty years ago. I'd studied math books and then, like that, I oriented my music, with what I felt was necessary—because it comes from very far back—and with what was calculable, let's say, to be able to be written. But these things have always remained. I don't do all those calculations anymore, I don't go into that field of probabilities, but it's still there. At the same time, I make little programs, etcetera, that allow me to go, to be [...], to be able to proceed, to be able to do things, you know?

JE: Yes. All right, then. But...

IX: ...but that's one thing. It's mixed with...

JE: ...of course, you maintain a way of proceeding...

IX: ...yes...

JE: ...and this way of proceeding—the stochastic, probabilistic sound—you dominate it and, in a way, you have changed the way of dealing with the technical, methodological relationships.

IX: Yes.

JE: Let's say it's an imprint on you. That's clear: something in your choices is stochastic. It also means not getting attached to many things; it's something completely related to these stochastic aspects and at the same time a somewhat macrocosmic vision...

IX: ...that's it, yes...

JE: ...of musical phenomena or compositional thinking.

IX: That's right.

JE: [...] But [...] even in all this, I don't think you allow microcosmic things to happen any longer; that's to say, aspects of your own microcosm...

IX: Not calculated, you mean? Unplanned? Not predictable?

JE: *Voilà*!

IX: Yes, of course, of course!

JE: ... I would say sequences...

IX: Yes, yes, yes, but that's always been there. It can't be avoided.

JE: Yes, but you used to...: Take for example *Achorripsis*... it was one of the "test pieces": a piece really in which you could see that it was a demonstration of stochastics.[32]

IX: Well, yes and no: it's not completely stochastic, just in large part only.

JE: Okay, but these are laws of distribution, of number of instruments, of number of events per predetermined duration...

IX: ...yes, yes...

JE: ...or by number of bars per section, etcetera. It was to demonstrate to the listener, in a very obvious way, what the stochastic method was for you.

IX: Mmm, yes...

JE: But there, let's say the permissiveness of your microcosm was minimal; it was, say one per cent?

IX: *Nein, nein, nein*! Ah no, no, no, no, no, no! Because even to do that, I had to have a fair amount of internal permissiveness. Listen! (Laughs)

JE: But you're more permissive today, aren't you?

IX: To dare to do that? (Laughs) No, I don't know. It's changed its appearance because I'm always criticizing myself: it's not just based on theories, either physical or mathematical, but also on things I'm trying to understand and that interest me and that aren't from the past, not imitative or reproductive, but new. That's what I think [about]: being new. Maybe I'm gaga and I don't understand anything anymore, that's another thing; nobody can say. When you're gaga, you don't realize things; it's the others who say – "Ah yes, that's the gaga guy," but you say—"No, I'm not gaga." (Laughs) You know what I mean?

JE: So, what I said was that you give way to many more personal fields... I'll phrase it another way...

IX: Yes, try it.

32 *Achorripsis* (1956–7), for twenty-one instruments. Contemporary Classical, "Iannis Xenakis—Achorripsis (with Score) (1957)" (19 Oct 2020), *YouTube*, https://www.youtube.com/watch?v=rEyqJPW3Hi8

JE: I think that before, there was a certain obstacle to manifesting yourself spontaneously in music and that you used all this protective, intellectual, very strong, very well-built, and extraordinary carapace.

IX: Thank you, thank you, thank you.

JE: *Je vous en prie*! (Laughs) [...] That, let's say, protected you in this way of proceeding in the composition...

IX: ...yes...

JE: ...once you'd managed to create this universe of your own—respected by everyone for its production, for the importance of the music, for the novelty, for the originality—at that point, you took a certain retreat and [said], "Well, what else is there to protect...?"

IX: ...you mean defend?

JE: Yes [...]. Saying, for example, "What is there to defend: sounds or action? Let's act in a much more immediate way, let things that arise on first impulse manifest themselves."

IX: If they're interesting, yes; if they're not, don't bother.

JE: Of course. Let's say you haven't stopped "technicking," but at the same time there's this manifestation, which is more obvious, in which you take much more of the risks that come from your microcosm and appear in your music.

IX: ...Maybe, maybe. Listen, lately I've been developing new techniques for instrumental music in particular. [...] Instead of having, for example, quadraphony with strings [...] I have sixty strings. So, what do I do with these sixty strings? Well, I make them play at the same time, each at an interval of a semitone or something like that, and that makes a harmonic magma that's different from what we know. And that, for example, is an experimental thing; but all the same, there's thought there. Why not have a continuum instead of individual pieces from Mozart or whatever? Because that's how it was! And why four voices? It's hard to imagine five voices, even if even earlier composers imagined twelve different voices. But why four voices and not all the voices? Sixty voices! Now that's an achievement! The same goes for the other instruments: instead of having four voices—for example, four horns, four trumpets—because that's about the average limit for large orchestras—let's play them four at a time without there being melodies swirling around, between them. That gives much more timbre, you know? And that's what interests me, because we're fed up with melody and polyphony itself, because we hear it in music all the time, including in today's light music. When I say light, I mean music where you see people gesticulating on stage, etcetera.

JE: Rock-n-roll?

IX: Yes, for example, rock-n-roll or anything, all the music you hear on TV, especially

because you don't hear other music there. It's melodic because it's easier and the instruments are melodic.

JE: Let's say that now you've taken up an aspect that wasn't there before in your music… under the melodic aspect, but now it becomes a hyper-cluster…

IX: That's it. That's it!

JE: …enormously dense, which can vary in density…

IX: Yes, but the problem is how to vary these hyper-clusters, as you say, without contours either in the melody or in […] nebulae that we don't understand.

JE: (Laughs)

IX: Yes, it's true, it's…

JE: But we perceive everything, don't we?

IX: From the point of view of perception and dynamics, yes, but it's not just the perception and dynamics of the thing. It's the dynamics of music that make you hang on or not to evolution—because unfortunately, music evolves. It's not like a painting, which is fixed; it's all there. But music is in time. So that's something that has to be taken into account in a way that's, I'd say, simultaneous. And so, for example, you invent timbres, but you forget the melodies, or you make traditional melodies, or something that resembles traditional melodies: look at the melodies from Japan to the United States—or the other way round, eh? (Laughs). You see, they're always the same! It's always the same, it's melodic, it's interesting sometimes, or it's beautiful, etcetera, but it's melodic! Do you understand what I'm saying?

JE: Yes. Now, to talk about your integration of melody… I remember that you used to often say "ah, melody, there's no such thing…" You had a strong rejection to it. But now you forget this rejection?

IX: Yes.

JE: We are always changing, criticizing ourselves, evolving, learning things, and taking every possible path, otherwise we'd be locked into a single path, and that would be silly. But I really admire your choice …

IX: You're right! (Laughs) I don't admire myself, you know; no, but I don't admire at all. At least someone admires what I do. That's good!

JE: For me, what seems very important to consider in your current evolution is that this permissiveness is greater in the microcosm, for direct choices instead of taking indirect ones. This direct choice—which stems perhaps from the importance of the graphic methods you've created, in which the "resulting scores" are indirect—manifests itself in the graphic, which is very direct. This impulse of the hand that drives thought […] through drawing …

IX: Yes, maybe. I wanted to simplify; is that what you mean?

JE: Yes, that's it. In other words, there are choices that are made indirectly by stochastic methods—if they are still there today, they are part of these indirect choices—, there are now other, much more direct choices that are made by hand, by drawing…

IX: Oh yes, live, yes, yes.

JE: By manual means of computing…

IX: …and because I trained in the meantime.

JE: Of course, but what's great, Iannis, is that at the beginning, you didn't have, let's say, a conservatory training.

IX: Ah, not at all!

JE: You really were the black sheep… (Laughs)

IX: …absolutely, yeah, yeah…

JE: …from the conservatory. Well, let's say, your conflict with the limitations of old teachers in conservatories, you've solved it with rational thinking.

IX: Yes. But I had a composition teacher who was a Greek from Russia. He had studied, he'd been… [33]

JE: He's the one has taught you Mozart's *Requiem* by heart.[34]

IX: Exactly, but you've got a great memory! (Laughs) […] So I had a base, if you like, but maybe not a huge one, because there's no point in having a huge base on the two things.[35]

JE: No, but let's say you didn't fit the standards predefined by the conservatory.

IX: No.

JE: And so you took a path completely off the beaten track, and went right past the music world to, in the end, demonstrate that you had created completely new paths on which the whole music world now incorporates or is in the process of incorporating.

IX: Yes.

JE: That's what's… great!

IX: You speak well, very well!

JE: But what's happened now since you've managed to do this? To demonstrate—because it's a demonstration—that you can make music by incorporating structure, by incorporating mathematics, by understanding other fields of thought—even biology, botany, astronomy—, and open up this dogmatic field of the little parish priests' seminaries, which is limited…

33 This is Aristotle Kondourov (1896–1969), cf. Matossian, 2005, p. 27.
34 Mozart's *Requiem* in D minor K. 626 (1791), for four soloists, chorus and orchestra.
35 Xenakis's idea of "two things" likely refers to composition and music here.

IX: Yes, yes, yes, absolutely…

JE: …to all free men. And that's where there's an enormous liberation of other people's thoughts, through your music.

IX: Really?

JE: This is where I think of Beethoven.

IX: Yes. Beethoven was Mozart's pupil, don't forget that!

JE: Bad student.

IX: Yes, bad student. (Laughs)

JE: Let's say that when you listen to Beethoven—to return to Beethoven—you get the impression that this man, who was a revolutionary, well, you can ignore his whole personal history.

IX: Ah, you must, you must, otherwise…

JE: But it's his music that brings us to a new, free space, in which the choices are made in a different way.

IX: What I'm going to tell you, to give you an example… in the nineteenth century, it was Brahms. Brahms, I liked him immediately when I heard him, so I could have studied what he had done […], read his scores, all that. But no, not at all. I liked his way of doing things on a higher level, if you like: his harmonic dynamics, for example…

JE: Its architecture?

IX: Its architecture and also the means beneath it. But I never studied him in any great depth, because I didn't want to be stifled by that sort of thing. It's a very important thing—but I still love Brahms as a special star of the nineteenth century, even of the twentieth century.

JE: Who is far away, whom you admire, but from whom you take nothing?

IX: No, I didn't try to imitate him. But what interested me was his personality. Now, you're going to say to me, "How come you liked this personality since you're, supposedly, not of the same personality?" Because we're multiple.

JE: Of course! I heard you say on New Year's Eve in '83 or '84, "Let's put on some Brahms, because that's the farthest musician from my universe."

IX: You have an extraordinary memory. How come?

JE: I know you. (Laughs)

IX: Ah, that's right, yes.

JE: You said it well: "He's the one who is the farthest… who is the most different." So we listened to the Quintette in F minor.[36]

36 Antonio Prieto Pérez, "Johannes Brahms, 'Quintet for Piano and Strings in F minor, Op. 34'" (9 January 2018), *YouTube*, https://www.youtube.com/watch?v=NmWt6foZflM

IX: That's it. I like it a lot. But you see Mahler,[37] for example, who's a very well-known musician—well, there are a lot of people who love him, and in particular my friend de La Grange, who spends his life writing about Mahler.[38]

JE: Yes, who did a lot of important work on Mahler.

IX: Yes. But I'm not interested, if a music doesn't interest me, I see lots of filaments clumping together. It's rare when I'm interested. But it's clinging to its present and its past, and not in the best way; it's not revolutionary enough, if you like.

JE: A very impotent side to his music.

IX: There. Do you believe that too?

JE: There's an anecdote in one of La Grange's writings on Mahler.

IX: What?

JE: I'll tell you about it later...

IX: ...okay... (Laughs)

JE: ... Mahler's meeting with Freud,[39] but let's get back to melody...

IX: Yes... Yes, then?

JE: Something you incorporate, already incorporating the melody there are the rhythms that come. Something that struck me a lot in *Pithoprakta* were the rhythms: these rhythmic strokes that had a certain order and, at the same time, destroyed what was somewhat in order, but also a certain chaos.[40]

IX: Yes.

JE: Now in your music you reincorporate a rhythmic element, but one which serves the melody and is almost monorhythmic...

IX: Mmm...

JE: And with this monorhythm, I think you're reassimilating things that Messiaen advocated.[41]

IX: Really?

JE: I hear certain rhythms and that's not all, I don't think you're picking up on [...].

IX: Ah, but let me tell you, Messiaen was very much inspired by ancient rhythms.

JE: Yes, Greek, Latin...

IX: A lot. Yes, but that's it, because you can't escape these things because you're

37 Gustav Mahler (1860–1911), Austro-Bohemian composer and conductor.

38 Henry-Louis de La Grange (1924–2017), Franco-American musicologist, biographer of Gustav Mahler.

39 Sigmund Freud (1856–1939), Austrian neurologist and founder of psychoanalysis.

40 *Pithoprakta* (1955–6), for forty-nine musicians.
Pierre Carré, "Iannis Xenakis—Pithoprakta (w/ Graphical Score)" (30 April 2017), *YouTube*, https://www.youtube.com/watch?v=nvH2KYYJg-o

41 Olivier Messiaen (1908–92), French composer and organist, with whom Xenakis studied at the Paris Conservatory intermittently between 1951–4).

in time and so you propose something "A." It is found a bit deformed a little later, with intermediate elements, but rhythm is something: time [...]. It's the reappearance of things, a phenomenon that exists in all human knowledge, whether in astrophysics, chemistry, whatever... there are repetitions all the time, but it's annoying.

JE: Yes, but there's a choice...

IX: That's why I've tried to get past that and to make continuous transformations.

JE: In rhythm?

IX: In the appearances of sound. We go from one place to another without intermediate milestones that make rhythm, but it's a continuous transformation, this which is different from the thing in the musical sense, because when you say—in tradition there are melodies, in other words, notes, and notes have to be set in time—and so you have strings of notes and these notes are set in time with rhythms, either equal or unequal rhythms, or feet, things.

JE: Yes, but you're talking about the continuity of rhythmic time, or durations in time. You're talking about a rhythm that has no measure, that's out of measure...

IX: That's right.

JE: And that is something that brings us back to Messiaen.

IX: It's a transformation...

JE: But Messiaen created an enormous independence—and Stravinsky[42] too mixed a lot of metrics at the same time...

IX: ...yeah...

JE: ...or juxtaposed metrics. But Messiaen abandoned this process and created enormously elastic metrics that ultimately lead us to eliminate the idea of measure, and ...

IX: I don't know.

JE: [...] when we perceive the melodies you make, these macro-clusters with melodies, I perceive a...

IX: Can you feel Messiaen in it? Can you hear Messiaen in it?

JE: I hear Messiaen and I'd even say that when you combine melody and rhythm, there's a connection with Messiaen. I had noticed this in another piece of yours, two or four years ago when I listened to it.

IX: But have you heard the latest pieces I've done for orchestra? No.

JE: I listened in...

IX: No (an alarm makes the words unintelligible).

42 Igor Stravinsky (1882–1971), Russian composer and conductor.

JE: What's this instrument of martyrdom?

IX: Eh? An alarm clock, I don't know.

JE: An alarm clock?

IX: Let it run...

JE: ...no, I haven't listened to any recent orchestral pieces by you. I mean, I've seen the scores. Yes, I've heard something conducted by Yuji Takahashi I think.[43]

IX: Takahashi, yes.

JE: There is a disc: *Real Time*.[44]

IX: That's right, yes

JE: And on this record there is a piece for orchestra by you which has quite a few moments of hyper- clusters with rhythms that are very... "à la Messiaen."

IX: Oh well...

JE: I'm not saying that in a critical sense, it's just that I think some of the things you're doing now are reincorporating elements... [...]. Would it then be permissible for you to open up a space for influences in this way of composing today? Why not?

IX: No, I don't know [...], I don't know.

JE: (Laughs) Are you upset that I say there is something of Messiaen?

IX: No, but I'm surprised.

JE: You're surprised?

IX: *Ja*!

JE: No, it's not... (silence). I heard, wait a second... a Trombone Concerto in Copenhagen.

IX: Yes.

JE: Right. So, the orchestra part also has this character.

IX: "Messianesque?"

JE: Not "messianic?" (Laughs)

IX: No. "Messianesque!"

JE: "Messianesque," yes.

IX: So, wait, which piece is it? ...

JE: Messiaenoid? (Laughs) I don't know how to say it.

IX: It's... Wait... what's the name of that piece you heard? I don't remember.

43 Yuji Takahashi (b. 1938), Japanese composer, pianist, conductor, and author. Y. Takahashi studied with Xenakis at the University of Indiana, Bloomington and also in Berlin as an associate Ford Fellow, while Xenakis was there in 1963–64. See also Chapter 3 about this period. Xenakis dedicated two works to Y. Takahashi: *Herma* (1960–61) and the previously mentioned *Eonta*.

44 Takahashi, 1992.

JE: Where? [...] on the *Real Time* record?

IX: No, not at all, the one with the trombone: *Troorkh*! That's what you heard. *Troorkh*: it's for trombone and orchestra.[45]

JE: Yes. *Troorkh*, yes.

IX: Ah, I don't know, maybe, it's difficult to listen to your own music.

JE: But, for example, the string quartet... what's it called, the one that's made of scales?

IX: Quartet... *Tetora*?[46]

JE: Is that *Tetora*? It's your penultimate quartet, isn't it?

IX: Yes, it's possible.

JE: That's right: there's *ST-4/1*,[47] then *Tetras*,[48] and then *Tetora*, right?

IX: Yes, hold on, I'll get that for you.

JE: Right. There, there is the very idea of scales or rhythms, or harmonies that are formed, or shaped. It's not that you're looking for these harmonies, but they form all the same—they make a certain recall in their sonorities that could have been elaborated by Messiaen.

IX: No, that... I don't know, if you say so, it's like that.

JE: (Laughs)

IX: *Troorkh*, that's it, trombone and orchestra. (He pulls out the score) But... I wrote it in '91 [...], three years already. (Silence) Let's move on!

JE: (Laughs) You don't want to talk about that?

IX: Huh? No, but that's because I can't tell you anything about it.

JE: Oh okay. Right...

IX: You can say that because you're on the outside, but I'm on the inside, so I can hardly...

JE: ...no, I would say that, for example, [...] the idea of continuum in rhythm is still discontinuous. The values you use are discontinuous values.

IX: Ah well, of course, but [...] you can't not be discontinuous in the rhythm. Because it's...

JE: Yes, through acceleration and deceleration? That would be equivalent to a

45 *Troorkh* (1991), for trombone solo and eighty-nine musicians.
Ryan Power, "Iannis Xenakis—Troorkh (Audio + Full Score)" (27 October 2021), *YouTube*, https://www.youtube.com/watch?v=HonX4NrO8FY

46 *Tetora* (1990), for string quartet.
Bob Sweeney, "XENAKIS The Complete Quartets: Jack Quartet Tetora (1990)" (23 April 2014), *YouTube*, https://www.youtube.com/watch?v=9OyLiAPuRXs

47 *ST-4/1* (1956–62), for string quartet.

48 *Tetras* (1983), for string quartet.

continuum of frequencies.

IX: Yes and no... yes.

JE: Shortening frequencies and durations, a *glissando* would be equivalent to an *accelerando* or *deccelerando*.

IX: Yes, but you always think of time as if it were notes. You have to see time in time; let's say, it's one after the other. Well, that's time. But it's very distinct from the rest, even if you, for example, do 2, 3, 5, 6 and then [if] you [have] those same numbers to say—"I'll take a 2, 3, 5, 6 melody"—, you're mixing things that can't be mixed. That's what I mean. I'm not saying that doesn't do it, but time is of a different essence. Because time is like having boxes: here you put one box—that's a certain domain of time—here, another box in another domain. Different things, you see? But you don't have to measure and say, "Oh yes, it takes longer." We do that, unfortunately, but it's not necessary. Do you understand what I mean? No, you don't.

JE: No, but it's okay...

IX: Never mind. (Laughs) *Tetora*, which you mentioned, it was in 1990 that I wrote it.

JE: Yes, but... let's go back to the idea of freedom, which has always been essential to you [...] It's what I was thinking of when I said that there would be elements that could be associated with Messiaen, in particular the rhythms, I thought of the idea that so many of your choices could incorporate known things, things that are part of a tradition to which you belong, that is, of your teacher...

IX: Oh no, no, no, not at all! Messiaen, no, no... Listen! I took his class because he didn't just talk about himself, he talked about Schönberg,[49] he talked about ... Debussy,[50] Hindu music, French music from 550 years ago—about Machaut,[51] for example—things like that. He talked about Stravinsky [...] well, a lot of things like that. And he also talked from time to time about what he was doing. What I really like in Messiaen's work are, for example, his organ pieces, which are really very strong from the point of view of thought.

JE: I think he managed to create a huge independence between rhythm and sound [...], he's one of the very few who managed to achieve that.

IX: Yes, but I don't know if it's a way of thinking about music, but it's a way of thinking about music that's quite traditional. Even if it's... [...]

JE: ...with him, you say?

IX: Yes. Although his rhythms are different—because he was into that—but there are parts of his music that are very traditional too. And that interested me a lot

49 Arnold Schönberg (1874–1951), Austrian-American composer, music theorist, author, and teacher.
50 Claude Debussy (1862–1918), French composer.
51 Guillaume de Machaut (1300–77), French composer and poet

less, in his pieces for orchestra or piano (a doorbell rings). That's Radu Stan.[52] I'll open up for him. Let's stop here?

JE: Yeah. *Jawohl*.

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52 Radu Stan (1928–2021), was a Romanian musicologist who worked at Editions Salabert (the main publisher of Xenakis's scores) in the Promotion of Living Composers Department. He devoted much of his energy to defending and promoting Xenakis. When he retired from the publishing house, Xenakis hired him as his agent, and he worked exclusively for him almost until the composer's death.

28. The Pythagorean Wall: A Visual and Auditory Drama

Julio Estrada[1]

The *Dekemvriana*[2]

In a photograph taken around 1965, Iannis Xenakis, close to his mid-thirties, appears with a conservative air and without showing the left side of his face.[3] A decade earlier, between the end of 1944 and the beginning of 1945, he had protested as a student during the dark Athenian *Dekemvriana* (December Days). Once the Nazis were expelled, England occupied Greece to prevent it from leaning towards communism; Winston Churchill (1874–1965) imposed the repression of all Greek links with the Stalinist enemy and armed the formerly pro-Nazi Greeks. The students demonstrated in front of the British-occupied barracks and, as Xenakis and his wife Françoise narrated, upon arriving at the square with his group, the Lord Byron Brigade, the future composer fired a nearby cannon, causing damage to the new enemy. In immediate response, a shell's shrapnel destroyed his face; he lost his left eye, and for a decade, he experienced a continuous complex noise caused by the deterioration of his auditory system—perhaps affecting his voice, which remained slightly muffled and rough.[4]

A musician still in training, when he emigrated to Paris in 1947 Xenakis needed to

1 I am grateful to Lucas Barroso Rouwet for the transcription of my lecture on which this text is based, presented on 1 October 2022 in the Meta-Xenakis International Symposium, during the SUICREA-UNAM, Mexico leg of our forty-one-hour non-stop marathon. See Estrada, 2022. The translation of this chapter is by the author (with guidance from the editors).

2 The so-called *Dekemvriana* refers to civil disturbances that took place in Athens between 3 December 1944 and 11 January 1945, involving factions of the Greek Resistance movement and the Greek government, backed by British forces. See Iatrides, 2015.

3 Lipnitzki/H. Roger-Viollet, "Iannis Xenakis" (1965), *Britannica*, https://www.britannica.com/biography/Iannis-Xenakis#/media/1/650599/15298

4 This version of the facts surrounding Xenakis's war wound differs—somewhat—from previously published sources, but this version, published here for the first time, is the one that both the composer and his spouse, Françoise, recounted to the author in 1994, in their home on Rue Chaptal, Paris, in a rare admission. See also this exchange in Varga, 1996, p. 18: "Varga: *You were wounded in January 1945*. Xenakis: Yes, I was hit by the shell of a Sherman tank. But by then I had also blown up a few of them."

 https://doi.org/10.11647/OBP.0390.30

describe what that noise sounded like; he thought he would benefit from the help of Arthur Honegger (1892–1955), whose *Pacific 231* (1923) imitates locomotive sonorities, or Darius Milhaud (1892–1974), but he only found guidance from Olivier Messiaen (1908–92), the post-war master, expert in Greek rhythm, composer of *Modes de Valeurs et d'Intensités* (1949) in response to integral serialism, and someone who understood the autonomy of the Greeks. Trained as an engineer, Xenakis worked as a calculator for Le Corbusier (1887–1965) and discovered Edgard Varèse (1883–1965), who was entrusted with the music of the Philips Pavilion (1958), and whose work focused on the matter of sound—such as the *glissando*, the continuous gliding of the sirens in *Ionisation* (1933). As Xenakis said of Varèse:

> His music was something special [...] I thought it was *musique concrète*, but no, they were traditional instruments that he used in his own way [...] there was practically no melody—he worked with timbre [...].[5]

Metastasis

Xenakis continued to learn music in parallel with his conception of the Philips Pavilion.[6] The tension of its high curved walls is derived from a geometry fundamental to the architectural continuum, and its aesthetics represent an architecture-sculpture intended to be observed as an artistic object.[7] The precedent is Anton Pevsner's (1888–1962) sculpture, *Developable Surface* (1938–9); the Russian had emigrated to France and, since the 1920s, had revealed the structure of an innovative model: wooden tensors covered with paper to obtain three-dimensional fans or hyperbolic paraboloids.[8]

The fluidity of multiple turns starting from one axis is an architectural challenge that the young Xenakis calculated in an unprecedented way: starting off from Le Corbusier's drawing—which comprised a "stomach" and an indication of the entrance and exit of the public—he projected the nine hyperbolic paraboloids that emerge from the base of the Pavilion.

5 Andrew Toovey, "Edgard Varese Film with Interviews: Messiaen Xenakis Maderna" (2 June 2012), *YouTube*, https://www.youtube.com/watch?v=QJHN8-cn9jw (at 6:26).

6 Wouter Hagens, "Expo 1958 Philips Pavilion 1958" (20 August 2008), *Wikimedia Commons*, https://es.wikipedia.org/wiki/Archivo:Expo58_building_Philips.jpg#file

7 A meaningful text by Le Corbusier notices this connection: "the Parthenon is the exceptional monument [...], a true sculpture and not a building" [*el Partenón es el monumento excepcional* [...], *una verdadera escultura y no un edificio*]. Laura Chaparro, "Le Corbusier, arquitectura geométrica a la medida humana" (27 August 2018), *OpenMind BBVA*, https://www.bbvaopenmind.com/ciencia/grandes-personajes/le-corbusier-arquitectura-geometrica-a-la-medida-humana/

8 Anton Pevsner, *Developable Surface* (1938–9), Peggy Guggenheim Collection, Venice, https://www.guggenheim-venice.it/en/art/works/superficie-sviluppabile/

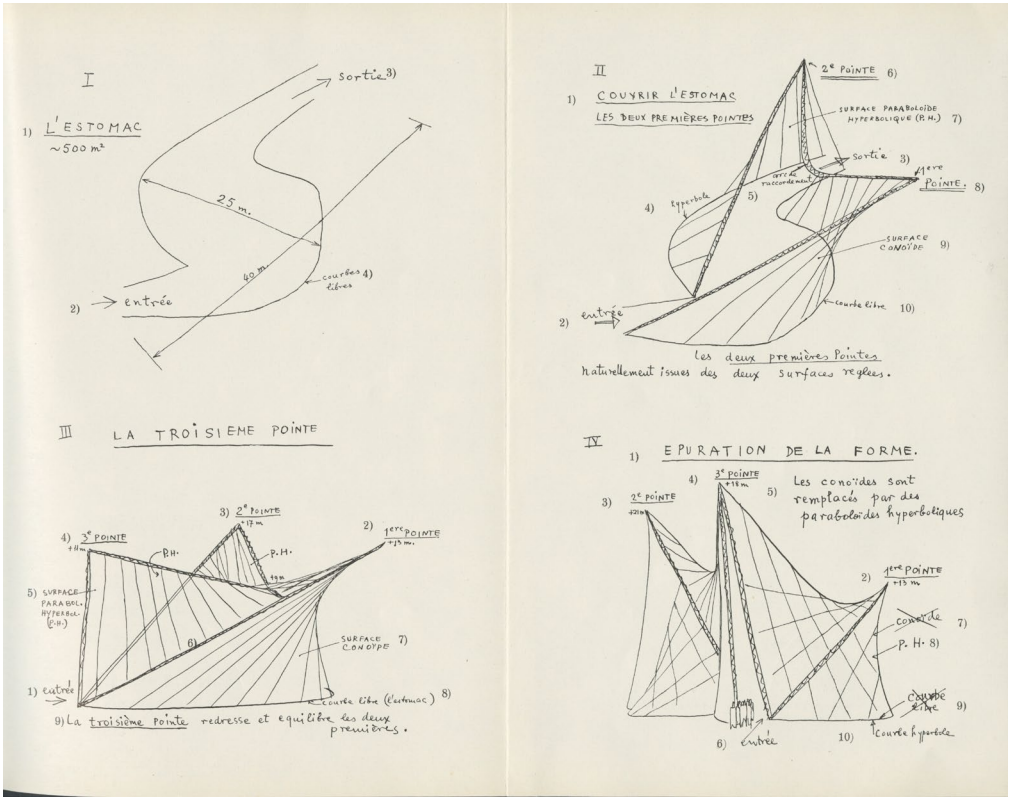

Fig. 28.1 Xenakis, the genesis of the Philips Pavilion, in four steps: from 1) stomach [*l'estomac*] to 2) covering the stomach [*couvrir l'estomac*] to 3) creating the third point to 4) refinement of the shape [*epuration de la forme*]; in *Gravesaner Blätter*, vol. 9 (July 1957), p. 25–6. Reproduced courtesy of Akademie der Künste, Berlin.

The Philips project was initiated between the Dutch firm and Le Corbusier in February 1956 and Xenakis's first sketches for it date from October of the same year.[9] Xenakis's designs though clearly echo his musical preoccupations when creating his breakout orchestral work *Metastasis* (1953–4): at the beginning, a unison followed by a set of straight lines—individual *glissandi* on all strings from the violin's low G—dispersing into a wide chord; at the close, another wide chord receding toward a point of unison one half-step higher than the initial pitch, low G#. Xenakis confirms this impression several years later:

> In the Philips Pavilion I realized the basic ideas of *Metastaseis*: [sic] as in the music, here too I was interested in the question of whether it is possible to get from one point to another without breaking the continuity. In *Metastaseis* this problem led to glissandos, while in the pavilion it resulted in the hyperbolic parabola shapes.[10]

Furthermore, according to other sources,

9 Xenakis, 2008, p. 93–94.
10 Varga, p. 24.

> From these first nearly-literal translations from music to architecture (Xenakis confessed to the conductor Charles Bornstein in an unpublished late interview that he felt as though he were "watching the sounds [of *Metastasis*] emerge from the ground" during the Pavilion's construction—literally erecting a music to be seen!) [...][11]

Despite that novelty, the extended middle part affirms the classical A-B-A form and the serial style, acknowledging the influence of Arnold Schönberg (1874–1951): two facts that merit further discussion.

In 1967, in a lecture by Xenakis at the Schola Cantorum in Paris, after listening to *Metastasis*, I intervened to present my perceptions: the woodblock beats reflecting the golden section during the unfolding of the initial *glissandi*; at the mid-point the dodecaphonic content; and the final *glissandi* in the opposite direction. Xenakis's arguments about the series, even if I quoted him the crab[12] and mirror[13] projections, were curious: "pure coincidence" he said. Twenty-five years later, the musicologist Radu Stan (1928–2021), then in charge of the composer's archives, confirmed my perception of the obvious, showing me the notebook with the notes of this series; however, this was the identity of the twenty-four transformations of the finite group theory, where the symmetries resulting from rotation and translation expand the traditional musical algebra (d-b-q-p): a new horizon for serialism! Why cover it up?[14]

1. The relatively recent publication by Anne-Sylvie Barthel-Calvet confirms my perceptions in 1967, except for one detail that had escaped me then: that of the "differential durations." As Barthel-Calvet states in her abstract, "Starting from a critique of serialism, Xenakis analyzes some aspects of *Metastasis*: the *glissandi*, the serial transformations, the differential durations, the golden section."[15]
2. Associating the massive continuum of strings to serialism and finite groups would have given a new boost to dodecaphony, as well as to Pierre Boulez (1925–2016) and Karlheinz Stockhausen (1928–2007), who had both also studied with Messiaen. The option adopted by Xenakis was to not divulge his finding, but on the contrary, to criticize serialism, strategically, the same year as the premiere of *Metastasis*.[16]
3. The secrecy with which Xenakis surrounded his advanced serialism seems to be, at least partially, a question of ego. Why adopt the same path as others if he had inaugurated the sonorous continuum, something that set

11 Kanach and Lovelace, 2010, p. 114.
12 See "Crab Canon" (3 May 2024), *Wikipedia*, https://en.wikipedia.org/wiki/Crab_canon
13 See "Mirror Canon" (3 May 2024), *Wikipedia*, https://en.wikipedia.org/wiki/Mirror_canon
14 See Barthel-Calvet, 2003, p. 162. It seems as though, also according to the same author, but elsewhere (Barthel-Calvet, 2012, p. 83) that this text originally appears in Xenakis's "Carnet 13," which spans from 26 December 1953–22 July 1954.
15 Barthel-Calvet, 2003, p. 187.
16 Xenakis, 1955.

him apart from the post-war musical world and turned him into a solitary creator, linked to mathematics and, very soon afterwards, to the computer through his exploration of the IBM 7090 at Place Vendôme in Paris. This silence both separated and distinguished him from the serialists.

4. Finally, the significant freedom to claim a "pure coincidence" with respect to the series does not prevent it from being heard in *Metastasis*, so that while in public he hides the dodecaphonic content, in private he embraces it, symbolically, with two wings in *glissandi*, one at the opening and the other at the end of the piece. This is Xenakis's duality: he encloses his own past and he embraces it within those *glissandi*.

Entrance to Music through Architecture?

While the origin of the Philips Pavilion clearly reflects Xenakis's authorship over Le Corbusier's, the musical work *Metastasis*—the last part of the triptych *Anastenaria* (1952–4)—whose first two parts were not premiered until 2000—has no link to any antecedent that reveals its musical origin. However, it was born by transferring the architectural projection of hyperbolic paraboloids into music by means of *glissandi*: the union of two pitches by means of continuous sliding of the finger on the string—used by Béla Bartók (1881–1945) in his string quartets (1909–39). It is a resource that Xenakis generalized and amplified, producing curves, or ruled surfaces, in sound: the union of several pitches through a sequence of *glissandi*. Transitioning from their architectural calculation to their auditory projection marks the audacious discovery that reaffirms a long-standing determination to be a musician and, moreover, an original one.

With Greek rhythm, the integration of noise, and *glissandi*, Xenakis resolved to turn the dense anarchy of the *Dekemvriana* into orchestral music: *Pithoprakta* (1955–6), whose nucleus recalls the shouting of slogans in the front row reappearing successively in the back rows, with students shouting and clapping. The most suitable formula to represent this evolution is the chronographic register, a method created by Joseph Schillinger (1895–1943), to compose and visually project music—horizontal axis: time; vertical axis: pitch, and to which Varèse also resorted to register the pitch and intensity of his *Poème électronique* (1957–8) for the Pavilion.[17]

Pithoprakta's "noisery" is visualized with the well-known dense web of gliding pitches, movement that seems to lead the masses through streets and squares if one follows the chronographic account: a group advances from left to right, scattering treble

17 An example of this method also appears in *New York Skyline Melody*, piano (1939), by Heitor Villa-Lobos (1887–1959), who assigns melodic pitches on millimeter paper following the silhouette of the city's buildings. See Francesc Serracanta, "Villa-Lobos," *Historia de la Sinfonia*, https://www.historiadelasinfonia.es/historia-2/siglo-xx/villa-lobos/. For a few images of Varèse's sketches for Le Poème électronique, see "Poème Électronique" (18 March 2020), *Wikidelia*, https://wikidelia.net/wiki/Po%C3%A8me_El%C3%A9ctronique

above, and bass below, with a gap in the center separating the two masses.[18] The title in Greek refers to "random actions," an evocation of the stochastic method—conjecture or directed probability, or "directed disorder," a formula that the composer associated with the idea of *mass*, as a filling of the space occupied by the collective movement of the manifestation, partially expressed as a sequence of pitches that slide in zigzag pattern.[19] Nothing needs to be precise but only to adopt the relative direction that leads to chaos; now, if direction and chaos are contradictory, what is interesting about the method is the representation of the rectilinear advance of a tangle. In contrast to the composer's own, almost exclusively mathematical explanation of his music, the public's understanding of probability could benefit from a more accessible analogy: the subjective noise he perceives is akin to that of a hornet's nest, and the visualization of noise is achieved through massive *glissandi*. These concepts are akin to the rigid, resistant reinforcement tensors, or rammed textures, born from his architectural creativity.[20]

The architectural tool applied by Xenakis when designing the music allows him to reveal the sound continuum. However, as far as the musical tool is concerned, the ear can hardly understand this unexplored territory, foreign to the music-theoretical knowledge of the time and complex even for the most experienced listeners. Hence, even when perception is based on visual-auditory synesthesia, the composer's ability to hear everything he draws must be rare, if it is understood that there is no previous sound memory or a method to distinguish how not four, but dozens, of fixed or sliding voices sound in continuous movement:

1. The ear, since it is impossible for it to be autonomous, requires the support of what it sees; that is to say, that which it must imagine in audiovisual mode.
2. The precision of the result therefore depends on the audiovisual imagination, a unique alliance allowing the approach of musical design from architectural design.
3. The impossibility of hearing such massive density in movement, its nourished macro- and micro-variations of pitch, as incalculable at the individual level as its micro-relationships at the global level, lead the method to admit the audible as "non-signifying."
4. The audible "non-significance" in a spatio-temporal evolution, by becoming part of the compositional resource, in turn opens the door to stochastics, an aleatory technique that participates in the creative production.
5. The audiovisual-stochastic link becomes the binomial of the method, whose creative object is derived from an architectural understanding, with

18 See, in particular, this short excerpt in Ariel González Losada, "Iannis Xenakis—Pithoprakta—(C.52–60)" (29 December 2012), *YouTube*, https://www.youtube.com/watch?v=RC3XCfDBIK8

19 The origin of the method comes from Xenakis's contemporaneous architectural design of the contiguity between the glass panes of the La Tourette convent (1954–60), also realized in Le Corbusier's studio, by permutations of the Fibonacci series. See also Xenakis, 2008, Chapters 1.14–1.20 for more information on La Tourette.

20 See Wannamaker, 2012.

the idea of the "texture" of the mass.

6. The impossibility of auditory perception, a priori or a posteriori, demands a figuration, to be obtained through the calculation of a potential set of variables: register of pitches, articulations, densities, durations, intensities, directions, or others.
7. The compositional system thus confects a combination of visual design and statistical calculation as the basis of an artistic adventure in order to confront, only afterwards, the music that is seen or deduced without being perceived by the ear.
8. The compositional strategy, by not relying on listening beforehand, requires the figuration of a material that works as a sample ("clouds" of *pizzicatti, glissandi*, or other things); a statistical visualization that composer and listener are going to experience simultaneously throughout the work.
9. The creation of such music leads to a fuzzy and therefore imperceptible territory, where not listening but visualizing listening implies that that territory will not be fully experienced, and that the artistic result depends both on architectural design and on mathematical virtuosity.
10. In the compositional method of the musical-architectural—a product of auditory-visual synesthesia and stochastic calculation—the individual non-significance within the massive movement is ultimately perceived as the evolution of a discontinuous matter: isolated sounds and intervals; or of a continuum: *glissandi*.

The Pythagorean Wall

Inserting oneself in music is, for Xenakis, a complex equation that requires him to explain his aesthetics, the link between the musical-architectural, and his theoretical search allied to mathematical tools—as he does in *Musiques formelles* (1963) and its later versions—as immersion in an unprecedented territory that marks the first stage of his work and the consequent recognition of an enigmatic figure; i.e., that of a composer-mathematician.[21] After years of experimental and artistic essays that apply mathematical language to a relatively different music, he continues to challenge the notion of music as language, emphasizing the specificity of communication. This underscores his departure from tradition and his adherence to a musical creation through analogy, devoid of any previous language, a theme developed by Pablo Araya.[22] When commenting on his *Diatope* (1978), Xenakis went so far as to state:

> Music is not a language. Every musical piece is like a complex rock formed with ridges and designs engraved within and without, that can be interpreted in a thousand

21 Xenakis, 1963.
22 See Chapter 11 in this volume.

> different ways without a single one being the best or the most true. By virtue of this multiple exegesis, music inspires all sorts of fantastic imaginings, like a crystal catalyst. I, myself, wanted to deal with the abysses that surround us and among which we live. The most formidable are those of our own destiny, of life and death, of visible and invisible universes. The signs that convey these abysses to us are made up of lights and sounds that provoke our two predominate senses.[23]

Music and language ask to identify the idea of composition in general, as a product from the a priori of the system. In contrast, the idea of musical creation locates the system a posteriori insofar as it demands the investigation of new theoretical, technical, and methodological tools. If, in the case of Ludwig van Beethoven (1770–1827), deafness prompted a solitary exploration that infused his music with a display of strength, airs of a military nature, and unprecedented structural innovations, in Xenakis's case, his visual and auditory ailments appear to inspire two distinct responses: on the one hand, a commitment to sound realism in music, where the intuitive can express its claim to the real, and, on the other hand, a self-identification as a musician-mathematician. This positions him at a unique juncture, between the perceptual [of reality] and the analytical [through mathematics] and, therefore, halfway between the compositional and the creative.

The designation musician-mathematician places Xenakis behind a Pythagorean wall or a veil, thus isolating the still-unprepared listener, especially when in an acousmatic situation.[24] If the intuitive and the experiential are perceived in Xenakis, the priority he gives to his theoretical-constructive rationalism serves to keep the spectator at an intellectual distance. Thus, in order to achieve the creative autonomy of a music tailored to his own capacities and needs, he deploys a kind of prosthesis that reinforces his perception of the artistic world with methods whose mathematical language replace music as language. This represents a decades-long intellectual armor Xenakis wore to advance in the competition towards the future of twentieth-century music, also aligned with an idea that was then in vogue, *art-science*. The arts do not operate with truths and, if they are or were languages for some, those truths that are more proper to them come from a perceptive experience rather than from the merely rational. Art and perception are assembled in a unity whose difficult rupture is greater than the ease of allying with mathematical language, beautiful for some, even if its territory is not aesthetics (a sophisticated and useless accessory with which to appreciate, prove, or demonstrate the richness of the link).[25] The mathematics-music binomial, of proven usefulness for the theoretical Xenakis, formulating novel notions or methods for music, i.e., the modular formation of scales, does not extend to the optimization of the perceptive quality of the artistic result. Assimilating probabilistic procedures or complex mathematical approaches with the ear, even with an explanation of the method and the objective, does not ensure the path to music

23 Xenakis, 2008, p. 261.
24 See Kane, 2014.
25 Using mathematics as a basis for music is difficult to achieve if it doesn't involve the perception of a creative ear.

but leads back to the aforementioned idea of "mathematical beauty," an enthrallment whose experience is difficult and artistically uncertain for musicians and audiences alike who, even if they are conservative, still resort to listening in order to appreciate the result in the field of art.[26]

In the 1950s and 1960s, several works with impersonal titles recall the stochastic method: *ST/4* or *ST/48* (1956–62), whose sequential or vertical connections, lacking any auditory reference, are still theoretical and unpredictable. Although the non-significant within massive stochastic processes produces a macro-spectrum that seems to work at times in *Pithoprakta*, the experience with small masses is less effective for the ear to deal with in detail, particularly when faced with a subject whose compositional process does not give priority to listening. Therefore, by not sharing with how others are hearing the experience of each result, perception is in the waiting: it observes at a distance and in the long term, including then memory; that is, it assumes or predicts what comes next. This is how our connection with music tends to work when we try to listen to the application of game theory to music through probabilistic decisions that govern the competition between two groups, as in *Duel* (1959) or *Stratégie* (1962), both for two orchestras, or *Linaia-Agon* (1972), for brass trio. Such "games" were part of the composer's artistic purpose, and the scores required the musicians to solve the matrices; therefore, the approach was threefold: musical, dramatic, and mathematical. Prior to the more recent recordings,[27] during the live performances I experienced, I expected meaningful responses—such as hearing more or less rhythmic or sonic energy in each response, or hearing a response to the "duel," or a sequence of events equivalent to a "strategy"—and when I did not get them, I became disappointed. Listening to such material is challenging because it does not necessarily allow one to appreciate the qualities of contrast between groups or individuals, nor the dramatic sense of knowing what an outcome could have. Such works tend to be valued more for their theoretical enunciation than for their artistic value. Neither non-mathematical musicians nor non-musical listeners need to listen to music with the express intention of verifying its theoretical or scientific propositions, but only to experience the nature of its evolution, where explanations are superfluous. Music cannot be explained but, if described, it is in terms of perception: observing with the ear, appreciating and judging its beauty in terms of the result. Even if music is based on mathematics, is exquisite in its structure, and may resemble it in its abstraction and its need to calculate the result, the processing of one and the other asks for different mental dispositions: mathematics requires affirmation and verification, while music, whether to be created

26 This discussion recalls Xenakis's short text from 1994, "Beautiful or Ugly": "[…] Personally, whenever I find something 'beautiful,' I replace the term by 'interesting.' In this case, interesting means 'that which lures,' without any allusions to 'beauty' which, in my opinion, is an adjective that is too naïve, superficial, on the surface of human reactions. […] Moreover, when I say 'interesting,' I can add degrees such as 'very,' 'barely,' 'slightly,' without ever negating its primary quality […]". (Xenakis, 2008, p. 130).

27 In particular, of *Linaia-Agon*, "Xenakis Edition 14-Linaia-Agon," *Mode Records*, https://moderecords.com/catalog/284-xenakis/

or to be heard, requires understanding through perception.

Observed at a great distance, the evolution of Xenakis's compositional and creative systems retains its intimate identification with the non-significance of "stochasticity," which is compensated by its marked affiliation to temporal drawing: a factor that facilitates the understanding of his intuitive contributions of plasticity to his design of musical space, as the images put forth by Xenakis in *Formalized Music* show.[28]

In each of these twenty squares there is an image made of straight lines with the same massive tendency, in which the order, be it unidirectional, bidirectional, dispersive, convergent, or rather curved, spiral, or in semicircle and, as it appears in the second ten, formed by points with an identical tendency (tendency here being equivalent to architectural texture)—giving a way of filling a surface with finishes, coatings, reliefs, or other forms typical of the plastic method. This refers first to the "point and line" of Vassily Kandinsky's (1866–1944) plastic science,[29] and second, to Walter Gropius's (1883–1969) proposal[30]—uniting the visual arts within architecture—to which Xenakis responded three decades later by amplifying the original spectrum of the Bauhaus with the insertion of his discovery: music *as* architecture.

The graphic formula, as a method of conducting constructive creativity, already expressed in dense lattices of curvatures or massive zigzagging, integrates the musical imagination with a visual imagination: hearing by reading what is seen. Such a contribution amplifies the process of listening and allows the musician to dispense with the mathematical; for the latter, something that may be inaccessible or "non-signifying." The synesthesia between vision and listening guides the deaf, at the same time as it describes by ear-sight when it guides the blind. What used to be a melody-harmony of columns supporting chords—in turn the struts of the melodic drawing—becomes an *auditory wall*: smooth, fluid, curved, and orderly in *Metastasis*, or irregular, granular, and disorderly in *Pithoprakta*; an appropriate denomination for the architectural model where a moving mass reveals flights of the imaginary, or where a wall narrates its fractures. If the idea of an image with a certain temporality is found in oriental painting, in front of which the spectator moves from side to side to appreciate a story unfolding in space, an auditory wall places the musical spectator in front of a question, entreating to imagine the visual equivalence of what is heard.[31] The new in art tends to be born of necessity, and Xenakis's sensorial identification with the chronographic register of music opens the way to a perceptual requirement—a reason that may have led him gradually to abandon experimentation and to refine the musical utility of the mathematics he employed—allowing him to interpret, from a consolidation of his audiovisual creative nature, his own personal loss.

28 Xenakis, 1992, p. 214.
29 Kandinsky, 1979.
30 See *Bauhaus Manifesto*, https://bauhausmanifesto.com/
31 Guillermo Pabillon, *Philips Pavilion Under Construction* (17 January 2017), https://es.wikiarquitectura.com/pabellon_philips_ilistr_period/

214 Formalized Music

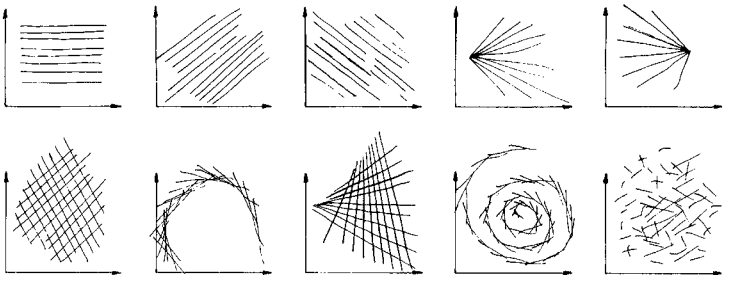

Fig. VIII–4

Let us now suppose the inverse, forms constructed by means of discontinuity, by sound-points; for example, string pizzicati. Our previous remarks about continuity can be transferred to this case (see Fig. VIII–5). Points 1.–7. are identical, so very broad is the abstraction. Besides, a mixture of discontinuity and continuity gives us a new dimension.

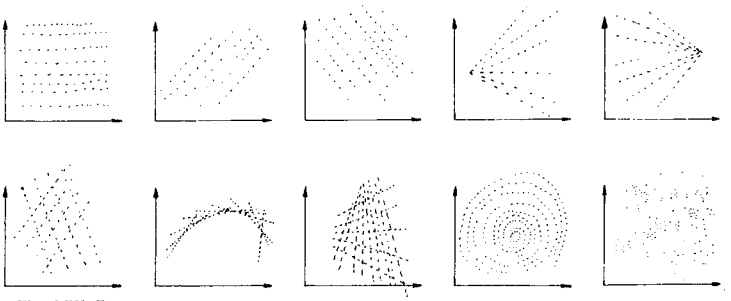

Fig. VIII–5

Fig. 28.2 Xenakis, 1992, p. 214. © Pendragon Press, reproduced by permission.

An important aspect of the music-architecture link lies in the openness to the physical space of representation, an element that denotes an intuitive and calculated choice of various spaces in works such as *Persephassa* (1969), for six percussionists, *Terretektorh* (1965–6), for orchestra, or the *Polytopes*.[32] In all of them, the spectator's ear is placed before a heterogeneous matter that gives it the idea of movement. Terretektorh[33] illustrates the link between Xenakian creativity and his unique perception of space: the musicians occupy fixed places in a wide circle, a sphere that explores two-

32 Xenakis, 2008, Part 4, p. 198–277.

33 Iannis Xenakis, "Study for Terretektorh (Distribution of Musicians)" (1965), *Lines & Marks*, https://linesandmarks.com/iannis-xenakis-observations/iannis-xenakis-study-for-terretektorh-2/

dimensionality. The conductor, in the center, indicates the path taken by the music, expressed through heterogeneous sonorities that advance, disperse, or come together, where the function of the texture approaches the combination between two main elements, time and space, the sequential and the vertical, in a serpentine movement whose head and tail give kinetic density to the work's spatial evolution.

Concrete Analogy

The notion of *analogy* in music is ancient—like the *crescendo* in Claudio Monteverdi (1567–1643) to evoke spatial proximity or, as in Antonio Vivaldi (1678–1741), to allude to nature. This notion resurfaces emphatically in the post-war period with an accident close to junk art: the technologies of the phonograph and of magnetic tape discover the "broken record," as Pierre Henry (1927–2017) and Pierre Schaeffer (1910–95) observed when faced with a simple matter, a *sound object* whose potential requires inventing alternative uses of the machine to generate *musique concrète*.[34] In the 1960s, Xenakis resorted to the flaw of that analogy which, without going through the sieve of musical writing, facilitates immediate access for the adoption, production, and transformation of audible matter. He therefore joined the musical research group created by Schaeffer at the National French Radio, GRM (Groupe de Recherches Musicales) to produce, amongst others, *Bohor* (1962), a work that refers to the experience of listening as being inside the sound (or from "under a bell") itself; perhaps the noise he had then already perceived for nearly twenty years.[35] In 1980, after that dramatic experience, he told Bálint András Varga (1941–2019):

> There is something else I have to tell you. I think I've become the way I am because of my wound. First my hearing was damaged because the explosion occurred directly by me. The massive sound volume irreparably damaged my inner ear: I can't hear high pitches as well as I used to and there's a constant noise—even now.[36]

Rebecca Kim reports that in his sketches, Xenakis identifies "four sound sources used to create Bohor […]: a Laotian mouth organ, prepared piano, Iraqi and Hindu jewelry, and Byzantine chant."[37]

I remember hearing *Bohor* in an old theater in Paris with the composer in control of the volume, always at the maximum amplitude, characteristic of his hearing, as if that energy—a subject developed by Mauricio García de la Torre—communicated the need to envelop oneself in noise together with the ear of the other.[38] The chronographic

34 "La naissance de la musique concrète et électro-acoustique", *INA* (Institut National Audiovisuel de France), https://fresques.ina.fr/artsonores/fiche-media/InaGrm00208/la-naissance-de-la-musique-concrete-et-electro-acoustique.html

35 "Iannis Xenakis's Bohor (1962)", *Columbia University*, http://sites.music.columbia.edu/masterpieces/notes/xenakis/notes.html; "Iannis Xenakis – *Bohor*" (23 December 2018), *YouTube*, https://www.youtube.com/watch?v=DODVNHukY0I

36 Varga, 1996, p. 48.

37 Rebecca Kim, "Iannis Xenakis's Bohor (1962)," *Columbia University*, http://sites.music.columbia.edu/masterpieces/notes/xenakis/notes.html

38 See Chapter 7 in this volume.

recording method of the work indicates the mixing of the sound sources based on the dynamic variation in each one, which illustrates a tendency to accumulate and distort the original sounds, in search of a blurred and indecipherable matter. The instruments used in the recording of *Bohor* seem to come from a free selection of the sources, in contrast with written music; the materials are sometimes heard in their original form and sometimes slowed down or compressed and then reassembled. That gradual advance towards chaos is cut short by a final tear that personifies evolution, from the beautiful to the brutal, and tells the ear how the invocation of precious resonances leads to impurity, a rude sign of auditory identification with broken matter.[39]

Seeing is Hearing

After years of working on handmade conversions of his drawings to the composition of instrumental and vocal music, Xenakis, as the head of the Center for the Study of the Mathematical and the Automatic in Music (CEMAMu), assumed for decades the need to conceive, produce, and optimize a computerized equipment for the production of electronic music through drawing. This was the UPIC (Unité Polyagogique Informatique du CEMAMu), his most characteristic contribution to technology as well as a new tool for music research and immediate experimentation.[40] The UPIC, being accessible to the non-expert, lets me highlight here the enriching experience I had in 1981 with a group of people with visual impairments in Bordeaux (Figure 28.3) whose drawings on the machine made them listen to the invisible, from hearing geographical contours such as the courses of rivers, or the borders between countries or between sea and land, etc., allowing them to display a powerful freedom to imagine their own space.

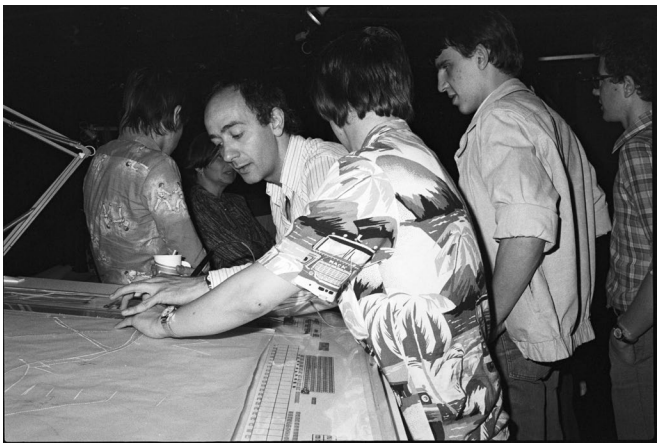

Fig. 28.3 UPIC Open House, Forum des Halles, Paris, 1981: Julio Estrada leading a composition workshop with a group of visually impaired youths. Photo by Bruno Rastoin (1978), courtesy of CIX Archives, Rastoin collection.

39 Rebecca Kim, "Iannis Xenakis's Bohor (1962) [Sketch]," *Columbia University*, http://sites.music.columbia.edu/masterpieces/notes/xenakis/sketchBig.jpg

40 Different authors have tackled the subject of said system; I direct the reader to a recent anthology of texts on the subject: Weibel et. al, 2020.

Mycènes Alpha (1978) is the first musical realization produced with UPIC:

> My first contact with Mycenae took place during a school excursion when I was fourteen. In front of the beauty of the site, of the Cyclopean ruins and the strange tombs, I experienced vast and implacable impressions. What I saw looked familiar, but also extraordinary, as if it belonged to another world. I buried this memory very deeply. Then, forty years later, as soon as I was free to return to Greece, the first thing I did was to visit, now as pilgrim, this same place, driven by what I instinctively felt was necessary and primordial.[41]

The description illustrates the idea of a polytope—multiple spaces, equally referring to a 3D spatiality—to take place at the archaeological site. In Xenakis's *Polytope de Mycènes*, human processions carried torches on a mountain and groups of animals adorned with bells roamed in formation. Earlier musical works were performed live, by an orchestra, choruses, percussion, between which "interpolations" (or "interludes") of individual pages of his (and the first) UPIC score, *Mycènes Alpha* were blasted through a PA system.[42]

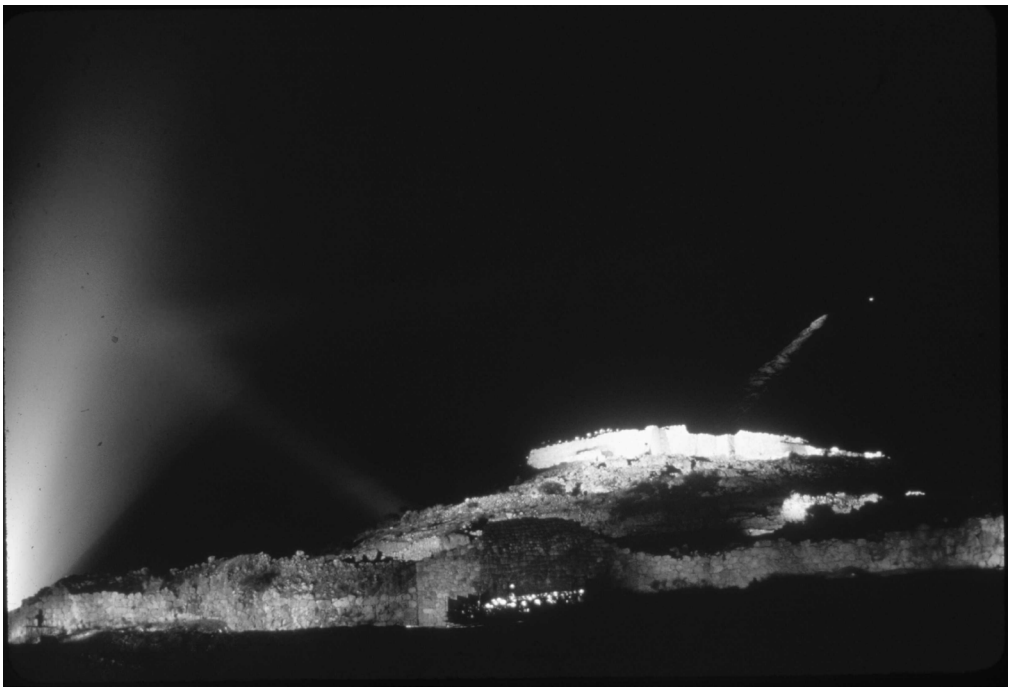

Fig. 28.4 Performance in Mycenae (Greece) of *Polytope de Mycènes*. Still of the ruins of the acropolis and the *Polytope*'s light show. Orchestra lit from below (1978). Photographer unknown, courtesy of CIX Archives.

41 Xenakis, 2008, p. 239.
42 Xenakis, 2008, p. 241–3.

The drawings of *Mycènes Alpha*, whose images, between the abstract and the figurative, and with greater spontaneity than those previously designed to be turned into instrumental and vocal works, provide a new reference for further reflection on the visual as access to the aural in Xenakis.[43] Indeed, often, when *Mycènes Alpha* is presented in concert version, these hand-drawn UPIC pages are projected on a screen as illustration for listening. For the most part, the imagery of the work tends towards a curved design that lends itself to a free interpretation of the content: clouds, tangles, zoomorphisms; a mode open to vision in order to recognize oneself through listening, in turn a modern, cognitive pedagogy that expands seeing and hearing. Meanwhile, other images of an abstract order explore superimpositions of horizontals that refer both to the stillness of the massive chords of *Metastasis* and to forms of superimposing electronic timbres, an aspect close to the mixture of the auditory wall. Among the pages of *Mycènes Alpha*, one in particular stands out: the combination of superimposed straight lines with the free figurative profile, the formula at the origin of a couple of elements: on the left of the page a helmeted character holding a weapon and pointing, in the sense of writing, to the figure next to him, whose smaller size and fragile stroke is perhaps perceived as a specter; at the bottom right, only four traces remain. Listen and see, in particular, between 7′20″–8′38″ of *Mycènes Alpha*.[44]

Xenakis described the *Polytope de Mycènes* (1978) as "a feast of light, movement and music."[45] *Mycènes Alpha* represents, beyond the exploration of an innovative technology, the freest immersion in the visual and auditory world created by the composer, whose figurative symbols of war allude both to the Athenian past and to his return to Greece in 1978 after the 1974 amnesty and more than a quarter of a century of exile.

In an interview in 1997, Xenakis put forward a discourse in which he seems to combat his former image by retracting the demand he imposed on himself, as if at the end of his career he was recalling his permanent aspiration to be free, something he only allows himself to declare when he recognizes the end:

> My music rests on movements of the soul, sometimes incoherent movements, but there is no theory. I am governed only by intuition, objectivity, and subjectivity. Everything. I am completely incapable of predicting what may happen in the compositional act.[46]

43 It is interesting to note that Éditions Salabert's catalogue of Xenakis's work (*Iannis Xenakis 1922–2001* (2002), Paris, Durand-Salabert-Eschig) specifies, under *Mycènes Alpha*: "Rental may include a set of slides to be projected during the tape performance."

44 Dodecatone, "Iannis Xenakis, *Mycenae Alpha* (Score-Video)" (25 June 2022), *YouTube*, https://www.youtube.com/watch?v=gl-g9Em6Eow

45 Xenakis, 2008, p. 254.

46 Bruno Serrou, "Iannis Xenakis: 'He buscado toda mi vida'" (29 May 2022), *Scherzo*, https://scherzo.es/iannis-xenakis-he-buscado-toda-mi-vida/

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29. Iannis Xenakis, Inventor of Music—Composer, Engineer, and Architect: The Voice of the "Inexpressible" and of "Revelation"

Cândido Lima

It is not as a musicologist, architect, historian, mathematician, engineer, physicist, or researcher that I write this text but as a composer and witness over several musical decades to one of the greatest creators in the history of music, Iannis Xenakis. I heard Olivier Messiaen (1908–92) on a radio program in France define Xenakis as "philosopher, mathematician, logician, poet, and musician not like the others." Many years ago, I proposed an inversion of that assertion: "poet and musician, philosopher, mathematician and logician, different from the others." In fact, Xenakis characterized what was beyond mathematics as "art," "music," "inexpressible," and "revelation." The composer often succinctly replied to those who labeled him a mathematician: "I am not a mathematician. I don't invent theorems!"[1]

Itinerary—Discovery—Mathematical Dialogues

I cannot recall the first time I heard Xenakis's music; was it before going to military service, or later, before going to Africa in 1965–66, or was it after coming back from Africa in 1968? I do not remember how or where I first encountered the composer's writings or writings about him. I know however that he was already a myth to me, he who was known as the "mathematician who made music." I was fascinated by his music, and the impression some works had on me (the first being *Nuits* (1968), at the 1968 Gulbenkian Festival in Lisbon, perhaps...), coupled with the subjects I was studying at the time at the Philosophy Faculty in Braga, Portugal. Those impressions created a bridge on which I still stand.

1 [*Je ne suis pas mathématicien! Je ne fais pas de théorèmes* !].

 https://doi.org/10.11647/OBP.0390.31

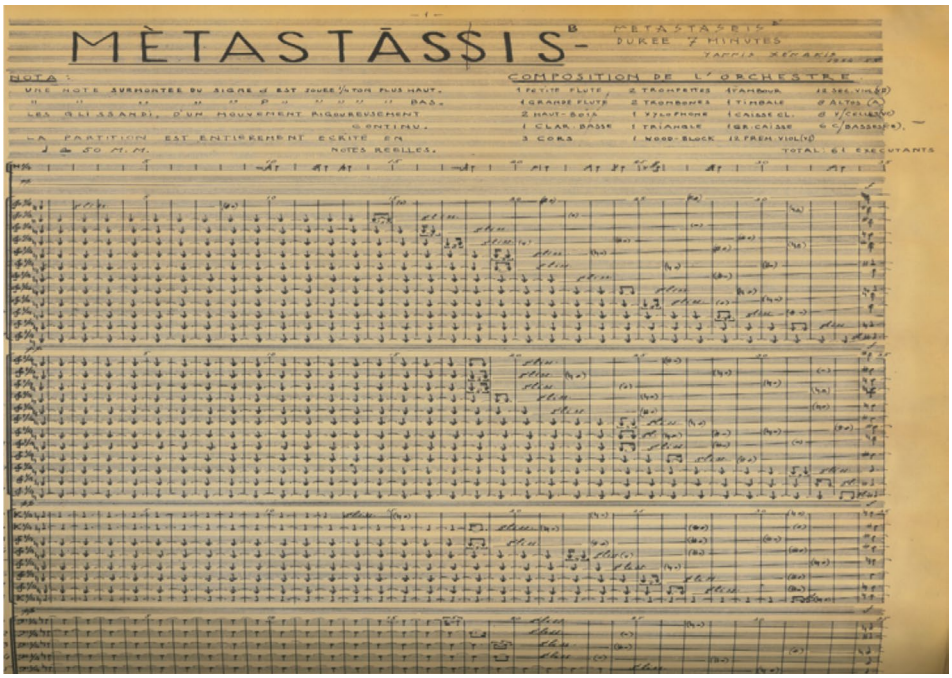
I acquired three books by composers around that time, found abandoned on bookshelves in the city library of Porto: *Musique, Discipline Scientifique* (1968) by Pierre Barbaud (1911–90), *Musiques Formelles* (1963) by Xenakis, and *Penser la Musique Aujourd'hui* (1963) by Pierre Boulez (1925–2016). These readings gave rise to dialogues with several members of Braga's illustrious faculty.[2] Further readings and study of subjects and authors that Xenakis cites in his two books *Musiques Formelles* and *Musique. Architecture* (1971) ensued. Around this same time, a year when I was studying molecular genetics, Xenakis wrote a text about his work *Eridanos* (1972) which has renewed relevance today in relation to the Covid pandemic: "[…] The central idea in this piece is the construction of organisms in the image of polynucleotide genetic chains. Here, only a fragment of the desoxyribonucleic acid (DNA) is considered, formed by a five-carbon sugar and a phosphoric acid. The elements H(ydrogen), O(xygen), C(arbon), P(hosporus) are presented by means of fixed sets of intervals which permute."[3] Such statements coincide with the notes I've recently found that I took during my classes at the time and that touch on the scientific world of those who advanced with revolutionary techniques that led to the creation of vaccines to combat the COVID-19 virus.

I lived in parallel worlds that ignored each other: on the one hand, in the tradition of the conservatories and private schools where I had been taught and where my professional and institutional activity was centered, and on the other hand, in solitary study of modern music and its astonishing inventions to which these books bear witness, to this day. What I wanted was to understand the relationship between mathematics and this extraordinary music that by then I already knew a little better, by virtue of the 1970 Darmstadt summer course I attended (thanks to a scholarship from the Gulbenkian Foundation), led by Karlheinz Stockhausen (1928–2007). In the following Darmstadt session, in 1972, Xenakis appeared, and his music left the hundreds of participants petrified. *Nomos Alpha* (1966), performed by cellist Siegfried Palm (1927–2005), with both performer and composer present, received endless applause! In one of our chance hallway encounters, I asked Xenakis which of his works he considered his most important. He paused, hesitated: '*Metastasis* (1953–4)… *Achorripsis* (1956–7) … *Herma* (1960–1)…" He had already composed brilliant works like *Persephassa* (1969), *Oresteia* 1965–6), *Eonta* (1963), far from his research on purely stochastic music (except for *Eonta*). His timid answer focused on philosophical and theoretical criteria and less on subjective criteria of aesthetic valuation; and this remained a constant in his attitude towards art throughout his career. Also, in Darmstadt in 1972, my works *Projecções* (1969–70) and *Paúis/Impressões do Crepúsculo* (*Fernando Pessoa*) (1967) were played, about which Xenakis made some comments, using the expression "very poetic work," terms not very characteristic of his vocabulary. He generally replaced such expressions with "interesting" or "uninteresting," and never called a musical work "beautiful" or "ugly," but measured "the level of the sound's intelligence."[4]

2 Such as the professors Júlio Fragata (1920–85), Vitorino de Sousa Alves (1915–2002), and Luís Archer (1926–2011).

3 Xenakis, 1985, excerpt from Composer's Preface in the score (published in French and English).

4 Cf. Xenakis, 2008, p. 130 (Chapter 2.02 "Beautiful or Ugly").



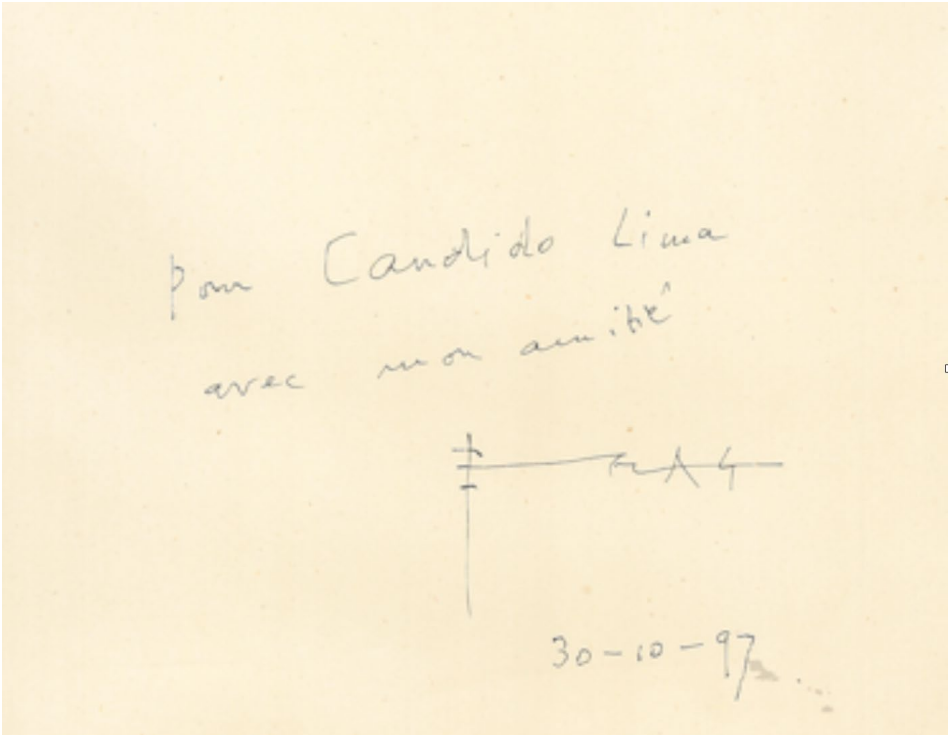


Fig. 29.1 (a) Score of *Metastasis*, in a copy offered to the author in 1997 by Xenakis, with (b) autograph (curious spelling of the title, coming from the composer himself!). Photo by author (2024).

Soon afterwards, in 1973, our paths crossed again at the La Rochelle Festival in France. During one of the rehearsals of this festival (with the conductor Michel Tabachnik), I sat next to him and said calmly: "I've learned you are going to Lisbon, invited by the Gulbenkian Foundation, next June. I'm President of the Musical Youth from Braga, a city just north of Porto. Could you possibly come to meet with the young students? I must tell you though, we have no money!" He replied, "For young people, maybe [...] How much money do you have?" "I don't know." "How about 100 dollars then?"

A few months later, many music students from Braga, Porto, and Coimbra gathered in Cinema Trindade for an unforgettable "Meeting with Xenakis," which the Porto and Braga Delegations of the Portuguese Musical Youth organized. Dr. João de Freitas Branco (1922–89), a musicologist and graduate in Mathematical Sciences, was the ideal travel companion for Xenakis between Lisbon and Porto, and he expressed his enthusiasm at length, in the newspaper article he wrote at the time: "The interlocutor was of good quality. He insisted where he should, and Xenakis went so far as to talk about homomorphism."[5] The proposed theme was: "Current problems in music composition"[6] with excerpts of recordings of works by the composer. Several years later, Xenakis told me about the quality of the participants in the Trindade Cinema, distinguishing them from those from Lisbon, another lecture which occurred a few days later (which I also attended): "I was struck by the seriousness, maturity of thought and responsibility of the students from Porto, Coimbra, Braga. It was a joy!"[7]

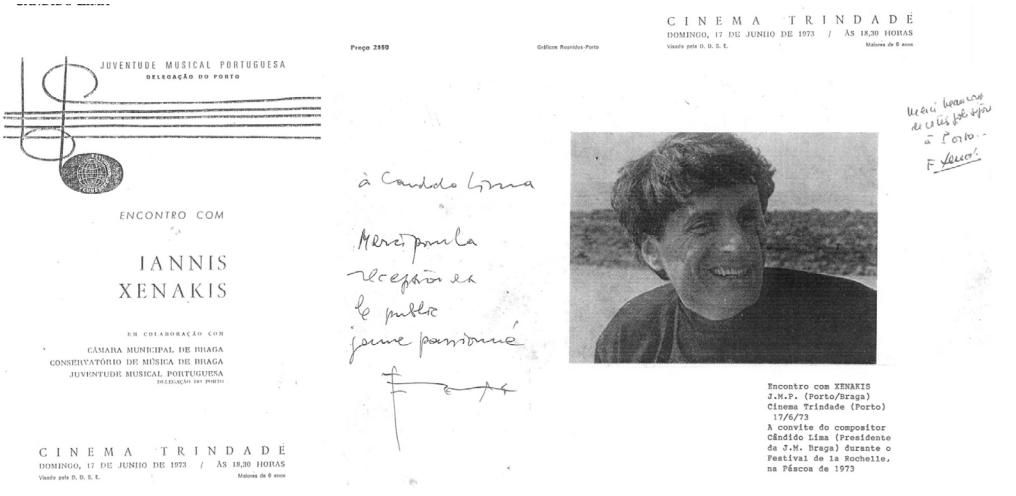


Fig. 29.2 Autographs of Iannis Xenakis and his wife, Françoise Xenakis (1930–2018), during the "Meeting with Xenakis" at Cinema Trindade, in Porto, promoted by Juventude Musical do (Musical Youth of) Braga, of which the author was then President, in collaboration with the Juventude Musical do Porto. Author's private collection.

5 In Branco, 1973 [*Mas o interlocutor era de boa qualidade. Insistiu por onde devia e Xenakis foi ao ponto de falar de homomorfismo*].

6 [*Problèmes actuels de la composition musicale*].

7 [*J'ai été frappé par le sérieux, la maturité de pensée et la responsabilité des étudiants de Porto, Coimbra, Braga. C'était une joie* !].

Later in 1973, I organized an excursion for students, filling two buses, with the support of the Gulbenkian Foundation Music Services, to hear works by Xenakis and the Portuguese premiere (!) of Claudio Monteverdi's (1567–1643) *Orfeo* (1607). This was the first of the school field trips sponsored by the Gulbenkian Contemporary Music Encounters.

It was certainly due to the sympathy that the remarkable Dr. Branco had for the music-mathematics binomial characteristic of Xenakis, that in 1975, as Secretary of State for Culture, he gave the green light to my application for a grant to study with Xenakis in Paris. It was then and there that the true story of my proximity to this great composer began, and that lasted until his passing over twenty-five years later. In our innumerable meetings—that were sometimes brief, sometimes long, over the phone or in his studio in Paris near Pigalle—I got to know more about the man and the composer, his nature and his work, his habits and his music. My study plan included studies in computer science and music informatics, electroacoustics, and ethnomusicology. Xenakis personally oriented me to the Groupe de Recherches Musicales (GRM), and recommended me specifically to Pierre Henry (1927–2017). I also attended mathematics classes on subjects applicable to the arts and music taught by Professor Bernard Girard (b. 1938) (at the Tolbiac Faculty). Girard later confessed in writing that from our dialogues were born not only clarifications for himself, but also the extension of his own mathematical reflections to include creation, devising a new computer course. There we experimented with Fortran (punch cards), anticipating the musical computer system created by Xenakis: UPIC—Unité Polyagogique Informatique du CEMAMu (Centre d'Études de Mathématiques et Automatique Musicale, Xenakis's research lab). Furthermore, I also followed a class on mathematical techniques as applied in the works of Xenakis with Patrick Saint-Jean (b. 1949). But mainly, I attended Xenakis's seminar Formalisation et Axiomatisation de la Composition Musicale et des Arts Visuels (Formalization and Axiomatization of Musical Composition and the Visual Arts) at the Paris 1 Panthéon-Sorbonne University. There, the composer focused his attention on mathematical tools, while, in our personal meetings in his studio, he insisted on not wasting time on the past, on philosophy or mathematics, nor on anything other than music. "Compose! Compose! You must write! Especially chamber music, it's easier to get played. Just make music!"[8]

8 [*Composez ! Composez ! Il faut écrire ! Surtout musique de chambre. C'est plus facile de trouver moyen de la faire jouer. Faites de la musique* !].

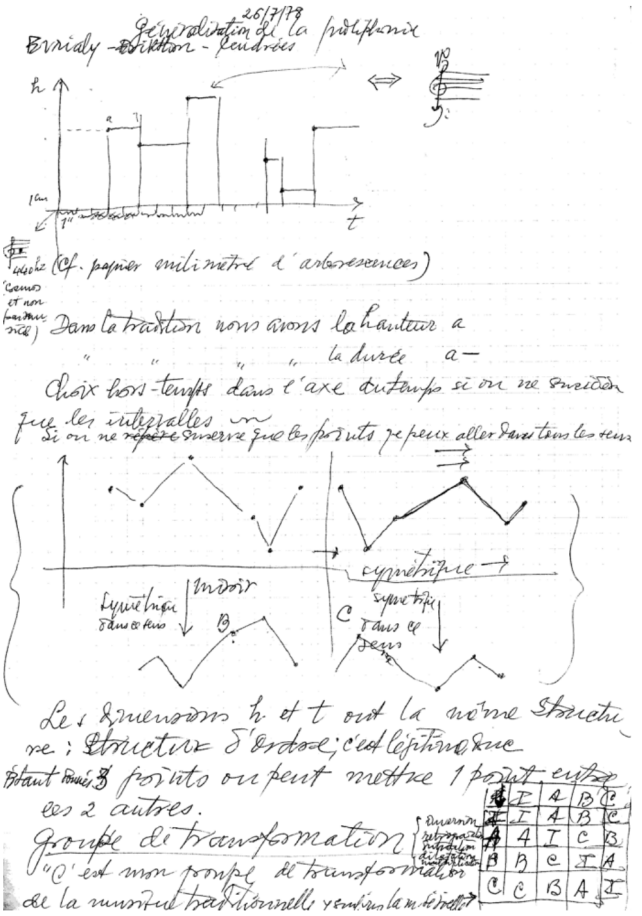


Fig. 29.3 Manuscript by the author, note on arborescences.[9] Seminar by Xenakis at the Paris 1 Panthéon-Sorbonne University, 1978. Author's private collection.

Encounters with Xenakis

From stochastic music to intuitive music, from symbolic music to his great incidental music for the Greek classics, from huge symphonic murals to fulminating works for orchestra with chorus, from unique and unusual melodies to exciting rhythmic sequences, from extraordinary abstractions to hypnotic concrete sound and rhythm, from the purely rational man to an extraordinarily sensitive one, from his guarded solitude to gigantic, electrifying, and inimitable music... I was so fortunate to make a fantastic and affective trip, which was a kind of embrace with the composer, with whom I spoke for the last time in his home in Paris at Rue Chaptal, just a few months before he died.

9 Arborescences are the generalization of polyphony, a technique used in *Evryali* (1973), for piano, *Erikhthon* (1974) for piano and orchestra, *Cendrées* (1973), for choir, countertenor, and orchestra.

Fig. 29.4 Iannis Xenakis with author, at Xenakis's home in Paris, 2000. Photo: Françoise Xenakis. Author's private collection.

The following pages are based on personal documents where his voice and some of his ideas were recorded, some that he transmitted to me for specific occasions, photographs that I took myself in his studio in Paris, manuscripts and notes I compiled by the thousand over the years, and many photocopies of his archives I made with the composer's permission. Many times, his serene and resigned voice went on in conversation as if nothing he did had any importance. The voice for his music disappeared after *O-Mega* (1997) for percussion and ensemble, which he himself declared would be his last.

Demystifying interviews with a composer-inventor of sounds by necessity, a user of mathematics as a contingency, a composer of "rare events," using language from the theory of probabilities, the history of music, and the history of human thought is no easy task. Below is a subjective and personal choice of thirty years of meetings in Paris, Porto, Darmstadt, Lisbon, La Rochelle, Zurich, in direct contact with his voice and the musical manifestations of the theoretical and artistic intuitions of a rare inventor, a revolutionary, a rationalist, and a classical poet of Ancient Greece or of the Renaissance.

Fig. 29.5 During a rehearsal of Xenakis's *Synaphaï* (1969) in 1977. Théâtre de la Ville, Paris. Xenakis, the author, Yves Cayrol, who at the time, was Pierre Boulez's assistant conductor for the Ensemble Intercontemporain. Photo by author (1977).

Two interviews were conducted in Paris at the composer's studio (1984), and another between Porto and Paris (by telephone, at the RDP-Delegação do Norte studios) (1991). The first was published in the short-lived magazine *MÚSICA*, and the second interview addresses questions for the seminar I organized at the French Institute in Porto under the title Créativité et Modernité (Creativity and Modernity). For the purposes of this chapter, excerpts have been chosen to highlight seven specific topics: Creativity, Modernity, Process, Non-European music, Brahms, Defining music, and Portugal.

Creativity

IX: I think that creative capacity, creativity itself, is universal not only among mankind but in all living beings, including plants and even in the subatomic world. No one has thought about the subatomic world yet, it hasn't been demonstrated; but I think it is there also, from the supposed "big bang" until today. [...]

When it comes to music, as in all fields, there is the question of education. The past, with its rules that were discovered, founded, created over generations by music schools and other art schools and are imposed on the following generations...these

inhibit one's creativity. It is necessary, especially from puberty, for individuals to remove themselves as early and as far as possible from these things. [...] That is how one trains creativity. In music it is the same thing; [...] it is difficult for us to be free, not only from the rules of composing pitches, melodies, harmony, structures, movement, but also for listening. Simply listening. But actually, I don't like to listen to music because it informs your thinking. You need to keep your thoughts unformed!

Modernity

IX: There is so much talk today about modernity that it has lost its value. And what does postmodern mean? Nothing more than art that takes a lot from the past. And this means that, on the level of creation, it is very weak.

Process

CL: Is there always a mathematical structure in your work?

IX: I've forgotten the mathematics. I'm much freer now. But mathematics is always in my head; I have probabilities running through my veins! Mathematics and theoretical things allow you to experience things, and once you have experienced them, it becomes a part of your flesh. And then you forget about mathematics and all that because, what counts is how you function, and this is something that the composer must never lose sight of. If he does, he's condemned.

We are but DNA's overcoats and DNA has no individuality, although everyone's DNA is different from other DNAs, but without specificity. You should read Dawkins's *River out of Eden*![10] [...] In art, there are ways of thinking that are close to other parts of human thought. Because every brain is unique, one can do, for example, mathematics with physics, music, painting, even politics: it's always there. Whether it's developed or not depends on the person.

CL: To what extent do operations—rotations, permutations, etc.—enter your music?

IX: It can be done manually, but it's not necessary, because a musician's imagination should exceed any calculations. It's simple as that!

CL: Again, what are the compositional techniques that are present in your music? I just gave a student *Anaktoria* (1969) to analyze. There's no mathematics there?

IX: It's intuitive, that's all!

CL: But what about other technical approaches that have nothing to do with mathematics?

IX: I can't tell you that! I'm not aware of those. But if one day you want, you can find things in these files! (Spreads his arms wide open showing his shelves of personal archives)

10 Dawkins, 1995.

CL: I've been here before, but for looking for other things. I can come back…

IX: If you have time to lose…

CL: To gain, you mean, of course! In every piece isn't there a cell, a pattern, or a gesture…?

IX: There is not a cell, nor a motif; there is a beginning. I start working, and then, little by little, it gets knotted, or it gets untied, it depends. And it goes on like that until the end of the work. For some years now, I have been writing relatively short pieces.

CL: Yes. Do you know why?

IX: Because I don't have any ideas, or I think I've said what I had to say in less time. A piece of music must not be a calculated thing; it must be strong. So, what does strong mean? It has to be intelligent. What does intelligent mean? That it makes a certain impression. I don't think in terms of the impression it can make on the public because I don't know them, and I don't care to know them. But as far as I'm concerned, I do something that makes an impression on *me*. But it doesn't always work! I think I'm making an impression and, in the end, it's nothing. Or on the contrary, I don't think something will make an impression, and it does. See, it's completely free, and completely convoluted!

CL: Does technology, electroacoustics, computer science intervene even in an unconscious way in all this?

IX: Yes, maybe, but not in a conscious way, because I work with instruments in an instrumental way; that is to say, there are no interpolations of electroacoustic thoughts. When I do electroacoustic music, there can be orchestral interpolations, but it's completely underlying. That's what I believe.

CL: Yes, unconsciously, or rather on a subconscious level.

IX: That's right, yes, unconsciously, or even consciously. If you're building a sound, it's the sound that counts. Whereas in the orchestra the sound is given, unless you make combinations of sounds that are not. That's why recently I've been writing double sounds for instruments that are mixed with other double sounds; they are more complicated, and richer.

CL: Does it create masses?

IX: It creates new textures. […] I can't imitate myself; I don't want repeat what I've already done. I need to find something else that's interesting, and that's very difficult to do!

CL: On the musical level or on the outside-time level?

IX: On the musical level, but also mixed with thinking, because no music can be differentiated from the more abstract thought behind it. […]

Fig. 29.6 Performance of *Morsima-Amorsima* (1962), aka *ST74-1,03-07-62*, with the explanation: "Stochastic, first work calculated by the 'electronic brain' 7090 IBM—on July 3, 1962 (1956–62)," performed by the Grupo Música Nova, in the Grand Auditorium of the Gulbenkian Foundation in Lisbon, during the Encontros Gulbenkian de Música Contemporânea, 4 May 1988; Alberto Gaio Lima (violin), Paulo Gaio Lima (cello), Adriano Aguiar (double bass), Francisco Monteiro (piano), Cândido Lima (conductor). Photographer unknown © Gulbenkian Foundation, reproduced with permission.

CL: You have an enormous concern about the connection and cohesion between the abstract and the concrete.

IX: Yes and no. I don't make a separation. [...] Don't forget that for a long time I was an engineer and an architect. As architect, you have to build; and as an engineer, you have to make it buildable. And, you have to make the people who live there happy. So, they are quite parallel.

CL: That's what you did for Le Corbusier (1887–1965), right? Practical things, in order to live well.

IX: For sure, when I worked for Le Corbusier, but also, apart from that, for example, the house I designed for Francis-Bernard Mâche (b. 1935) in Greece,[11] or another house in Borego Springs, not far from San Diego, in California, for the American composer Roger Reynolds (b. 1934) (which has yet to be constructed).[12]

Non-European Music

CL: There was a time when I was convinced that your music came from nothing, had no source, had no origin; that is, it was something literally unheard of. That is true! But as time went by, I discovered little by little the sources or certain

11 See Xenakis, 2008, Chapter 3.03.
12 See Xenakis, 2008, Chapter 3.10.

sources... in particular, African music, because I know a little bit about that because I lived there for several years. Basically, can we say that your music, its force, its energy, its rhythmic pulse, stem from a kind of European observation of extra-European cultures: Togo, Cameroon, etc.? When I hear *Persephassa* or *Nomos Gama* (1967–8), it reminds me the sounds of the big drums of the music from the North of Portugal, very naive music, but the energy is similar. And since I was little, I'm very attracted to this energy.

IX: About the musical flux, I'll tell you something: at the beginning of the 1950s, I was around thirty years old, and I discovered through recordings, first of all, Hindu music because I had a fellow architect friend[13] who had records of music from North India. Japanese music too; I had another friend who lent me records or tapes,[14] and then, when I went to Japan in the early 1960s, I discovered the music of the Noh theater, which is very little known here in Europe, and then Chinese music. So: Indian music, Chinese music, Japanese music. In the music of Java...

CL: Java or Bali, or both?

IX: Both. Javanese music is a little more traditional, like Hindu music, with Indian influences. Balinese music is special, with the gamelans, and Javanese music is different but similar to it; it still has connections with Indian music.

CL: I tried to find similar approaches by focusing on certain works, for example, *Jonchaies* (1977) and *Pleiades* (1978). Can one say you have "borrowed" from the scales found in Bali and Java?

IX: In *Jonchaies*, yes, there are scales because the problem of scales is very important; which scale to choose? How to construct it? I found in those places scales that were very powerful; that is to say, they were throbbing, not throbbing, but they were very driven. But I tried not to imitate them, because it's useless to imitate. [...]

CL: They were "driven," but in what sense?

IX: What I mean to say is that they were very characterized by quartertones and half-tones which pointed to relationships with the music of Greek folk music (but not Arabic music, because you know that the theorists of the tenth and eleventh centuries were very influenced by ancient Greek music). I had studied Aristoxenus of Taranto (*ca*. 375–35 BCE) and I used my findings, just to a certain extent by the way, because in all the modes, there were tetrachords. So, I discovered, for example, that in Japan, there were tetrachords that were

13 Certainly, Xenakis is referring to Balkrishna Doshi (1927–2023), who also worked in Le Corbusier's studio for some time with Xenakis. The two remained friends throughout their lives.

14 Here, Xenakis must be referring to his friend who attended the Paris Conservatoire around the same time he was auditing Olivier Messiaen's class there, the Japanese composer Toshiro Mayuzumi (1929–97).

conjunct; do-fa, fa-sib, but, at the same time, it was very interesting because they *were* tetrachords: very ancient musical thought was based on tetrachords and not on the octave. But I wrote about these things in *Musiques Formelles* which was recently released again in New York.[15]

CL: Since you mention Aristoxenus, isn't your sieve theory a sort of culmination of Aristoxenus's scales?

IX: Of course, it is! That's true. But it's an endeavor that has been going on for years! I tried to generalize this in an abstract way: What is a scale and how can one create scales from arithmetic? Basically, it's very simple! [...]

CL: Let's get back to the affinities I feel between your music and African music.

IX: I haven't studied African music. What interested me was Indian music, music from Java, Bali, Japan, and a little bit from China (but not so much).

Brahms

CL: Which composers concern you or are closest to your sensibility?

IX: I must say that from European music I feel closest to Brahms (1833–97), although I did not copy him!

CL: Do you know why? Do you have a reason? Is it his harmony? His rhythm?

IX: Just generally speaking.

CL: I also love Brahms!

IX: You too, yes? His musical flux! How he handles it, even though his harmonies are a bit classical, he has an imagination on a higher level with regards to form that is exciting. Maybe the most interesting thing from Brahms, like a sort of summary of all he had done, is the *Tragic Overture* (1880). It has everything in it! Everything he had done in his symphonies up to the 4th (1885); it's all in there.

CL: What about his *Requiem* (1868)?

IX: No... I'm mostly interested in his orchestral pieces and pieces for small ensembles.

CL: Is it their flux and their form that interest you?

IX: The overall form and what happens within, in order to arrive at that form.

Defining Music

CL: What is music for you? Once and for all...

IX: It is considerations in sound that may have some relationship with the thoughts of mathematicians, physicists, etc. and even biologists, why not? That doesn't

15 Xenakis, 1992.

mean that it is a translation or an interpretation, however.

CL: An expression then, no? Or is it a synthesis?

IX: No. It is in parallel, if you wish…

CL: Insofar as you have used in a very essential way certain models… […]

IX: They are not models; they are parallelisms. […]

CL: I'm searching for the exact word…

IX: Parallelism! They go together, side by side. […]

CL: Let's look at a very precise case: in *Pithoprakta* (1955–6): at one point you use Poisson's Law. Should we then speak of a "parallelism" between this musical passage, and clouds, and their evolution?

IX: It can be found everywhere: in clouds, in insects…

CL: But we can explain them by a mathematical law, or…

IX: Maybe this can help: there are mathematical expressions that can be used to reconstruct things that are in you or that you see but that you don't know how they work. When we travel by plane, you see clouds below you, cloud formations that are extremely interesting: either regular, or by filaments… Those exist in nature everywhere!

CL: What I wanted to say is that there seems to be an identification when you use a mathematical structure, for example, group structure, in *Nomos Alpha*, for example. From the moment the music has an external source, a kind of source, or a part of a source, which is found in a certain model, this model starts to be part of a new universe.

IX: Listen: if you take abstract logic, it is a result of something that exists in man even if he never studied logic. This is very important! Because otherwise… I say that they are parallel phenomena because man has a brain which acts in the same way whether it is in music, in painting, or in science, even in politics! They are each separate even if there is a common place, which is the brain...

CL: I remember discussing this together with you about fifteen years ago: about the law of nature, the laws that exist in nature.

IX: Yes. A law is a summarization, knowledge; that is to say, it is a framework in which the brain navigates around things that formerly were not understood. Then man discovered and invented laws to understand, but they are not definitive! Laws are never definitive! And what one has in one's head, also, is not definitive, but it needs a certain control to be able to express itself!

Fig. 29.7 Concert program from the Salão do Ateneu, Porto, 27 March 1984; (right): the author, composing on the UPIC system at CEMAMU outside of Paris (Issy-les-Moulineaux); (left): a UPIC "page" (a few seconds of music from the author's work Autómatos da Areia, August 1978). Author's private collection.

Portugal

IX: Portugal has been on my side for a very long time, especially, of course, the Gulbenkian Foundation. First, under the artistic direction of the divine Madalena Perdigão,[16] who provided critical support, with commissions, and even money to develop the UPIC! Without the Gulbenkian, who knows when and even if we would have managed to build the first digital-to-analog converter in France in the very early 1970s! They alone made that possible for us. Later, under the brilliant direction of Luís Pereira Leal,[17] commissions continued, and the Foundation's orchestra often programmed my music in their annual festival, and invited many international artists and dedicatees as well to give the Portuguese premieres of solo and chamber works. If I remember correctly, the Gulbenkian

16 Her husband, José de Azeredo Perdigão, was the first acting President of the Gulbenkian Foundation and held that position from 1956 until 1993, the year of his death. Madame Perdigão held her position as Artistic Director through 1974.

17 Luís Pereira Leal became the head of the music department at the Gulbenkian Foundation in 1978 and held that position through 2010.

commissioned seven or eight works, some of them amongst my most ambitious, such as *Cendrées* or *Dämmerschein* (1993–4).[18] What was also really remarkable is that they were often generous enough to commission (or co-commission) new works while allowing them to be premièred first elsewhere.[19]

CL: And don't forget about when they invited you to the Foundation to present the UPIC and organize workshops for both children and for local composers. [...]

IX: Indeed, you were there too! Always faithful in promoting my work.[20] Did I ever thank you? Well... now I am!

Fig. 29.8 Iannis Xenakis and his unforgettable smile in the composer's studio, Rue Victor Massé, Paris, 1995. Photo by author.

18 Chronologically, these were *Nuits* (1967), *Cendrées* (1973), *Phlegra* (1975), *À Colone* (1977), *Tetras* (1983), *Ata* (1987), and *Dämmerschein* (1993–4). Furthermore, several other works appear to have received some level of support from the Gulbenkian Foundation: *Polytope de Cluny* (1972), *Psappha* (1975), *Kottos* (1977), *Gendy3* (1991), and *Dox-Orkh* (1991).

19 For example, *Nuits* was premiered at the Royan Festival in 1968, *Phlegra* was premiered in 1976 in London by the London Sinfonietta, and *À Colone* was premièred at the Metz Rencontres Internationales de Musique Contemporaine in 1977.

20 Indeed, from 1978 until today, the author, Cândido Lima, has been extremely active in promoting Xenakis's music and thought through Portuguese national television and radio broadcasts, lectures, press articles and university seminars. Furthermore, and much to Xenakis's personal delight, it was Lima's personal and private recording of Xenakis's defense of his *Doctorat d'état* in 1976 that led to the publication of *Arts/Sciences: Alliages* in 1979 (translated as *Arts/Sciences: Alloys*, published by Pendragon Press in 1985).

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30. The UPIC System of Iannis Xenakis: Autoethnography as *Rapprochement*

Peter Nelson[1]

The UPIC (Unité Polyagogique Informatique de CEMAMu) system, conceived by Iannis Xenakis in the 1960s and 1970s, and realized with a team of collaborators at CEMAMu (Centre d'Etudes de Mathématique et Automatique Musicales) in Paris during the latter half of the 1970s, was a device for the creation of music consisting of a large, digitized drawing board connected to a purpose-built minicomputer (see Figure 30.1).[2] It brought together two aspects of Xenakis's life, the architecture studio with its distributed design process, and the radiophonic studio—with Pierre Schaeffer's (1910–95) Groupe de Recherches Musicales (GRM) as a model—and its concern for the direct creation of sonic materials by technical means, using the new technology of the digital computer.[3] Xenakis had asked Schaeffer to create a computer facility at GRM, but Schaeffer had refused.[4] The UPIC put the physical act of drawing, and the spatial and graphical paradigms of design at the heart of the act of composition, providing direct access to the sonic consequences of the design process. By 1987, the system was stable and had developed from its initial prototypes, with their lengthy computation times for the generation of sound from the graphic input, to have real-time capabilities. A number of production models of the UPIC were available in studios internationally, as well as in the Paris studio of the organization Les Ateliers UPIC, of

1 I am most gratefully indebted to Anthony Gritten, who read and commented on an earlier draft of this article.

2 CEMAMu (Center for Studies in Mathematics and the Automation of Music), was founded in 1965 at CNET (Centre de Recherche et Développement de France Télécom (Center for Research and Development of France Telecom)), Issy-les-Moulineaux, France, with grants from the French Ministry of Culture. For a broad overview of the UPIC, see Weibel et al., 2020. For a discussion of the meaning of "Unité Polyagogique Informatique" see below.

3 The Groupe de Recherche de Musique Concrète (Research Group for "Concrete" Music) (later GRM) was founded by Schaeffer in 1951. For a discussion of "concrete music" see Schaeffer, 2012. Xenakis became a member of the group in 1954 and created his first five electronic works there: *Diamorphoses* (1957), *Concret PH* (1958), *Analogique B* (1959), *Orient-Occident* (1960), *Bohor* (1962), representing one-third of his electroacoustic output.

4 Asserted in a public interview between Xenakis and Richard Steinitz, Huddersfield Contemporary Music Festival, 1987. (Recording in the author's personal archive.)

 https://doi.org/10.11647/OBP.0390.32

which I was an associate from the presentation of the UPIC computer music system at the Huddersfield Festival of Contemporary Music in 1987, until its presence at the Radio France concert celebrating Xenakis's seventieth birthday in 1992.[5] Les Ateliers UPIC was an educational organization, based around the UPIC technology, and situated first at the Parc de la Villette in Paris, and later at Massy in the Paris suburbs, in a building shared with the performing ensemble L'Itineraire. As an associate, I presented the UPIC system at public events, in Paris and internationally, mentored composers working with the system, took part in workshops for young people and for student composers, and wrote a number of works myself on the UPIC.[6] Xenakis himself was only peripherally involved in the work of the atelier, but we met first in Paris in the summer of 1987, when he demonstrated the UPIC to me at CEMAMu, and later that year at the Huddersfield Festival where he was a featured composer. It was due to his impression of me during the workshops at Huddersfield that I was invited to become an associate of the atelier. Subsequently, our paths crossed from time to time, always with a friendly directness that led us to discussions of ideas and practicalities without much social padding. He was interested in discussing ways in which the UPIC might be improved and developed, both technically and conceptually, so it was, for him, neither a finished "product" nor a cherished and guarded project, but rather an ongoing investigation, deeply wedded to his ideas about education and the needs of young people as well as to the development of the computer as an aid to music composition. It was also a practical tool, and not intended as the foundation for any sort of cultural institution. In this respect, the CEMAMu and Les Ateliers UPIC were very different from IRCAM (Institut de Recherche et Coordination Acoustique/Musique), with which they competed for both prestige and funding.[7]

I have called this chapter an "autoethnography," but I do not want simply to reminisce. Autoethnography is an attempt to fuse personal narrative and sociocultural exploration. While one of its aims is to legitimize every-day, personal, subjective experience and the "insider" view, as a counter to notions of objectivity and theoretical abstraction, the participant observer still has to make sense of what they experience, and that involves a direct encounter between those experiences and whatever framing narratives can be found to make sense of them. Unlike the work of Georgina Born, this is not an attempt to establish any sort of foundation for the study of the sociocultural formations of music. Nor is it an attempt to argue for one institution—CEMAMu—over another—IRCAM—though their activities through the 1980s ran in parallel and provide some interesting contrasts. All the same, I do take some cues from Born, particularly the notion that cultural forms and institutions operate "through many

5 For a brief history and discussion of Les Ateliers UPIC, see Després, 2020.

6 *Tournoiments de Spectres* (1988), *Alliages/Rituels* (1990) for real-time UPIC performance, with Pierre Bernard and Alain Dépres, *Ichthys* (1992) for UPIC and ensemble.

7 For a discussion and critique of the cultural formation of IRCAM, see Born, 1995.

simultaneous, juxtaposed, and interrelating forms or mediations."[8] I will start by considering some of the framing narratives that I have found useful and identifying some of the terms that support these narratives. However, in thinking about my own experience, I want to focus on the multi-facetedness and interdisciplinarity that grounded Xenakis's whole creative output, and to consider how this is reflected in the UPIC and in the experiences of those who worked with it.

Fig. 30.1 The author demonstrating the UPIC system in Quebec, 4 February 1989. Still from video, Archives: composer de la musique par le dessin à l'aide de l'UPIC, Radio-Canada, https://ici.radio-canada.ca/info/videos/media-7644182/archives-composer-de-la-musique-par-le-dessin-a-laide-de-lupic, 1'56".[9]

The framing narratives against which I want to measure my own experiences follow cues from three rather separate conceptual sources. First, the UPIC, as a conglomeration of technical devices, and material and social processes, seems to me to fall under the category of an *apparatus*, described by Giorgio Agamben (b. 1942) as "a heterogeneous set that includes virtually anything. [...] The apparatus itself is the network that is established between these elements," and we will come in a moment to consider what these "elements" might be.[10]

8 Born, 1995, p. 17.

9 Unité Polyagogique Informatique du CEMAMu translates as the Computerised Polyagogic Compendium of the CEMAMu; cf. Varga, 1996, p. 121, and "UPIC—Presentation", *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/cix_upic_presentation?lang=en; Agostino Di Scipio, "UPIC" (2023), *Les Amis de Xenakis*, https://www.iannis-xenakis.org/en/dictionary-upic/

10 Agamben, 2009, p. 2–3.

This mention of the theme of the network raises, as the second conceptual source, recent work that draws music into the orbit of science and technology studies, located around the writing of Antoine Hennion and Bruno Latour (1947–2022), which try to map and take account of *all* the components of a situation and their inter-relations, regardless of the type of those components.[11] More specifically, this approach reorientates the discussion away from key persons, objectified works, and specified devices in order to consider the processes, assemblages of actors and materials, and the power differentials that form and motivate the living presences of people, communities, and technical means.

Thirdly, the interdisciplinarity that seems to me to be foundational for Xenakis resonates with the notion of the engineer, a figure defined by a messy combination of the theoretical and the practical. It is no coincidence that Engineering was the focus of Xenakis's studies at the Athens Polytechnic. In his book on Galileo (1564–1642) as engineer, Matteo Valleriani identifies two epistemological foundations for his investigation, that might be useful in the current discussion. The first is the notion of *mental models*, that is: "knowledge representation structures based on default logic, which allow inferences to be drawn from prior experiences about complex objects and processes even when only incomplete information on them is available."[12] This fits with the fundamental processes of the UPIC, which prioritize immediacy and physical gesture over precise calculation, and the instincts of drawing and spatial design over knowledge about aspects of sound. The second is the notion of *challenging objects*. Valleriani defines these as: "historically specific material objects, processes or practices entering the range of application of a system of knowledge without the system being capable of providing a canonical explanation for them."[13]

I am going to propose *music*, in the context of this discussion, as constituting one such "challenging object," and to suggest that the "mental models" around music exist as an overlay of theory-based calculation and experientially mediated "rules of thumb" that represent embodied, social, material, and performative—that is "action-based"—types of knowledge in entirely informal and ad hoc ways. This goes against the production of "universalizing explanations of music" that "read these properties as imminent in music."[14]

What I want to do in this chapter is to consider my experience of the UPIC from this set of perspectives. First, I will think through some of the components of the network constituted by the UPIC, to get a sense of what needs to be considered. Then I will try to flesh out these components, using my own experience of them, while also using the conceptual frames just outlined to make sense of my experience. Finally, I will try to think about the implications of this whole discussion for the continued presence and relevance of the UPIC as a viable musical apparatus.

11 See for example Hennion, 2015; Latour, 2005.
12 Valleriani, 2010, p. xii.
13 Ibid.
14 Born, 1995, p. 20.

The Network of the UPIC

The network of the UPIC, to be true to Agamben's "heterogeneous set," should include concepts and practices, as well as social instantiations, locations, and sets of values, and probably whatever else results from the interactions of the participant with the network. During my own association with the UPIC, I gathered a very partial view of what the components of the network might be, and how they operated, and in a sense my account of these gives as much insight into my own concerns as a working musician as it does into the UPIC as a technology in its own right. But it is the purpose of autoethnography to explore relations and interactions, and to eschew notions of objectivity and explanation.

My first encounter with the UPIC was at the CEMAMu, in the summer of 1987, where Xenakis himself supervised a couple of days of initiation before the presentations at the Huddersfield Festival later in the year. It was clear from the start that the extreme openness, of being able to draw freely on a blank page, favored an unstable notion of pitch: it is easy to draw a curve or diagonal, difficult to draw a horizontal line without perturbation (unless you use a ruler!). In their history of the UPIC,[15] Gérard Marino, Marie-Hélène Serra, and Jean-Michel Raczinski, three of the technical collaborators on the design and construction of the UPIC system, note that early discussions of the UPIC concept centered on the graphic materials for Xenakis's early orchestral work *Metastasis*, in which the *glissando* is developed as a key sonic entity: an entity that was to remain central to Xenakis's musical thought. They write: "graphic representation has the advantage of giving a simple description of complex phenomena like *glissandi* or arbitrary curves. Furthermore, it frees the composer from traditional notation that is not general enough for representing a great variety of sound phenomena."[16]

Whether or not this is in fact true, it gives the graphic image, and the process of drawing—as a sort of direct access to the imagination—the status of an initial insight. As Xenakis wrote,

> The computer should not only be used for sound synthesis, but also for [...] large-scale construction. [...] The obstacle lay in the computer field: how do you pass on to the machine the notation and concepts that musicians learn in conservatoires? The solution was the hand: for the musician to give orders to the computer using drawings, not punched cards or programmes.[17]

This insight rests on an acknowledgment of the ways in which graphic practice grasps complexity, as a sort of *mental model* that allows an ad hoc manipulation of processes

15 Marino et al., 1993.

16 Ibid., p. 260.

17 Xenakis, 1979, p. 9 (author's translation) [*Il ne faut pas se servir de l'ordinateur uniquement pour la synthèse des sons, mais également pour* [...] *les constructions à grande échelle.* [...] *L'obstacle se situait du côté de l'informatique : comment transmettre à la machine une notation et des concepts que le musicien apprend dans les conservatoires ? La solution, c'était la main : que le musicien donne ses ordres à l'ordinateur par l'intermédiaire de dessins, et non de cartes perforées ou de programmes*].

and phenomena that are otherwise difficult to calculate. It became the key feature of all of my own public presentations of the UPIC system, in which drawing, without thinking about the process as a sort of "music notation," became a means of access for people of all ages and backgrounds, regardless of their musical, or even their drawing capabilities. Graphism is not necessarily pictorial so much as it is diagrammatic, where the critical thing is the clear representation of an idea rather than the production of a beautiful image.[18] Thus, the development of a technique of using the UPIC rested on a dialogue between sound phenomena and graphic phenomena.

However, the graphic and sonic entities of which the *glissando*, with its sonic continuities, is the default type present certain performance difficulties on traditional instruments, thus: "In addition, if such a system could play the score by itself, the obstacle of finding a conductor and performers who want to play unusual and 'avant-garde' music would be avoided."[19] This, entirely cultural and political critique, remains a part of the UPIC's inheritance, despite Xenakis's development of the *glissando* as a fundamental musical material in numerous solo, ensemble, and orchestral works for conventional instruments. The performance element of the system, as a sort of rapid prototyping environment for the process of composition, proposes the UPIC as a DIY solution for unconventional sonic strategies, bypassing the social difficulties presented by human performers. While this might also be true of the resources of the electronic studio as a category, the explicit inclusion of "performance" into the ambit of the UPIC had consequences for some of the works written on it, and colored the relationship between sound and image.[20] Thus, for the performances of *Mycènes Alpha* (1978) presented by Les Ateliers UPIC, slides of the UPIC pages would be shown in synchronization, not as a sort of cheesy Mickey Mousing, but because the strange aesthetic of the graphic images complements and contextualizes the sonic result. Finally, the notion of machine performance is radically opened up by the suggestion by Marino, Serra, and Raczinski that: "the system should not impose predefined sounds, predefined compositional process, predefined structures, and so on. It is essential for the creative mind that ideas not go through theories or limitations that might not suit the composer."[21] This echoes Xenakis's own view when he writes: "In musical composition, construction must stem from originality which can be defined in extreme (perhaps inhuman) cases as the creation of new rules or laws, as far as that is possible; as far as possible meaning original, not yet known or even foreseeable."[22]

This presents a moment of what James Mooney and Trevor Pinch call the "sonic imaginary." "In a sonic imaginary," they write, "sound itself has a sociomaterial agency and makes a crucial difference in how worlds are enacted. [...] we treat the

18 Cf. Tufte, 1991.
19 Marino et al., 1993, p. 260.
20 For example, Xenakis's *Taurhiphanie* (1987), performed live at the arena in Arles, 13 July 1987. Cf. Nelson, 2010.
21 Marino et al., 1993, p. 260.
22 Xenakis, 1992, p. 258.

imaginary as an emergent phenomenon from the material world."[23] The "material world" here includes not just the technical device of something like the UPIC but also the conceptual, social, and actively embodied practices that make up the *apparatus*. Mooney and Pinch conceive of this as "a way of imagining and bringing forth a shared sonic world or experience grounded in technology, institutions, and networks."[24] This way of thinking binds the *challenging object* of music to its material and social situation, rather than to some specific, internally registered and imagined sensory experience. In categorizing sound as "an emergent phenomenon," Mooney and Pinch are also suggesting that it may not "come first," as we shall see in a moment. The emergence of the sonic imaginary says something not just about the circumstances from which it emerges, but also about the circumstances into which it appears. One could almost imagine it as a process of divination, in which the invocation of sound—its calling into being through, in this case, the graphic techniques of the UPIC—is an address to something deeper than sound that calls it to action through sound. Xenakis's concern for the fundamentals of nature, and the forces that reside there, includes a desire to let those forces speak; to set up the circumstances within which "worlds are enacted."

Since the sonic imaginary figures as a set of material and social premises, what might these consist of in the case of the UPIC? First, the size and the technical specificity of the system required a studio setting, with all its gate-keeping and administrative support. In the case of Les Ateliers, this consisted only of one audio technician and a studio director, with a constantly changing group of associates such as myself, available on a temporary basis for specific projects. Thus, the UPIC studio did not have the sort of institutionalized technical expertise enshrined in the iconic radiophonic studios of the twentieth century, so clearly documented by scholars like Tatjana Böhme-Mehner and Jennifer Iverson, where the studio technicians themselves provided a significant part of the actual material of their "sonic imaginaries."[25] The concept of the diagonal or *glissando*, noted above, speaks to the graphic representation at the heart of the UPIC's conception, which resulted in a graphic approach to sound, without "pre-sets" or indeed any of the other techno-specific sonic strategies such as filtering, speed transposition, echo and reverberation, etc. The radically open possibilities of the graphic environment meant that there was really no "hidden knowledge" available through technical expertise. The graphism evident in the studio, however, did focus on certain strategies: the diagonal is one, and its development into arborescence was another. This graphic approach extended to notions of musical structure, which was thus predicated on concepts of spatial design, rather than on the cinematic concerns of *musique concrète*, or the serial and systemic concerns of classical electronic music, both of which have *transformation* at their core. Lastly, as will be discussed below, the sonic imaginary included a sort of openness, even roughness that was not present in

23 Mooney and Pinch, 2021, p. 114.
24 Ibid.
25 Böhme-Mehner, 2011; Iverson, 2019.

the hi-fi, emulative aesthetics of conventional studios. The "challenge" of the object of music, created on the UPIC, extended through material and structure to the quality of the sound itself.

The heterogeneity of the list of features above that evoke the sonic imaginary of the UPIC testify to a certain uncertainty about the purpose of the UPIC. The technical synthesis of sound, for instance, does not appear as a key feature, and the notion of rapid prototyping is related to a much more general concern for "complex phenomena." This uncertainty of purpose was reflected in my own experience of attempting to explain the workings of the system to other composers, yet this multiplicity, evident also in the description of the system by Marino et al., in fact prompts the system's name: the first two letters U and P stand for Unité Polyagogique. Xenakis explains this phrase in one of his published interviews with Bálint András Varga (1941–2019):

> *Polyagogique* is my coinage: *agogie* means training or introduction into a field; *poly* means many. When designing we are working in space with our hands (geometry); in constructing rhythmic models we have to compute distances (geometry and arithmetic); also general forms. And finally there's the sound. All those things together [...] make *polyagogique*.[26]

This account of the UPIC's core conception seems to me to propose music—let's call it that—quite explicitly as the sort of challenging object outlined above: we know what music is in general, but there is no "canonical explanation" for it. Xenakis seems even to explode this object into multiple "fields": space, rhythm, sound, each with its own sort of epistemology—geometry, arithmetic etc.—that the UPIC seeks to combine into a unity. My attempt to generate complexity here is deliberate, since this apparatus, which seems to present as a simple means of drawing sounds, turned out to be a device of legendary intransigence in actual operation. As Dimitris Kamarotos remarks:

> One of the reasons why many surprising difficulties for the users remained after their first contact with the system was due to the influence of how the system was promoted: as an intuitive, non-technically inclined system encouraging creativity. People were promised they would be able to make music, or at least complex, interesting sound structures without any knowledge of computers, or even music.[27]

The Sound of the UPIC

When Xenakis speaks of *agogie* as "training or introduction I think he is not really describing the UPIC as a tool for education and learning in the obvious sense: learning to use the UPIC is an education in itself; an exploration of the challenging object that is music. The extreme openness of the technical apparatus of the UPIC makes it a fertile space for puzzlement as well as creative play, and in that sense, it is, in Agamben's

26 Varga, 1996, p. 121.
27 Kamarotos, 2020, p. 255.

terms, a sort of "profane" device. Agamben is concerned with the ways in which an apparatus is implicated in the very formation of the subject who encounters it, or, in the case of the contemporary technologies he so despises, the "de-subjectification" of the subject, where the practices, discourses, and bodies of knowledge that mark an apparatus—the mobile phone is Agamben's particular target here—induce a docile and disciplined abdication of identity. Agamben is interested in the notion of the profane because, "'to profane' signified [...] to restore the thing to the free use of men."[28] The openness of the UPIC—its blank space for drawing, unaided, with only the impetus and gestural potential of the human hand and eye—makes it a space for searching, not just for sound but also for the creative subject in relation to sound, and for the imagination of an original disposition of events in the world. For the individual creator, of course, this is both liberating and problematic. Some of the famous composers who came to create work in the studio left puzzled and clutching only materials that they intended to use later within their usual creative practice.

It seems to me emblematic of the conception of the UPIC that sound comes at the end: as Xenakis says (cited above), "And finally there's the sound." When Brigitte Condorcet (Robindoré) refers to the perception of the UPIC's sound as being "somewhat harsh," she is registering the frequent sense of disappointment of people using the device for the first time.[29] Because of the vagaries of drawing waveforms by hand, or even using wave elements extracted from pre-recorded samples, sound was not the specified outcome of a process of design, but rather the unspecified outcome of a process of searching that involved a drawing together of strands of existence: the existence of the atelier with its machinery and its *camaraderie*, the existence of the maker of the sounds as experienced in the process of creation, as much as the existence of the drawn arc, with its configuration of waveform, dynamic envelope, and other attributes. In all the workshops I was involved in, it was necessary to effect a sort of *rapprochement* between the users and the device: one had, in a sense, to develop a relationship to the UPIC's very individual openness in order to find out what it could give you. In this sense, the UPIC worked as a sort of socializing device for bringing people, domains, and disciplines into connection, rather than as an efficient compositional tool with its own set of sophisticated techniques and resources. In this sense it contradicted both the large—and small—system paradigms of music production using a computer. It set up the circumstances for action, within which sound and music were only a part of the enterprise. Thus, the UPIC does not figure as a Modern, labor-saving device of transparent access. This seems to me to fit with Xenakis's entirely un-modern approach, and in this context the sound of the UPIC perhaps fulfils only un-modern expectations. It was never the intention—as it was with other computer sound generation attempts like the MUSIC-X languages or the Moog synthesizer—to model instrumental or bio-physical sound production, or to

28 Agamben, 2009, p. 18
29 Condorcet, 2020, p. 403

implement black-box instantiations of generic compositional techniques. In particular, the human interface of the UPIC remained resolutely physical and optical, rather than intellectual.

"It Can Be Put in Everyone's Hands"[30]

The sense of a core concept of the UPIC, however it gets related by the key players in its formation, is clearly molded by the institutions within which the UPIC first emerged. It was Xenakis's intention to make the UPIC available, through individual access, workshops, and demonstrations to a wide and diverse group of users of all sorts: other composers and sound artists, young people and students, even the general public. When people encountered the UPIC for the first time—or even as regular users—they entered a studio environment with a particular set of objectives, practices, resources, and expectations. The UPIC itself was large and technically imposing; each device was unique and hand-built, requiring the sort of dedicated technical support only available within an institutional environment. Thus, although the interface was conceptually simple, it presented as a sort of secret knowledge since this device was unlike anything in even the conventional electronic studio: no piano keyboard; no patch-chords; no programming language: simply pointing and touching within a graphism containing multiple, virtual layers. But at the same time, there *were* no secrets. The *mental models* in use by participants in these workshops were, as Xenakis explained and conceived them, a drawing together of different representations of a common knowledge: on the one hand, an exploratory investigation, through drawing, of the gestures and images of human culture, and their sensory effects as pressure waves; on the other hand, an innate and individually mediated practice of temporal narrative where the metaphor of sound as space is dominant. In this sense, the UPIC figures as an interface which, as Ksenia Fedorova presents it, "enables the representation of 'objects' that do not have a phenomenal or material existence—such as imaginary and virtual objects, but also fantasies and desires."[31] This made it a powerful play-surface on which users could encounter the sonic consequences of their understandings of the cosmos—whether based in science and rationality, or in narrative and imagination. The encounter was always engaging because of the direct, hands-on experience which was potentially transformational. As Fedorova writes, "What in thermodynamics is 'work' and in a graphical user interface is a response to a software system, in the case of a human self is transformation of its position as a relational being."[32] These relations were sometimes specific. Xenakis, for example, was fond of saying that, since young people were short of stature with high voices, whereas adults were tall with low voices, there was a logic

30 Statement on the flyleaf of the promotional booklet, *L'UPIC du CEMAMu*, Paris 1987 [*Elle peut être mise entre toutes les mains*].
31 Fedorova, 2020, p. 16.
32 Ibid.

that suggested that sounds at the bottom of the UPIC table would be higher than those at the top.[33]

On the other hand, there were expectations represented by the various *social* factors in play-the fact that work in Les Ateliers was almost always in groups, with the practices of sharing and competition that groups evoke; the presence of a technician, that not only made technical problems evaporate but also provided a sense of theater in which the work was elevated to a sort of performance in itself, within the "stage" of Les Ateliers. The posters, photographs, and printouts on the walls of the studio—and the demonstrations that were an important part of the induction process—introduced particular sorts of drawing artefacts and sonic elements that became objects of either attraction or repulsion in the individual work of participants. In particular, the graphic elements of Xenakis's own *Mycènes Alpha* stood as an indissoluble part of the UPIC's apparatus: a piece that was always performed when Les Ateliers presented a concert of participants' works. This, despite the fact that each of the complete works that Xenakis made on the UPIC—*Mycènes Alpha*, *Taurhiphanie*, and *Voyage absolu des Unari vers Andromède* (1989)—develops a unique and radically different graphical approach.

Conclusion

What this brief discussion proposes is a decentering of our view of the UPIC as a tool that makes simple the musical possibilities of the *glissando*. The UPIC still has a fascination for us, but it is not quite the same as the fascination we have for other musical devices of the past, like the Moog synthesizer or the vinyl record. These devices seem to allow the reliving of an otherwise historical moment; a re-appropriation of a previously experienced sense of excitement and possibility, often enhanced by contemporary digital additions, that collapses the super-saturated *ennui* of an internet age in which everything seems to be instantly available, without effort. On the other hand, the UPIC seems like a device that is almost not yet accomplished: a glimpse of something still to be realized, where producing music does not necessarily get easier with practice. Les Ateliers did not figure, like IRCAM, as a quasi-scientific enterprise predicated on notions of progress and discovery. What the UPIC reveals is a concern not with the "future" of music, or with the past of music, but with the *possibility* of music as it arises out of the conjunction of living beings and the forces both within them and around them. This is a view of music whose sociocultural foundation implies a sociality that includes the cosmos, in an ancient Greek sense, though this can be seen mirrored in the contemporary views of, for example, Latour.[34]

I have written elsewhere[35] about my view of the UPIC as an apparatus for a sort of *sonic divination* mentioned above: an apparatus whose original voice mediates sound

33 Personal recollection but see also, for example, the interview previously cited (fn. 4).
34 Latour, 2005.
35 Nelson, 2024, forthcoming.

from beyond the known world; a method of tapping into—to follow for a moment the notion of the hyperobject explored by Timothy Morton—forces and energies that we cannot otherwise know.[36] For me, UPIC remains, as Xenakis explicitly envisaged, a polymorphous conception: not so much a device for composing, as a sort of graphic search engine, allowing us—through the drawing action of the hand—to rake through the infinite terrain of sound to see what is still there to be heard.

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Plate 9 Iannis Xenakis on his last day of teaching at the Université de Paris Paris I-Sorbonne, 1988.
Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

META-XENAKIS (OR WHERE DO WE GO FROM HERE?)

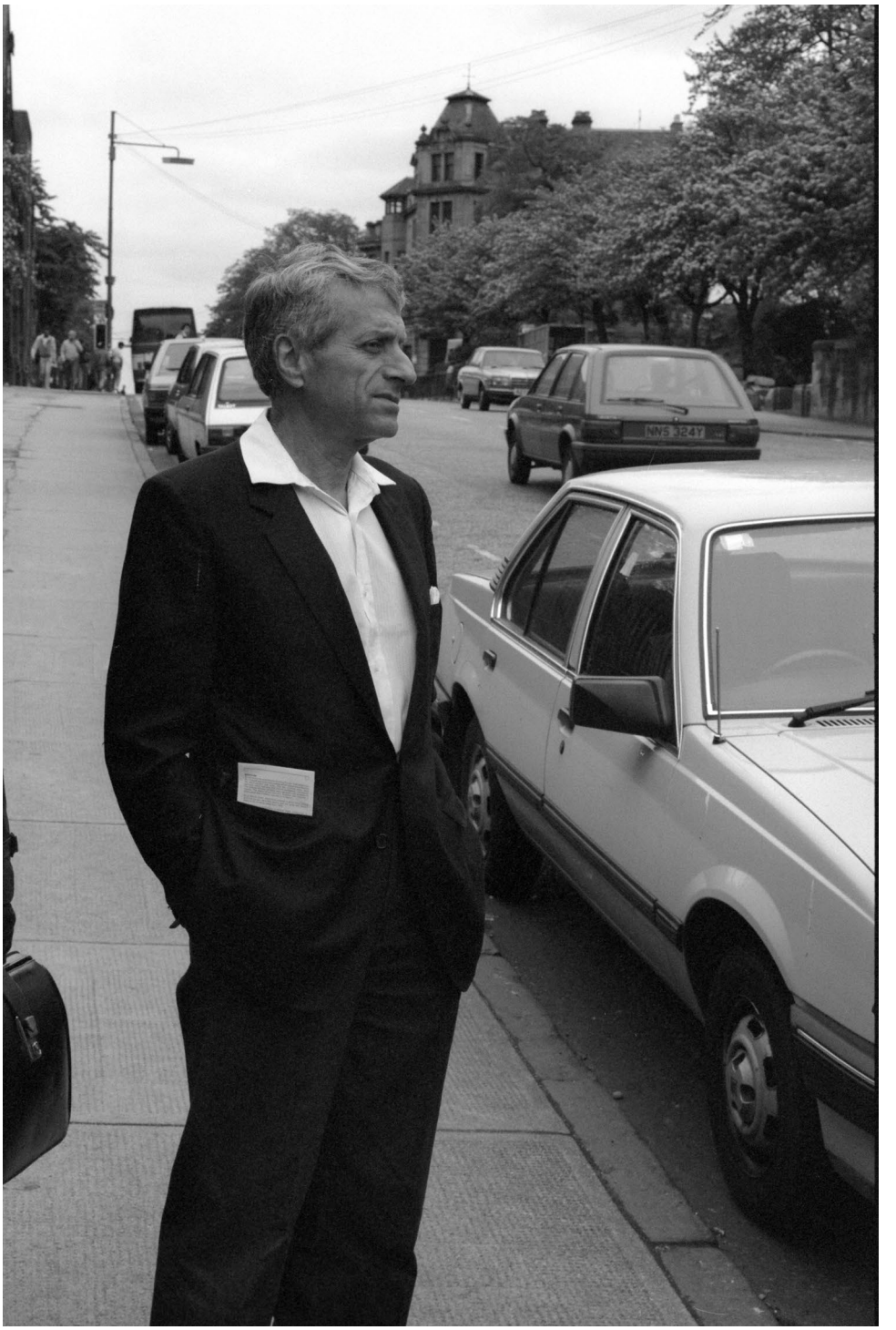

Plate 10 Iannis Xenakis awaiting his driver to go to the Alliance Française de Glasgow for the celebration of 65th birthday, Glasgow, 1987. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

31. UPISketch: New Perspectives

Rodolphe Bourotte

When we consider the needs we may have in the field of electroacoustic music composition, a tool allowing a graphic representation of sound and musical phenomena may seem interesting to develop. UPISketch is one of these tools.[1] This presentation will focus on describing the abundance of ideas that the development of such a tool can inspire. UPISketch is a subset of graphical score systems: it is positioned on the question of graphical representation of quantitative data. This is a particular posture, one that has its roots in the following statement:

> Music notation is the representation of several physical values evolving over time. Since the nineteenth century, experimental physics has made much use of graphs and plots—visual representations to visualize experiments or observations. Interestingly, the notation of music is a reversed process compared to scientific graphs: instead of representing observed values, music notation describes, like a timed map, the physical state we seek to observe (with our ears) in our environment at successive moments.[2]

In this sense, it can update the breakthroughs that Xenakis made through his mathematical approach, by making them newly accessible via an intuitive graphic interface. Possibilities, in the process of implementation, will be evoked, both on the graphical aspect and for sound synthesis. The legacy of Xenakis's research on sieves and probabilities is inescapable, and it is possible to imagine an extension of it in the graphical domain with UPISketch, in a junction that had never been realized with UPIC (Unité Polyagogique Informatique du CEMAMu (Centre d'Études de Mathématique et Automatique Musicales)).

The Origin

UPISketch is a sound composition tool, which was developed by Centre Iannis Xenakis (CIX) in 2018 in cooperation with the European University of Cyprus within

1 UPISketch is available for free on the Centre Iannis Xenakis (CIX) website: "UPISketch" (9 March 2022), *Centre Iannis Xenakis*, https://www.centre-iannis-xenakis.org/upisketch

2 Bourotte, 2020, p. 298. See also Delhaye and Bourotte, 2013.

 https://doi.org/10.11647/OBP.0390.33

the framework of the Creative Europe Interfaces Network. Its development was part of the Interfaces action "Urban Music Boxes and Troubadours."[3] The impetus for the project came from the fact that, more than ten years after UPIX (UPIC software version) development was halted, no software had all the following characteristics:

- An intuitive interface that makes it possible to quickly produce a composition, even without musical or computer experience.
- A short reaction time between the user's gesture and the resulting sound or image.
- Each drawn curve has an internal representation, and its parameters can be individually determined.
- Drawings can be extremely precise.
- Drawing and sound synthesis tools are integrated (no external software dependencies required).
- The basic physical values are frequency and intensity.

The table below illustrates the differences between some possible UPIC epigones:

Characteristic / Program	Real Time	Vector Drawing	Drawing Accuracy	Reference page for drawing a score	Sound Synthesis	Audience
UPIC/UPIX	Yes	No	Medium	Yes	Simple	All-audience
Ossia Score	Yes	Yes	Good	No Page concept	Complex	Specialized
Iannix	Yes	Yes	Good	As a special setting	No	Specialized
HighC	No	Lines	Unfaithful	Yes	Simple	All-audience
MetaSynth	Yes	No	Insufficient	Yes	Fourier	All-audience
UPISketch	Yes	Yes	Good	Yes	Complex	All-audience

Table 31.1 Table of UPIC epigones.

3 "Music Workshops: 'Let's Draw Music!': Education, Training & Workshops," *Interfaces*, http://www.interfacesnetwork.eu/post.php?pid=122-music-workshops-let-s-draw-music

Since the Interfaces Creative Europe project's completion in 2020, we have had the possibility to further develop UPISketch, so it can be used not only on tablets, but also on desktop computers: using Windows, Mac, and Linux operating systems, the latter since 2022 thanks to the contribution of Rodney DuPlessis, then a PhD candidate in composition at UCSB.[4]

Xenakis's centennial in 2022 and the Meta-Xenakis consortium offered the opportunity to launch the first International UPISketch Composition Competition.[5] The internationality of submissions was impressive: participants came from eight countries and four continents. This event allowed us to receive a lot of documented material on the composition process using UPISketch, and also a good amount of user feedback, both of which are helpful in guiding the next steps of development as well.

Sound Synthesis

The First Synthesis Method

A few words should be said about the first method of synthesis that was implemented in UPISketch. There was the wish to take advantage of the richness inherent in already existing sounds, whether they come from acoustic or synthesized instruments. This decision triggered the interest for providing a library of default sounds.[6] With UPIC, one could load a waveform, representing a tiny portion of the information that a natural sound contains. All UPIC users experienced this limitation. Therefore, we extended this to the duration of a note, or even a phrase of several seconds, which allow access to other aspects of timbre or timbral evolution over a longer term.

Figure 31.1 shows the principle of the synthesis: we choose existing periods of a sound, and rearrange them by resampling, removing, or duplicating some of them when necessary.

4 University of California, Santa Barbara, where he has now completed his PhD; see *Rodney DuPlessis*, https://rodneyduplessis.com/#home

5 "Open Calls," *Meta-Xenakis*, https://meta-xenakis.org/open-calls/#upisketch

6 This created an aesthetic shock for some of the former users of UPIC, who, when discovering UPIC, then found an infinite potential for composing sounds themselves, with a sort of *tabula rasa* mindset. However, most former UPIC users finally prove to be very inclined to use the possibility to import sounds in their UPISketch endeavors.

The synthesized signal is then obtained by superposition/addition of the elementary signals centered on new positions t_w : write markers. These positions determine the pitch and the duration of the synthesized sound :

$$\begin{cases} \tilde{s}(t) = \sum_j \tilde{s}_j(t) \\ \tilde{s}_j(t) = s_i(t_r^i - t_w^j) \end{cases}$$

t^j_{co} is the position corresponding to t^j_w .
It depends on t^j_w and on the time dilation factor :

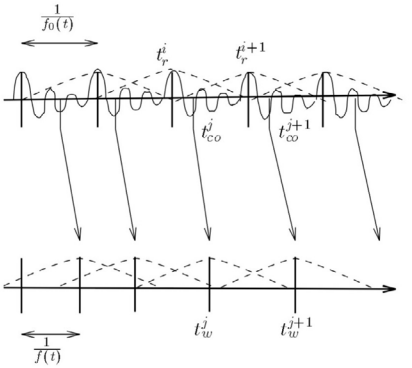

Fig. 31.1 Excerpt from the first UPISketch milestone specifications © CIX 2017, reprinted with permission.

But there is a drawback in this principle: this technique introduces the necessity to analyze the fundamental pitch of the original sound. This is an imperative step in order to recreate a sound at a different pitch from the original, when recreating it in the time domain. Such an analysis can be made, for example, with the program Tony.[7] From there we dispose of a list of pitches versus time. Willing to impose an absolute pitch to this sound implies that we calculate, *for each analyzed pitch*, the transposition to apply in order to obtain the desired pitch.

ANALYSED PITCH (Hz)	DESIRED PITCH (Hz)	Transposition to apply
98,05	110	11,95
95,93	110	14,07
96,65	110	13,35

7 *Tony* (2015), Queen Mary's College, University of London, https://www.sonicvisualiser.org/tony/. As of 2022, UPISketch and Tony use the same pitch analysis library; i.e. PYin: https://code.soundsoftware.ac.uk/projects/pyin

103,01	110	6,99
102,67	110	7,33
125,58	110	–15,58
122,78	110	–12,78
134,76	100	–24,76
137,83	100	–37,83
142,87	100	–42,87
141,08	100	–41,08
146,3	100	–46,3
149,71	100	–49,71
143,28	100	–43,28
145,39	100	–45,39
149,01	100	–29,01
144,62	120	–24,62
143,43	120	–23,43
145,75	120	–25,75
140,34	120	–20,34
134,84	120	–14,84

Table 31.2 Transposition inferred from desired pitch and actual analyzed pitch.

However, as the first UPICian postulate was to propose an efficient, fast, and easy (intuitive) interface that even children could use, it was necessary to call upon an automatic analysis of this fundamental pitch. Being automatic makes it fallible, hence in turn it can sometimes produce undesirable—or interesting—artifacts…

Mathematical Expressions

Not only for historical reasons, but also to be open to new types of synthesis allowing more reliable and precisely reproducible results, in the version 3 of UPISketch, released in 2022, we proposed pure oscillators. Using the default definitions entails selecting a default synth prior to drawing, and then verifying by visualization what it has done:

Media 31.1 Output sound exported from UPISketch, viewed in Audacity.
https://hdl.handle.net/20.500.12434/8410c834

To go further we can also define a waveform by using a mathematical expression. This has been made possible by the exprtk library by Arash Partow.[8] Some examples of the syntax in this library are presented below:

```
(00) (y + x / y) * (x - y / x)
(01) (x^2 / sin(2 * pi / y)) - x / 2
(02) sqrt(1 - (x^2))
(03) 1 - sin(2 * x) + cos(pi / y)
(04) a * exp(2 * t) + c
(05) if(((x + 2) == 3) and ((y + 5) <= 9),1 + w, 2 / z)
(06) (avg(x,y) <= x + y ? x - y : x * y) + 2 * pi / x
(07) z := x + sin(2 * pi / y)
(08) u := 2 * (pi * z) / (w := x + cos(y / pi))
(09) clamp(-1,sin(2 * pi * x) + cos(y / 2 * pi),+1)
(10) inrange(-2,m,+2) == if(({-2 <= m} and [m <= +2]),1,0)
(11) (2sin(x)cos(2y)7 + 1) == (2 * sin(x) * cos(2*y) * 7 + 1)
(12) (x ilike 's*ri?g') and [y < (3 z^7 + w)]
```

Code 31.1

This is a first implementation, and as specified in the UPISketch documentation, the modification of such definitions is likely reserved for experienced users.[9] However, in an upcoming version, formulas will be much easier to use and saved with the UPISketch project (.upixml). Math expressions will be entered this way:

8 *C++ Mathematical Expression Library*, http://www.partow.net/programming/exprtk/
9 "UPISketch Version 3.0 - Desktop: OSX/Windows - User manual/Guide d'utilisation" (14 Feb 2022), *Centre Iannis Xenakis*, https://rodolphebourotte.info/wp-content/uploads/2022/01/UPISketchUserManualDesktop.html

Media 31.2 Tweaking the waveform definition for math expression synthesis.
https://hdl.handle.net/20.500.12434/b537144c

By assigning this edited expression, `2 * sqrt (1 - (x / (2 * pi)) ^ 2) - 1`, to a gesture, we obtain the following output: a quarter of a circle repeated on each period. The variable x stands for the angle between 0 and 2π, which is updated at each new sample, according to the drawn pitch.

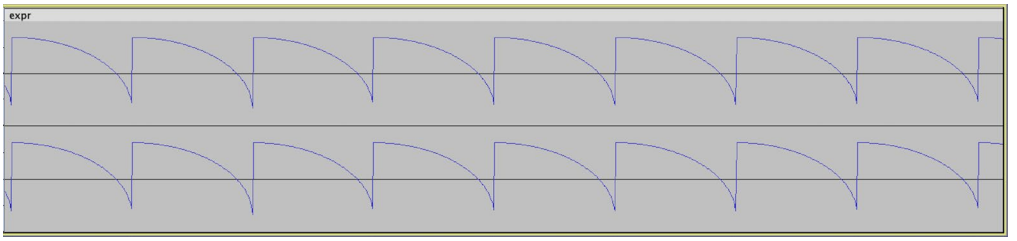

Fig. 31.2 Resulting waveform from math expression: 2 * sqrt (1 - (x / (2 * pi)) ^ 2) - 1. Figure created by author (2022).

In the future, we hope to include the following possibilities:

- To allow definitions for more than a single sound period (with the possibility of adding an additional parameter in the equation so as to define a more global variation).
- To save these definitions along with the project.
- To create a user library of these definitions.

Splines and Audio

Seen in a xenakian context, splines represent a very interesting topic. The Génération Dynamique Stochastique (GENDYN)[10] method invented by Xenakis is well known, and uses breakpoint functions to define a single period of sound, as well as functions which control points that are modified stochastically at each period:

10 Dynamic Stochastic Synthesis.

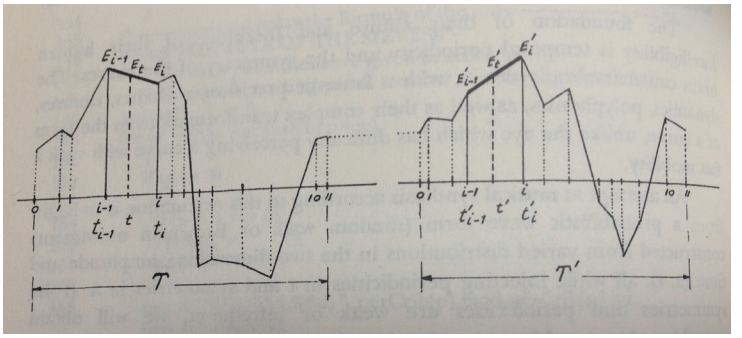

Fig. 31.3 GENDYN graphic description.[11] © Pendragon Press (1992), reprinted with permission.

There have been several modifications to this first proposition, notably using splines, under the supposition that this mathematical object may represent the way sound pressure is propagated in the air in a more natural fashion by any kind of acoustic instrument. Obviously, we can object that this could be a step backwards on the search for unearthly sounds. However, maybe the straight lines chosen in 1991 were, in fact, chosen because of some computer limitations? In any case, here are some examples:

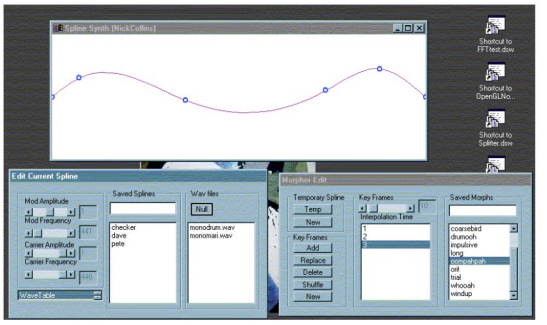

Fig. 31.4 SplineSynth © Nick Collins (1999), reprinted with permission.

The example below uses a pressure-sensitive touch-device to control the amplitude of the vertical and horizontal variation of control points.

Media 31.3 Spline waveform modulation. © The author (2017).
https://hdl.handle.net/20.500.12434/8432bfdf

Now, with the participation of Matt Klassen, we are working on implementing an original form of synthesis, based on a simplified vector representation of audio.[12]

11 Xenakis, 1992, p. 290.
12 Matt Klassen is a professor at the DigiPen Institute of Technology (Redmond, Washington, USA): see

Fig. 31.5 Audio spline interpolation demo video screenshot.[13] © Matt Klassen (2022), reprinted with permission.

Several innovative aspects in Klassen's work can be mentioned:

- He starts from existing sounds and makes a vector interpolation from splines.
- He introduces the notion of keycycles, the equivalent of keyframes in animation software.
- This technique allows a high level of information compression: if you want to mix several sources together, rather than calculating the temporal interpolations between keycycles for each of the voices and then adding these voices together, one only needs to interpolate first the keycycles themselves, and then perform a single temporal interpolation.

"Very Free but Accurate"[14]

Now, I would like to relate some more personal thoughts, related to my musical practice.

Thinking about the question of the aleatory and the continuous, this indication at the beginning of one of Paul Méfano's (1937–2020) scores comes to mind:

https://azrael.digipen.edu/research/

13 The screenshot comes from "Spline Modeling Software Video 4" (10 June 2022), *YouTube*, https://www.youtube.com/watch?v=CMWp3qlqlek

14 This section's title is a reference to Paul Méfano, former president of the CIX: [*Très libre, mais précis*].

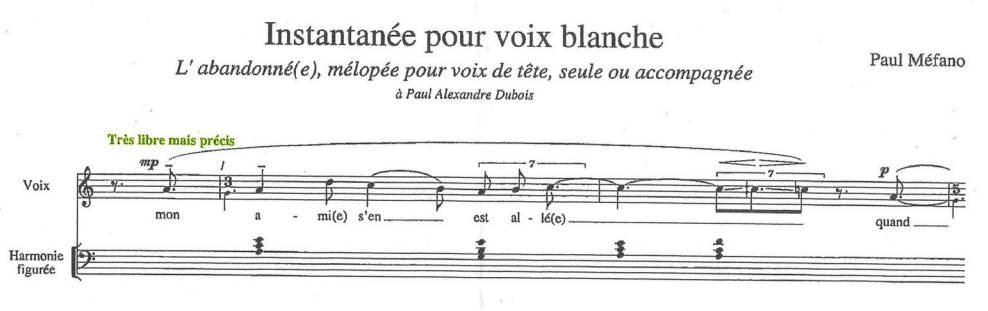

Fig. 31.6 Excerpt from *L'abandonné(e)*, score by Paul Méfano © BabelScores (2000), reprinted with permission.

Not only the aleatory in music can be a conceptual tool in composition, it also can raise a number of issues regarding notation and interpretation. The history of written music shows a variety of ways to address accuracy. Even if centers of interest may change, in general, there is a large amount of information to be dealt with by the interpreter. The following score, for example, focuses rather on proposing to get into a certain state of mind. The musician can also be asked to raise his/her awareness and self-relation to the sound and the environment, etc.

> Keep the next sound you hear
> in mind
> for at least the next half hour.[15]

I will not argue here about the value of different approaches concerning which musical information should be fixed by the composer. The very thing I am interested in is how to create complexity in a simple way. For example, the identity of a piece does not necessarily depend on the exact predetermination of the sound events that compose it. A musical piece can be seen as a succession of statistical characteristics. This is where Xenakis intervened. In pieces like *Pithoprakta* (1955–6) or *Metastasis* (1953–4), changing one sound here or there in the final score would be harmless. A real change would rather come from a modification of the overall statistical tendencies. Indeed, we can be tempted to organize things on a different level:

15 This text can be found in Oliveros, 2013.

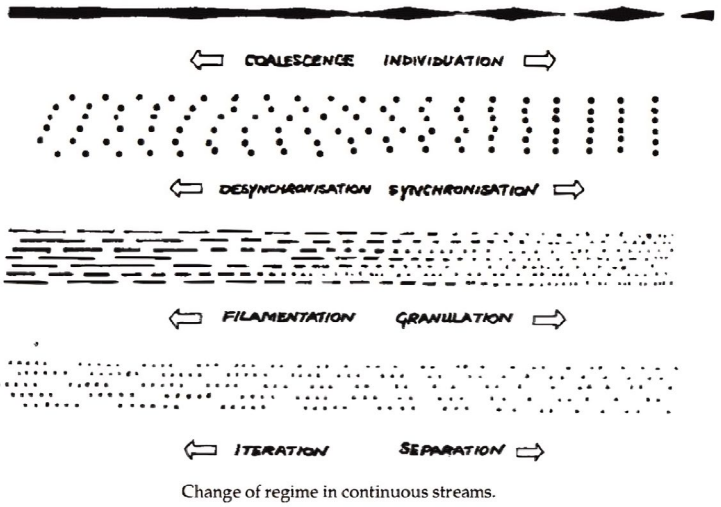

Fig. 31.7 Some musical production typologies, as illustrated by Trevor Wishart.[16] © Trevor Wishart and Simon Emmerson (1996), reprinted with permission.

This schema advocates again for a global control rather than defining each and every single event. Nature itself is "very free but accurate." The following statement may sound especially obvious nowadays, with the advent of artificial intelligence (AI) image generators, but it is worth keeping our context in mind: the image below could be very different in the details of its geometry, but we would nevertheless feel the same looking at it, sensing its overall aspect.

Fig. 31.8 Photograph of a shore in Brittany, by the author (2022).

16 Wishart, 1996, p. 187.

I have explored two ways of managing these so-called global variations for populations of sounds:

- One, in an analogic way (score on paper), by adding symbols expressing choices or limits within which the values must be contained, or by indicating mean values with an amount of possible deviation. This is no exclusive novelty, yet here is how I gave indications of tendencies within my piece *Interrupted Exceptions* (2005):

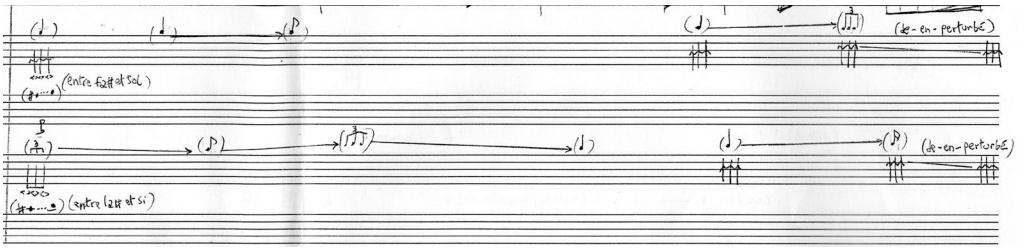

Fig. 31.9 Excerpt from *Interrupted Exceptions*, score by the author (2005).

- The other way, digitally, with a real-time display device, that would start work from the same paradigms: I call this system *Comma*.[17] Media 31.4 shows what it looked like some years ago.

Media 31.4 *Comma* (2004), Max/MSP and cathodic screens.
https://hdl.handle.net/20.500.12434/56bfb6e1

17 The proprietary software applications cited throughout (including *Comma*), if not yet, will be available soon at: https://rodolphebourotte.info/software

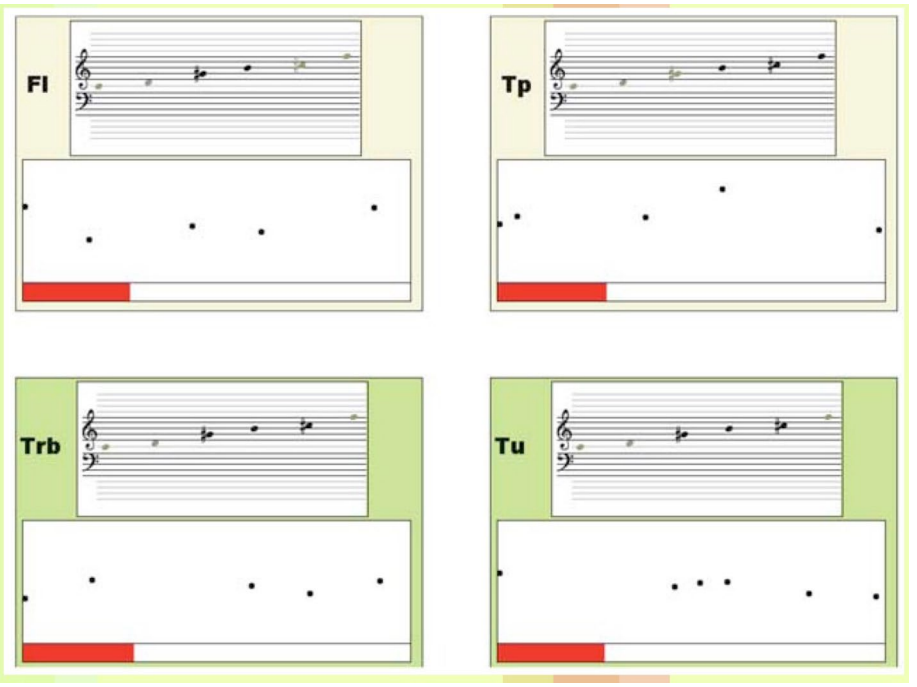

Fig. 31.10 *Comma*, screenshot (2004). Figure created by author.

The particularity in both cases (the analogic case of *Interrupted Exceptions* and the digital case of *Comma*), is that the composition consists of describing in real time the evolution of random parameters, such as density, rhythmic regularity, dynamic agitation.

Below is an example of a meta-score:

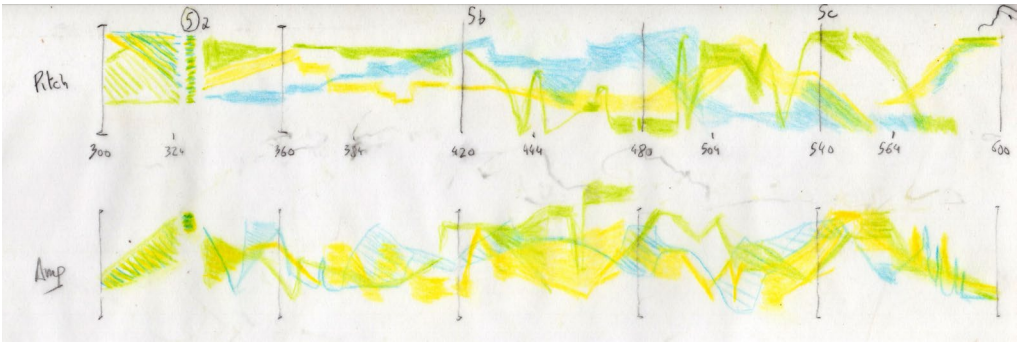

Fig. 31.11 *Comma*, hand-drawn meta-score (2018). Figure created by author.

…with, in Figure 31.12 below, the way it has been entered in Max/MSP, so that it would send information to my other software (*CommaTransmitter*/*CommaReceiver*) via Open Sound Control (OSC):

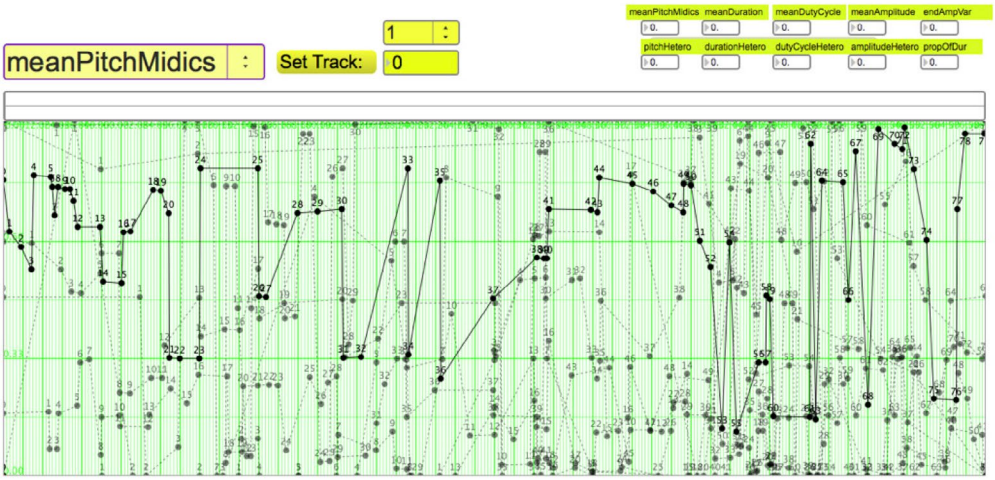

Fig. 31.12 *Comma* meta-score as translated into 2D curves in Max/MSP (2018). Figure created by author.

This meta-score feeds the *CommaTransmitter*, which in turn sends the appropriate instructions to the *CommaReceiver* owned by each instrumentalist. A second phase in the development of this tool occurred in 2018, thanks to a residency at the European University of Cyprus in the framework of the same Creative Europe project Interfaces, at the end of which we set up a group of instrumentalists to play around with the new version, running under OSX and iOS.[18]

There is a difference though between *Interrupted Exceptions* and *Comma*. In the former, the performer has to interpret symbols to generate the events; while in the latter, events are directly read, as they are already generated by the *CommaTransmitter* application.

Information Density

There is another challenge regarding the control of multiplicity. We have shown that in the history of Western written music there is a growing interest in multiple characteristics of sounds. This has resulted in a global increase in the quantity of described musical information: pitch, tempo, dynamics, timbre... Furthermore, it is interesting to note that be it in the case of a score with only pitches or of an ultra-detailed score, there is always additional information that escapes notation. In both cases, the composer expects something "very free but accurate" but deals with the human factor of the performance in a different way. (See Fig. 31.13.)

18 "Residency for Electronic Music Artists in Cyprus," *Interfaces*, http://www.interfacesnetwork.eu/post.php?pid=50-residency-for-electronic-music-artists-in-nicosia-cyprus

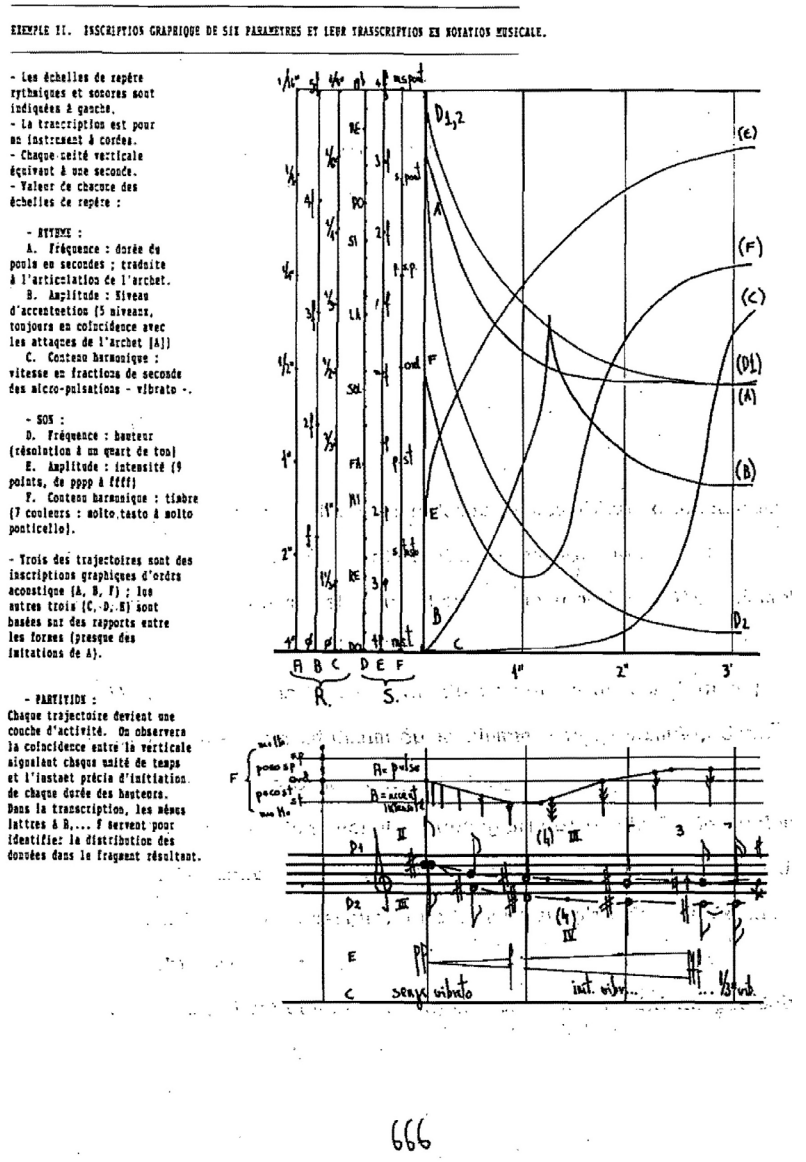

Fig. 31.13 Julio Estrada, *Théorie de la Composition* (II), p. 666.[19] © Julio Estrada (1994), reprinted with permission.

This evolving musical mindset has induced the need to find a way to manage all this information without being overwhelmed; also in electroacoustic music where, a priori there is no limitation of the number of parameters. For instance, how would we control—in an intelligent manner—an audio plugin when the plugin covers 165 parameters?!

19 Julio Estrada, "Théorie De La Composition (I)," in Estrada, 1994.

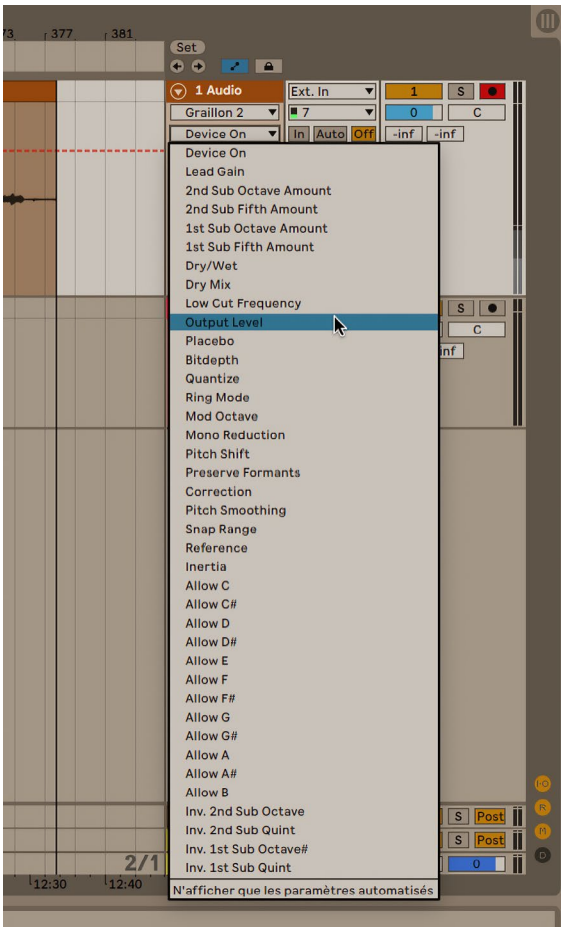

Fig. 31.14 List of parameters held by an example plugin (2022). Figure created by author.

The answer resides in creating meta-parameters that define sound objects more globally. A sound would then be defined by the position of a meta-parameter in a multidimensional space. There is still a lot of ongoing research in this domain, since the representation of such a space, either in 2D or 3D, is quite insufficient. Indeed, "small-D" implies the superposition of several curves and forbidden trajectories. To understand this, it suffices to try to describe graphically, in two dimensions, the position of a point in a 2D space versus time, which is the basic pitfall for graphically controlled ambisonic automation. To date, there is no clear-cut direction of work on UPISketch regarding this question.

In our cognitive world, we are not used to dealing with more than three dimensions. However, we are often very interested in monitoring and controlling many more than three curves. But these curves can only appear to us as a superposition in the 2D space of a page (and adding only one dimension only delays slightly the main problem of our small-D cognitive worlds).

UPIC-GENDYN, or UPISketch-Comma Unification

From the reflections above, we may infer the following: we are interested in unifying the two very different concepts residing respectively in UPIC and GENDYN. This is not a new concern as it has been evoked in the past by Peter Hoffmann:

> Indeed, it could have been interesting to integrate GENDYN synthesis within UPIC. Thoughts have been given to this possibility (personal communication by Jean-Michel Razcinsky of CEMAMu in 1996). It is interesting to compare the UPIC system with the GENDYN program. They are in many aspects complementary, and it seems as if one concept compensates for the shortcomings of the other.[20]

This implies providing composers with a graphical editor of musical data in the form of drawn curves. But these curves would gain a special flavor: they would handle not only completely determined phenomena as is the case with UPISketch and UPIC, but also random ones, as with GENDYN and *Comma*.

It is also possible that UPISketch becomes an interface to control the *Comma* system. This would be a much simpler interface to use than the one created with Max/MSP. It would also allow a homogenization for access to both the production of music notation in real time, and the production of probabilistic sound events from the internal synthesis engine of UPISketch.

But, as it can also be good to get some perspective when examining an idea, I am also interested in comparing computer/no computer experiments. Such experiments will take place in 2024, thanks to the project *tekhnē* funded by the European Union in collaboration with the GMEA.[21] Media 31.5 represents a start of an implementation, to get a feel of how this could work in UPISketch:

Media 31.5 A coded draft for a UPISketch probability drawing, using a pressure-sensitive device (drawing tablet and pen).
https://hdl.handle.net/20.500.12434/e19599e1

Interestingly, this approach may look like a representation of the wave function, the famous mathematical object used in quantum physics:

20 Hoffmann, 2009, p. 127.

21 "About" (n.d.), *tekhnē*, https://tekhne.website/about.html; *Groupe de Musiques Expérimentales d'Albi*, https://www.gmea.net/

Fig. 31.15 A trajectory in classical mechanics, versus quantum mechanics (2022). Figure created by author.

Conclusion

Xenakis brought to musical creation more than his own music and more than formulas; he also awakened a state of mind and theoretical ferments which can only lead us to enrichment, both by the development of science, of techniques, and of our culture.

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32. Somax2 and Reinterpreting Iannis Xenakis

Mikhail Malt and Benny Sluchin

Somax2 Introduction

Somax2 it is currently being developed by Joakim Borg, Gérard Assayag, and Marco Fiorini at IRCAM.[1] Somax2 comes from a long lineage of computer-aided improvisation environments developed by the Representation Musicales (RepMus) Team at IRCAM, based on what we call the "OmMax co-improvisation paradigm." This paradigm is based on a loop process between Listening, Learning, Modeling and Generating process. The previous Omax environment has been refined into several co-creative softwares: ImproteK/Djazz, Dyci2, and Somax itself. The actual version is a recent development including algorithm improvements from the former Somax version and previous work among members of the RepMus team.[2]

Software agents provide stylistically coherent improvisations based on learned musical knowledge while continuously listening to and adapting to input from musicians or other agents in real time. The system is trained on any musical materials chosen by the user, effectively constructing a generative model (called a "Corpus"), from which it draws its musical knowledge and improvisation skills. Corpora, inputs, and outputs can be MIDI as well as audio, and inputs can be live or streamed from MIDI or audio files. Somax2 is one of the improvisation systems descending from the well-known Omax software, presented here in a totally new implementation. As such, it shares with its siblings the general loop (listen/learn/model/generate), using some form of statistical modeling that ends up creating a highly organized memory

1 *Joakim Borg*, https://www.ircam.fr/person/joakim-borg; *Gérard Assayag*, https://www.ircam.fr/person/gerard-assayag/; *Marco Fiorini*, https://forum.ircam.fr/profile/fiorini/. The development of Somax2 is part of the project REACH supported by the European Research Council under Horizon 2020 program (Grant ERC-2019-ADG #883313) and project MERCI supported by Agence nationale de la Recherche (Grant ANR-19-CE33-0010).

2 See Borg, 2020, 2021a, 2021b; Assayag, 2021; Bonnasse-Gahot, 2012; Carsault, 2017, 2020; Carsault et al. 2021.

 https://doi.org/10.11647/OBP.0390.34

structure from which it can navigate into new musical organizations, while keeping style coherence, rather than generating unheard sounds as other machine learning (ML) systems do. However, Somax2 adds a totally new versatility by being incredibly reactive to musicians' decisions, and by putting its creative agents to communicate and work together in the same way, thanks to cognitively inspired interaction strategies and a finely optimized concurrent architecture, make all its units cooperate together smoothly.

Somax2 allows detailed parametric controls of its players and can even be played alone as an instrument in its own right, or even used in a composition's workflow. It is possible to listen to multiple sources and to create entire ensembles of agents where the user can control in detail how these agents interconnect and "influence" each other.

Somax2 is conceived to be a co-creative partner in the improvisational process, where the system, after some minimal tuning, is able to behave in a self-sufficient manner and participate in a diversity of improvisation set-ups and even installations.

The following links provide demos and performances:

- Project page: http://repmus.ircam.fr/somax2
- Forum Ircam Somax2 page: https://forum.ircam.fr/projects/detail/somax-2/
- Somax2 demo: https://vimeo.com/558962251
- Somax2 public performances: https://vimeo.com/showcase/somax2-perfs
- REACH Project and performances featuring AI software: https://vimeo.com/showcase/musicandai

Somax2 in a Nutshell

In Somax2, everything begins with the learning process, where a MIDI or an audio file is segmented and analyzed from the point of view of pitch and chroma vectors, building what we call a "Corpus"; i.e., a set of N-gram models of each parameter layer (Figure 32.1).

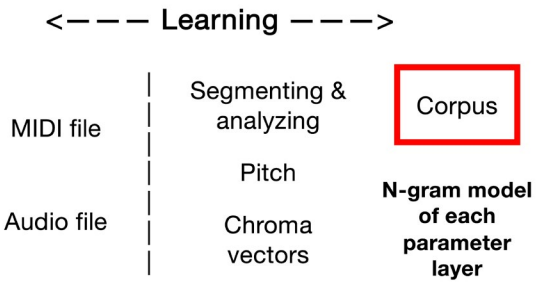

Fig. 32.1 Somax2 learning step. Figure created by authors.

After this first learning stage, we reach to build a Corpus. This Corpus will be a navigation model for the system (Figure 32.2).

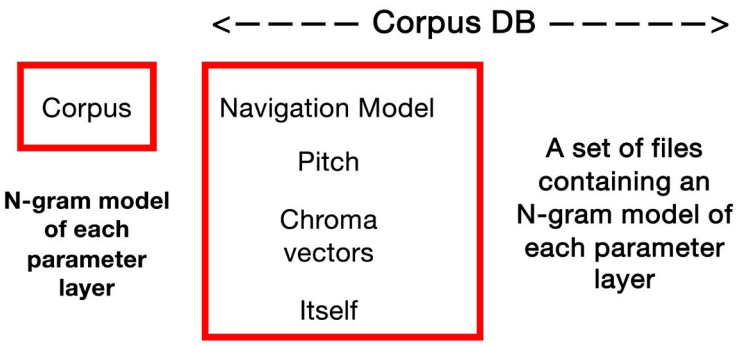

Fig. 32.2 The corpus as a navigation model. Figure created by authors.

Each corpus can be called by what we call "a player," that can generate, in an autonomous way, musical material (audio or symbolic-MIDI) (Figure 32.3).

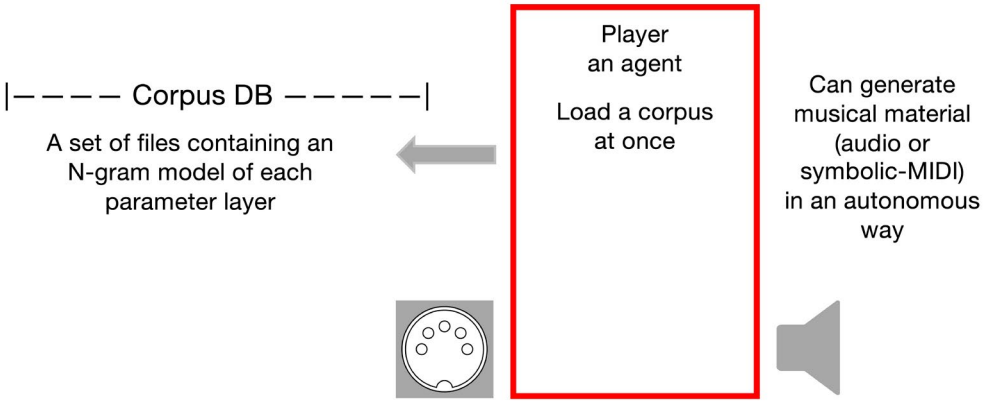

Fig. 32.3 The agent player bounded on a given Corpus. Figure created by authors.

But, also, the player(s) (we can have several at the same time) can have their behavior influenced by a MIDI device or by an audio stream (Figure 32.4).

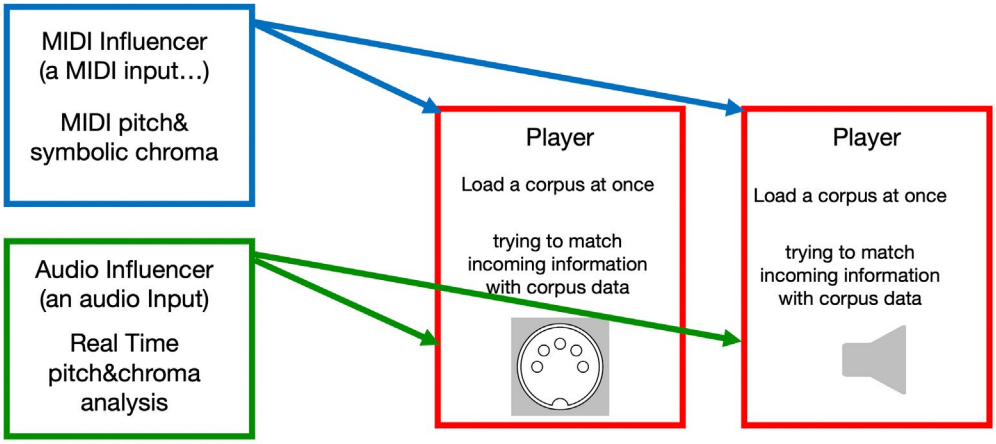

Fig. 32.4 Somax2 players being "influenced" by external, audio, or MIDI data streams.

An important aspect of this matching part is the pitch and harmonic memory, which we can set in Somax2. At each step, the player not only tries to match the actual incoming information but it also takes into consideration past information. This is a very important parameter (Figure 32.5).

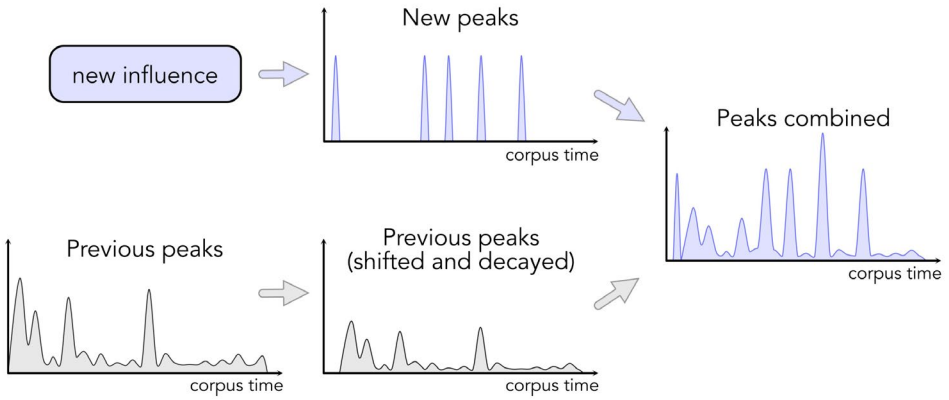

Figure 2.4: The process of shifting and decaying previous peaks in a single layer upon receiving new influences (the process of matching the incoming influence to the corpus has been omitted for clarity).

Fig. 32.5 Pitch and harmonic memory model. Borg, 2021a, p. 8.

For a more detailed description, we suggest reading Joakim Borg's excellent internal technical report, "The Somax2 Theoretical Model."[3]

3 Borg, 2021a.

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33. Xenos: A Xenharmonic Dynamic Stochastic Synthesis Virtual Instrument

Raphael Radna

Introduction

Xenos is a virtual instrument that implements and extends Dynamic Stochastic Synthesis (DSS), a direct digital synthesis method devised by Iannis Xenakis. Xenos adapts DSS for use in contemporary computer-based composition environments; written in C++ with the JUCE framework, it offers efficiency, cross-platform compatibility, and ease of use. As a plugin, Xenos leverages host software features, such as MIDI input and parameter automation, to increase the applicability of DSS to a broad range of computer music composition and performance contexts.

Xenos also introduces a novel pitch quantization feature to DSS. While traditional DSS produces continuous pitch, Xenos can optionally be tuned to an arbitrary scale, enhancing the algorithm's suitability to compositional styles that require fine control of pitch organization. Furthermore, the Xenos pitch quantizer can use microtonal and xenharmonic scales: any scales comprised of intervals that deviate substantially from those of the equal-tempered chromatic scale. Several scale presets are included, and it is also possible to load custom scales in the Scala format: a popular interapplication exchange standard for musical scale specification.[1]

In Greek, *xenos* means "foreigner" or "stranger." It is one root of the term *xenharmonic*, meaning "foreign harmony." Xenos was given this name as commentary on the marginal position of direct digital methods within the domain of sound synthesis, in reference to its xenharmonic quantization capabilities, and in homage to Xenakis. However, Xenos does not aim to replicate Xenakis's compositional methods but rather to preserve and extend DSS, abstract it from any particular style of composition, and make it eminently accessible to composers engaging with diverse musical aesthetics. Xenos is therefore released as free and open-source software, with the hope that it might increase awareness and usage of this nonstandard sound synthesis technique and important part of Xenakis's legacy.[2]

1 Manuel Op de Coul, "Scala Scale File Format," https://huygens-fokker.org/scala/scl_format.html

2 Complete source code and plugin binaries for MacOS, Windows, and Linux are available at "Xenos,"

 https://doi.org/10.11647/OBP.0390.35

Background

Xenakis and Stochastic Music

At his centennial, Xenakis remains among the most influential avant-garde composers of the twentieth century. An innovator in the integration of mathematical concepts and procedures with the arts, he pioneered the field of stochastic music: the application of statistical probabilities to music composition. He employed this technique in much of his published music, including the early orchestral works *Metastasis* (1953–4) and *Pithoprakta* (1955–6), which, contrasting the prevailing serial methods of the time, he conceptualized as masses formed by the statistical means (probabilities) of independent sound events.[3]

From the 1960s onwards, Xenakis used computers to execute the numerous calculations required by his compositions.[4] As advancements in computing surged in the late 1960s, the potential of digital sound synthesis rapidly became apparent. New computer music capabilities would, for the first time, enable stochastic procedures to touch the shortest timescales of music, inaugurating the domain of stochastic timbre generation. It is in this context that Xenakis developed a theory of the stochastic synthesis of audio waves. He published some germinal ideas in "New Proposals in Microsound Structure," the final chapter of the 1971 edition of *Formalized Music*, which presents several time-domain methods of digital synthesis that use probability distributions to produce noisy, complex timbres.[5] Xenakis first employed these techniques in the *Polytope de Cluny* (1972); later, he consolidated and developed them into the Dynamic Stochastic Synthesis algorithm, which debuted in *La Légende d'Eer* (1977).[6]

Xenakis returned to stochastic synthesis in the late 1980s. With Marie-Hélène Serra, he created the GENDY program,[7] which implemented a variation of the original DSS algorithm. Xenakis used this software to compose *Gendy3* (1991), a fully automated computer music composition with DSS as its only sound source. *Gendy3* is arguably Xenakis's most purely algorithmic work, as its pitches, timbres, textures, and form are all generated by software-controlled stochastic processes without intervention by the composer beyond initial parameter selection. Its low-level sonic activity and high-level formal structure are thus unified by their basis in the same theory, an important implication and attraction of stochastic composition.[8]

GitHub, https://github.com/raphaelradna/xenos

3 Xenakis, 1956, p. 3.

4 Serra, 1993, p. 237.

5 Xenakis, 1992, p. 243–4.

6 Luque, 2009, p. 79.

7 While Serra (1993) and Xenakis (quoted in Robindoré and Xenakis, 1996) render the name thus, the same software also appears in the literature as GENDYN. These terms are interchangeable.

8 Xenakis, 1992, p. vii–viii.

Theory of Dynamic Stochastic Synthesis

DSS is a type of direct digital synthesis: a group of techniques founded on the properties of the digital audio domain and without reference to pre-existing acoustic or perceptual models. It is a special case of *breakpoint interpolation synthesis*, a family of *waveform segment techniques*.[9] In DSS, the *cycle* (basic recurring unit) of a quasiperiodic waveform is defined by a series of breakpoints in amplitude-time space. The waveform is produced by linear interpolation between adjacent breakpoints. When a cycle ends, it undergoes a process of stochastic perturbation in which the breakpoints are displaced by random walks. A random walk is a stateful random number generator that produces its value by adding some randomly generated "step" to its previous value. Each breakpoint represents two random walks: one each in the horizontal and vertical dimensions. The horizontal dimension affects pitch, and the vertical dimension affects amplitude; both influence timbre. The displacement of the breakpoints produces successive variations of the cycle, resulting in an evolution of pitch, amplitude, and timbre over time.

The random walks are governed by several parameters that affect the nature and degree of variation between cycles. These are the *probability distribution* that produces random-walk steps, such as uniform, logistic, or exponential;[10] the *step size*, which is the maximum allowable difference between successive values of a random walk; and the *elastic barriers*, numerical limits that reflect excessive random-walk values back within a circumscribed range.[11] The mature form of DSS, as implemented in GENDY, uses second-order random walks: two random walks in series, in which the value of the first determines the step size of the second.[12]

Figure 33.1 illustrates the effect of the DSS technique on a waveform. *C* represents an initial cycle, and *C′* represents the subsequent cycle, i.e., the next iteration of the algorithm. Each contains twelve breakpoints and segments.

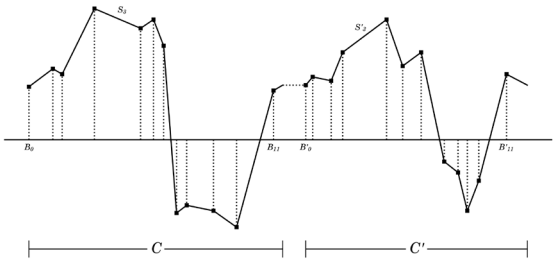

Fig. 33.1 Two contiguous cycles of a waveform generated by DSS. *C′* is a variation of *C*, produced by stochastic displacement of the breakpoints defining its contour. Figure created by author (2024).

9 Roads, 1996, p. 319–20, p. 342.
10 Serra, 1993, p. 248–9.
11 Xenakis, 1992, p. 290.
12 The two random walks comprising a second-order random walk are also called primary and secondary walks.

The cycles proceed continuously, with B_{11}, the last breakpoint of C, leading directly to B'_0, the first breakpoint of C'. However, the breakpoints shift positions between iterations, in both their horizontal and vertical dimensions, as a result of the random walks. The displacements of the breakpoints, constrained by the random-walk step sizes and elastic barriers, account for the differences in contour between C and C'. While these two cycles are clearly similar in form, the effect of random variation on local features is also apparent, e.g., in how the negative slope of segment S_3 becomes positive at S'_3. Additionally, a greater or lesser sum of breakpoint abscissae varies the wave period; because C' is not as wide as C, the frequency of this wave would increase. When made audible, these accumulated variations affect the pitch, amplitude, and timbre of the generated tone, producing dynamic sonic behavior in which the degree and rate of change is parametrically controlled.

Assessment of Dynamic Stochastic Synthesis

As his motivation for developing DSS, Xenakis describes a search for a total theory of sound synthesis: a "most economical way" of producing waves in the time domain that encompasses "all possible forms from a square wave to white noise."[13] Generating either of these edge cases is trivial; the challenge lies in creating "waves representing melodies, symphonies, [and] natural sounds." DSS approaches this problem by injecting periodicities and symmetries into a probabilistically determined wave: it starts from a chaos condition and imposes constraints that induce stability.[14]

An advantage of DSS is that its parameter space enables interpolation between pitch and noise, and exploration of intervening timbres. Its economy lies in its few interrelated parameters, which afford considerable diversity of musical behavior. With parameters that permit only slight variations of the wave cycle, tones of stable pitch and timbre emerge. Conversely, the more the parameters allow profound dissimilarities between cycles, the more the resultant tone loses its periodicity and tends toward noise.

Xenakis exploits these properties to create scenes of contrasting character in *Gendy3*, the definitive manifestation of DSS. In his discussion of this work, Sergio Luque identifies three sections that feature similar behaviors in all voices.[15] Due to their relative homogeneity, these textures are particularly instructive as to the nature of DSS. Each spectrogram in Figure 33.2 analyzes a fifteen-second excerpt from one of these sections. They all exhibit high levels of energy throughout their spectra, indicating a general brightness of timbre. Figure 33.2a (17:03–17:18) represents the use of fixed pitches to create melodies, chords, and clusters. The horizontal striations indicate sustained voices and their harmonics; the abrupt transitions between regions

13 Xenakis, 1992, p. 289.
14 Ibid.
15 Luque, 2009, p. 83.

of spectral coherence mark their sudden entrances and exits. Figure 33.2b (14:25–14:40) represents fluctuating pitch (*vibrato*) and *glissandi*. These behaviors are reflected, respectively, in the wavy lines visible in the first half of the spectrogram and the rising diagonals near its end. Figure 33.2c (5:15–5:30) represents noisy DSS timbres. The extreme, sustained density and intensity of the spectrum are immediately apparent. However, the noise retains a faintly pitched quality throughout, as evidenced by the horizontal striations running along the bottom of the spectrogram.

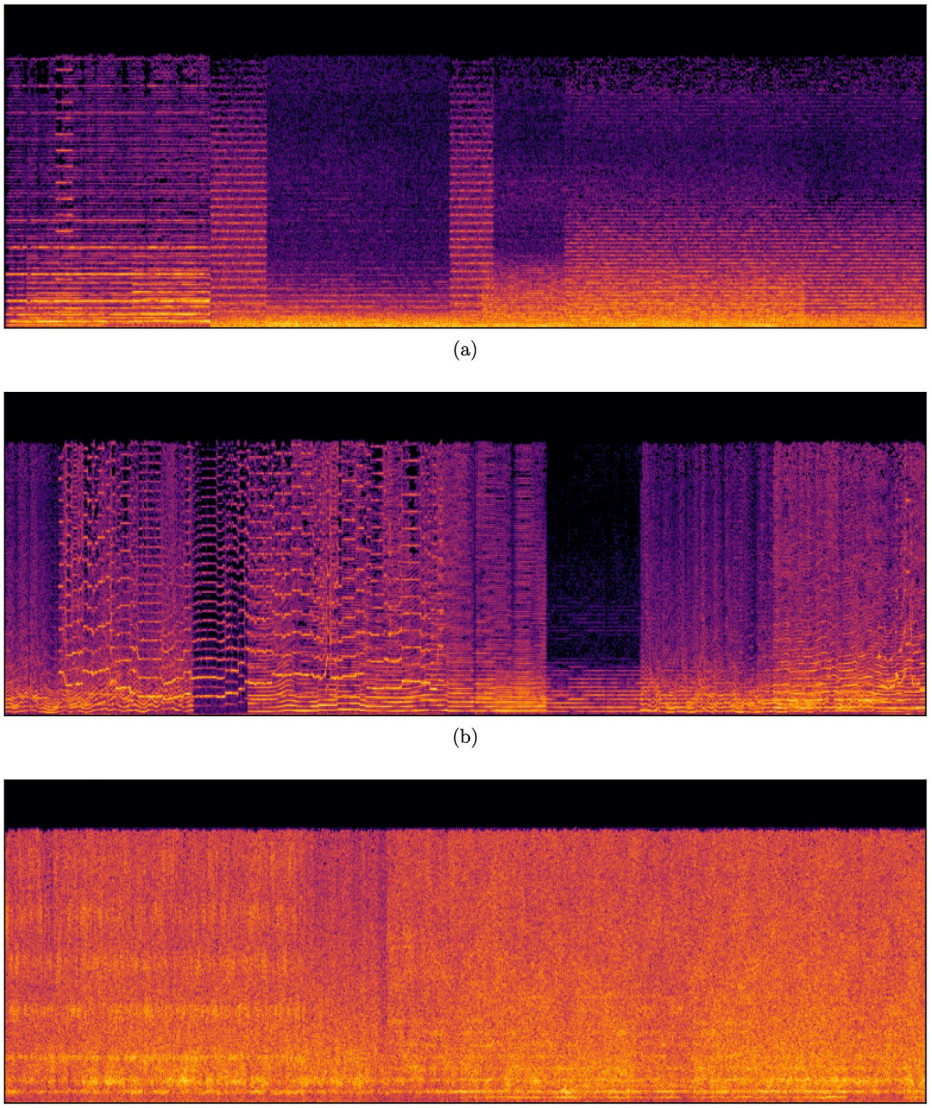

Fig. 33.2 Spectrograms of three homogeneous textures from *Gendy3*. (a) Fixed pitch. (b) Fluctuation and *glissandi*. (c) Noise. Figure created by author (2024).

Xenos

Motivation

DSS produces a variety of compelling sounds but is problematic to control. Lacking basis in acoustic or instrumental models, its pitch and timbral features are emergent, arising from parameters only indirectly connected to perceptual characteristics.[16] Indeed, Xenakis described composition with DSS as "a struggle," likening the process to reining in "wild horses."[17]

It should be noted that GENDY was a non-real-time application. Xenakis therefore could not manipulate DSS parameters while listening to the algorithm, which undoubtedly contributed to the challenges he experienced. Furthermore, the parameters of each GENDY voice were static.[18] While Xenos is far from the first implementation of DSS to overcome these limitations (this distinction belongs to Peter Hoffmann's New GENDYN Program),[19] real-time operation remains a significant aesthetic departure. Immediate aural feedback facilitates compositional decision-making and promotes proficiency with DSS, while dynamic modification of synthesis parameters affords an additional dimension of control, enabling gestures and textures that evolve in radical ways.

Though unpredictable, DSS is capable of a variety of behaviors with respect to pitch. In his sketchbook, Xenakis annotated parameters with the pitches that they induced,[20] indicating his desire to exercise a degree of deterministic control over the harmonic products of the algorithm. The design of Xenos is informed by similar concerns. Xenos makes DSS more practical for general-purpose composition by adjusting the way that it specifies pitch and presents related parameters to the user. It additionally leverages the inherent microtonality of DSS via pitch quantization.

Xenos also aims to encourage composition with DSS through its implementation as a plugin. Since the plugin is arguably the most widely used class of virtual instrument, it offers an attractive medium for preserving and democratizing historical, nonstandard synthesis algorithms and other lesser-known computer music techniques. Packaging DSS in this ubiquitous and long-lived format extends access to a broad group of current and future composers of electronic music, who might find new creative applications for it.

Finally, the Xenos project is motivated by the desire to make a cross-platform and widely compatible DSS instrument available as open-source software. Because Xenos is built with JUCE, an industry-standard C++ framework for audio programming, it is

16 Curtis Roads, personal communication, 2022.
17 Robindoré and Xenakis, 1996, p. 13.
18 This might appear contradictory, but the "dynamic" element of DSS is its continually morphing waveform, which it achieves even with fixed random-walk parameters.
19 Hoffmann, 2000, p. 31.
20 Hoffmann, 2004, p. 139.

easily modified or extended by interested developers from the community. The Xenos source code includes original implementations of a DSS voice, a frequency quantizer, and a Scala parser, all of which may be incorporated into new projects.

A Perceptual Pitch Parameter

The elastic barriers of the pitch random walk specify the minimum and maximum pitches of a DSS voice. Xenos expresses these via two metaparameters: *pitch center*, which is a MIDI pitch, and *pitch width*, which defines a range about the center in equal-tempered semitones. Incoming MIDI note-on messages trigger voices and define their pitch centers; the pitch width is a single parameter affecting all voices. This design more readily fits the model of the traditional musical note, facilitating adaptation of DSS as a MIDI-equipped, polyphonic plugin; it is also more perceptually informative, allowing intuitive reasoning about the range of each voice during composition or performance.

From here, Xenos closely follows Xenakis's original design. The high-level pitch metaparameters reduce to minimum and maximum periods (in samples). Elastic barriers constrain the randomized duration of each linear segment within these values divided by the number of segments. The period (and therefore frequency) of each cycle results from the sum of the individual segment durations.

Pitch Quantization

Xenos introduces a pitch quantizer that tunes each wave period to the nearest degree of a user-defined scale. Its effect is to precisely compress or expand the cycle so as to snap the DSS voice to an exact pitch.[21] Quantization retunes fixed pitches, converts *vibrato* into *ostinato*, transforms *glissandi* into scalar melodies, and filters noise through specific pitch collections. Table 33.1 describes the fourteen scale presets included in Xenos.

Scale	Cardinality	Description
Pentatonic	5	Equal-tempered pentatonic
Pentatonic (Pythagorean)	5	Just-intoned (three-limit) pentatonic
Blues	6	Equal-tempered minor blues
Blues (seven limit)	6	Just-intoned blues with septimal blue notes

21 Because quantization occurs at the end of an otherwise quite orthodox DSS scheme, it is easily bypassed in favor of more traditional behaviors.

Scale	Cardinality	Description
Whole-tone	6	Equal-tempered whole steps
Major	7	Equal-tempered diatonic major
Major (five limit)	7	Just-intoned diatonic major
Minor	7	Equal-tempered diatonic natural minor
Minor (five limit)	7	Just-intoned diatonic natural minor
Octatonic	8	Alternating equal-tempered whole and half steps
Overtone	8	Thirteen-limit collection using intervals from the first four octaves of the harmonic series
Chromatic	12	Equal division of the octave into twelve parts
Bohlen–Pierce	13	Equal division of the third harmonic into thirteen parts
Quarter-tone	24	Equal division of the octave into twenty-four parts

Table 33.1 Scale presets included in Xenos.

The quantizer can also import arbitrary scales in the Scala format. Scala (.scl) files implement a simple, human-readable syntax for specifying original scales and are supported by a long list of commercial and experimental music software.[22] Because Scala can represent intervals as either ratios or cents, it is a very flexible and powerful tool for composing xenharmonic music.

Variable Random-Walk Order

Most DSS implementations use either first- or second-order random walks; Xenakis himself employed the former in *La Légende d'Eer* and the latter in *Gendy3*.[23] The choice is musically consequential: a first-order walk wanders erratically throughout the random-walk space, imposing a noisy quality on any parameter it influences, while a second-order walk swings between the extremities of the range, producing a quasi-pulse shape that engenders a semblance of regularity. Figure 33.3 graphs both a primary walk and the secondary walk it feeds; their juxtaposition highlights the filtering effect of a second random-walk stage. Xenos implements second-order walks but offers first-order walks as an option.[24] It thus covers both of Xenakis's revisions and allows simultaneous use of different orders for the pitch and amplitude random walks.

22 Manuel Op de Coul, "Scala Scale File Format," https://huygens-fokker.org/scala/scl_format.html
23 Luque, 2009, p. 80–1.
24 Second-order walks, by definition, contain primary walks. To use the primary walk directly, one scales its output to the range of the secondary walk that it feeds.

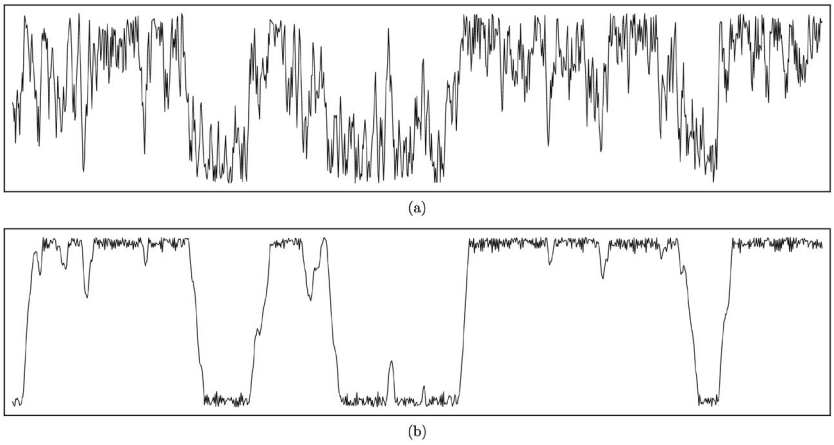

Fig. 33.3 Comparison of characteristic random-walk behaviors. (a) First order. (b) Second order. Where (a) is high, (b) tends toward the upper boundary; likewise, where (a) is low, (b) tends toward the lower boundary. Figure created by author (2024).

Variable Number of Linear Segments

Xenos supports varying the number of linear segments in a wave cycle between 2 and 128.[25] Using a greater number of segments models the complexity of a composite wave with components at various frequencies, amplitudes, and phases, resulting in a brighter timbre. Figure 33.4 compares the waveforms and spectrograms of DSS with four and sixteen segments. The pronounced frequency banding reflects constrained pitch fluctuation.

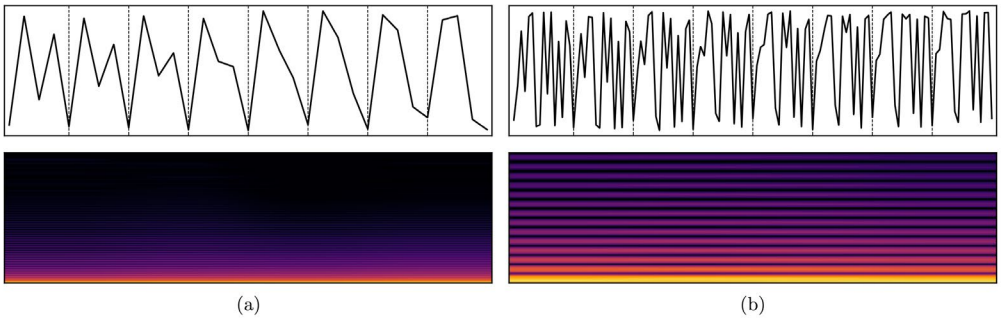

Fig. 33.4 Eight contiguous cycles of a DSS waveform and resulting spectrogram. (a) Four segments. (b) Sixteen segments. Figure created by author (2024).

25 This upper limit is arbitrary but practical, as the more segments there are, the shorter each must be (assuming a constant period). While DSS is possible with a single segment, this would only produce noise.

Variable Amplitude Envelope

In GENDY, the amplitude random walk alone shapes the amplitude of an individual voice ("sound field"),[26] which thus tends to begin or cease sounding rather instantaneously. Xenos implements an additional per-voice amplitude envelope using a classic, four-stage design. This feature brings DSS more in line with standard synthesizer architectures, enhancing its capacity for practical sound design by enabling a variety of deterministic, time-varying amplitude contours.

Graphical User Interface

Like most nonstandard synthesis techniques, DSS is obscure within the general domain of electronic music and likely opaque to many potential users. The Xenos graphical user interface (GUI), shown in Figure 33.5, thus aims to present all controls clearly and with an apparent logic that makes the instrument easy to learn and rewarding to use.

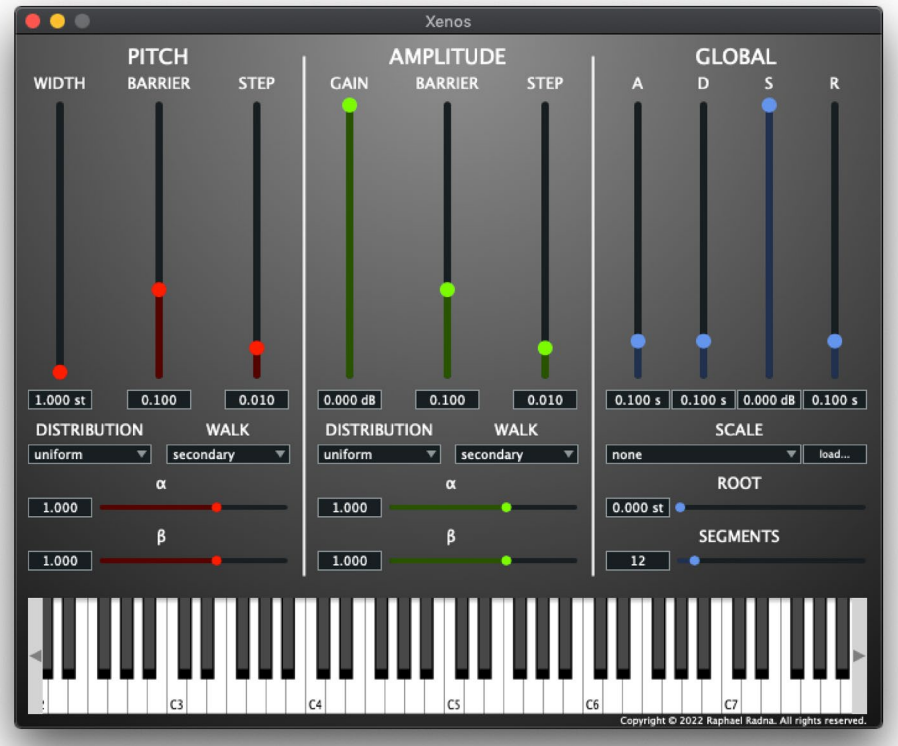

Fig. 33.5 Xenos plugin interface. Figure created by author (2024).

26 Xenakis, 1992, p. 296–97.

The GUI is divided into three color-coded panels that group related controls: the Pitch panel (left) contains the pitch random-walk parameters; the Amplitude panel (center) contains the amplitude random-walk parameters; and the Global panel (right) contains the parameters affecting the amplitude envelope, the pitch quantizer, and the number of linear segments. Table 33.2 details the parameters of the Xenos instrument.

Group	Parameter	Description
Pitch	Width	Secondary elastic barriers as a range about a voice's center pitch in equal-tempered semitones; defines the minimum and maximum pitch of each voice
	Barrier	Primary elastic barriers as ratio of the secondary walk space; limits the difference between successive pitch secondary-walk step sizes[27]
	Step	Primary step size as ratio of the primary walk space; limits the difference between successive pitch primary-walk steps
	Distribution	Stochastic distribution for generating pitch random-walk steps
	Walk	Order of the pitch random walk
	α	First parameter of the pitch stochastic distribution
	β	Second parameter of the pitch stochastic distribution[28]
Amplitude	Gain	Secondary elastic barriers as a bipolar range about zero (linear amplitude) in decibels; defines the minimum and maximum amplitude of each voice
	Barrier	Primary elastic barriers as ratio of the secondary walk space; limits the difference between successive amplitude secondary-walk step sizes
	Step	Primary step size as ratio of the primary walk space; limits the difference between successive amplitude primary-walk steps
	Distribution	Stochastic distribution for generating amplitude random-walk steps
	Walk	Order of the amplitude random walk
	α	First parameter of the amplitude stochastic distribution
	β	Second parameter of the amplitude stochastic distribution

27 The Barrier parameter has no effect when the primary walk is selected.
28 Only the Gaussian, logistic, and sinus distributions respond to a second parameter.

Global	A	Amplitude envelope attack time in seconds
	D	Amplitude envelope decay time in seconds
	S	Amplitude envelope sustain level in decibels
	R	Amplitude envelope release time in seconds
	Scale	Scale for pitch quantization
	Root	Pitch class of the first degree of the scale in equal-tempered semitones
	Segments	Number of linear segments per cycle

Table 33.2 Xenos parameters by group.

Host Software Integration

Xenos acquires much interactive functionality through integration with a plugin host, typically a digital audio workstation (DAW). Using Xenos within such an environment provides benefits such as MIDI sequencing, physical controller mapping, and parameter automation. These affordances are well known and understood by electronic musicians of all backgrounds; applied to Xenos, they offer a familiar and convenient entry point to experimental synthesis.

The DAW routes incoming MIDI data to a track containing a Xenos instance. In addition to note-on and note-off events, Xenos responds to pitch bend messages, enabling an additional, deterministic layer of pitch transposition up to one octave above or below voice pitch. Sustain pedal messages are also implemented.

A suitable DAW will facilitate control of Xenos parameters via physical devices and will typically offer an automatic mapping feature. This allows assignment of external hardware controllers (usually faders and dials, but also wheels, pedals, breath controllers, touch-sensitive surfaces, etc.) to any parameter, a crucial element of many composition and performance workflows.

Finally, using Xenos within a DAW enables automation: the specification of parameter value as a function of time. Any Xenos parameter can be automated, including those that represent a discrete choice, such as the Distribution, Walk, and Scale parameters. Automation curves can be drawn manually, generated algorithmically, or captured from controller gestures.

The unifying principle of these interfaces is the abstraction of the control apparatus from the DSS process. As a result, any interactive or algorithmic composition system that can produce MIDI events can drive one or more Xenos instances. Beginners are thus empowered to explore DSS intuitively via familiar and convenient MIDI control schemes. At the same time, ambitious composer-programmers can define parameterized, time-variant gestures that produce the low-level MIDI instructions needed to realize specific

DSS events according to any criteria. Xenos might thus appeal to electronic music composers of diverse aesthetic concerns, technical orientations, and creative practices.

Musical Applications

This section considers specific musical applications of Xenos through fourteen sound examples that illustrate characteristic timbres and gestures.[29]

Media 33.1 demonstrates traditional DSS sounds similar to those heard in *Gendy3*, including fluctuating pitch, *glissando*, and noise. These behaviors are attained through various settings of the pitch random-walk parameters. In general, low Barrier and Step values are required to induce behaviors other than noise.

Media 33.1 Typical DSS behaviors in Xenos: fluctuating pitch, *glissando*, and noise.
https://hdl.handle.net/20.500.12434/6fb46f5c

DSS easily produces noise by applying large step sizes and wide elastic-barrier distances to the random walks. Such settings cause discontinuous motion of the breakpoints, resulting in dissimilarity between adjacent cycles. Because DSS affects pitch and amplitude independently, Xenos can create a variety of noise colors. Many of these exhibit a subtly harmonic quality; only the most extreme settings overcome the periodicity inherent in the algorithm. Media 33.2 demonstrates noise generation, first by increasing the pitch Barrier and Step parameters, then by increasing the amplitude Barrier and Step parameters, and then by both methods combined.

Media 33.2 Noise generation by discontinuous pitch fluctuation, discontinuous amplitude fluctuation, and both techniques simultaneously.
https://hdl.handle.net/20.500.12434/d4b9dc80

The choice of random-walk order asserts additional influence over the instrument's behavior. Media 33.3 presents a noise texture produced by the amplitude random walk,

29 By its nature, DSS can produce both very high and very low frequencies; as such, it is prone to both aliasing and DC offset. These sound examples have been filtered below 20 Hz and normalized, but are otherwise unprocessed.

first using the secondary walk and then the primary walk, with all other parameters held constant. The secondary walk produces greater periodicity, preserving traces of pitch, while the primary walk produces an aperiodic wave with a far noisier timbre.

Media 33.3 Effect of second- and first-order random walks on amplitude. A first-order walk produces a more uniform distribution of values, resulting in a noisier timbre.
https://hdl.handle.net/20.500.12434/0940e955

Perceptually, the most immediate effects of the amplitude random walk concern timbre.[30] In Media 33.4, the vertical movements of the breakpoints create gradually drifting peaks and troughs in the waveform, shifting emphasis among harmonics of the pitch period and imparting a sense of continuous spectral evolution.

Media 33.4 Stochastic spectral emphasis among harmonics of the pitch period, produced by the amplitude random walk.
https://hdl.handle.net/20.500.12434/b215e59d

Media 33.5 varies the number of linear segments in the wave cycle from eight to sixty-four and back, affecting spectral brightness. Though dynamically variable, this parameter is, by definition, discrete, and far more sensitive at the lower end of its range.

Media 33.5 Effect of the number of wave-cycle segments on timbre. A greater number of segments increases brightness.
https://hdl.handle.net/20.500.12434/e661056c

The stochastic distributions influence the random walks in various ways. They typically follow one of two general tendencies: *symmetrical* distributions generate values around

30 The rapid, random fluctuations of the breakpoints occur at the microsound timescale and do not usually lend themselves to audible variations in the loudness of a sound object.

a mean, producing a chaotic fluctuation within a range of values, and *asymmetrical* distributions converge on one of the boundaries of the random-walk space, producing a directed, continuous trajectory toward one elastic barrier or the other. Table 33.3 classifies the available distributions according to this typology.

Symmetrical	Asymmetrical
Uniform	Arcsine
Gaussian	Exponential
Poisson	Triangular
Cauchy	Sinus
Logistic	
Hyperbolic Cosine	

Table 33.3 Classification of stochastic distributions available in Xenos by behavioral tendency.

However, even within these categories, different distributions produce contrasting behaviors. Media 33.6 compares the effects of the Cauchy and hyperbolic cosine distributions on the pitch random walk, with all other parameters held constant. The Cauchy distribution imparts a frenetic fluctuation, while the relatively smoother slope of the hyperbolic cosine distribution produces a gentler pitch variation.

Media 33.6 Effect of Cauchy and hyperbolic cosine distributions on pitch. While both produce fluctuation, the roughness of the former contrasts the smoothness of the latter.
https://hdl.handle.net/20.500.12434/b6539f51

Application of an asymmetrical distribution to the pitch random walk produces continuous *glissandi*. Since these begin at a voice's pitch center and terminate at an interval defined by Width, they can be applied quite deterministically. The other pitch random-walk parameters influence the *glissando* rate and direction. Media 33.7 demonstrates ascending and then descending one-octave *glissandi* via the arcsine distribution.

Media 33.7 Ascending and descending one-octave *glissandi* produced by the arcsine distribution, continuous.
https://hdl.handle.net/20.500.12434/bb02e5db

Because Xenos centers a DSS voice on a MIDI pitch, it can be played like a typical keyboard instrument. Media 33.8 produces deterministic melody and harmony via standard MIDI sequencing. No quantization is applied; a narrow Width (ca. one semitone) simply constrains the voices tightly around their center pitches. The pitch random walk subtly detunes the oscillators within this range, simulating tape wow and flutter effects.

Media 33.8 Deterministic pitch control via MIDI sequencing with constrained pitch width.
https://hdl.handle.net/20.500.12434/b0746e07

Variation of the pitch width thus enables interpolation between determinism and chaos. Media 33.9 demonstrates this technique with four voices that begin in octaves and then split off into wild, independent *glissandi* before converging once again. The effect recalls the arborescences employed by Xenakis in several of his works: organic, branching structures reminiscent of trees or lightning in form.[31] The quasipalindromic morphology of Media 33.9 suggests a particular affinity with Figure 33.6, a section of Xenakis's graphic score of *Mycènes Alpha* (1978), for the UPIC graphical synthesis system, featuring an expanding and contracting network of arborescences.[32]

Media 33.9 Chaos and convergence: varying the pitch width alternately constrains several voices to their center pitches and allows them to fluctuate.
https://hdl.handle.net/20.500.12434/7e472a7b

31 Varga, 1996, p. 207.
32 Xenakis, 1987, p. 13.

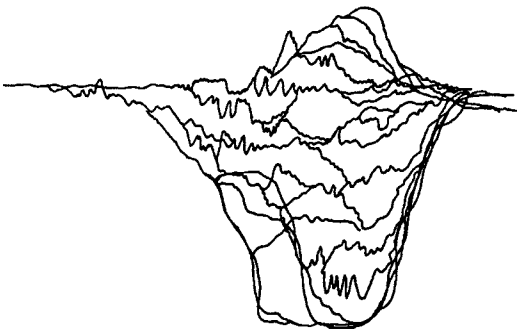

Fig. 33.6 Converging arborescences in *Mycènes Alpha* by Iannis Xenakis. The traces represent frequency over time; their branching and converging contours thus denote an expansion and subsequent contraction of frequency range. Xenos produces analogous gestures via variation of its Width parameter. © Les Editions Salabert. Used with permission.

Pitch control in Xenos is further refined by its quantization feature. Media 33.10 quantizes a single, meandering *glissando* to the pentatonic scale, producing a pleasant, folk-like melody.

Media 33.10 Quantization of a single voice to produce melody.
https://hdl.handle.net/20.500.12434/ac4fae7c

With multiple voices, quantization produces counterpoint. Media 33.11 quantizes three voices to a five-limit major scale. The absolute pitch differences between the voices compound with their stochastic fluctuations to create *glissandi* at different rates and in random directions. Quantization transforms these into stepwise motion; from the interplay between the voices emerges the four types of contrapuntal motion (parallel, similar, oblique, and contrary) and various contrapuntal devices (passing tones, neighbor tones, suspensions, etc.) The pure tuning makes for an especially radiant quasi-chorale texture.

Media 33.11 Quantization of several voices to produce counterpoint.
https://hdl.handle.net/20.500.12434/214cb279

Quantization discretizes a continuous *glissando* produced by an asymmetrical distribution. Media 33.12 features the same one-octave *glissandi* of Media 33.7 but quantized to quarter-tones. This quantization highlights the acceleration or deceleration inherent in each *glissando*, depending on its direction and due to the logarithmic nature of pitch perception.

Media 33.12 Ascending and descending one-octave *glissandi* produced by the arcsine distribution, discrete.
https://hdl.handle.net/20.500.12434/c568af43

With certain settings of the amplitude random walk, Xenos can simulate granular synthesis. Media 33.13 interpolates between a sustained tone cluster and a quasi-granular texture. As the amplitude Barrier value increases, the smooth dynamic contour gives way to an increasingly iterative and chaotic texture in a manner reminiscent of injecting asynchronicity into a grain stream. Later, increasing the Step parameter results in a much noisier timbre, an effect perceptually analogous to reducing grain size. The turbulent Cauchy distribution is well suited for this application.

Media 33.13 Simulation of granular synthesis with dynamic parameters. Modifying the parameters of the amplitude random walk enables transitions between smooth and iterative textures, and between harmonic and noisy spectra.
https://hdl.handle.net/20.500.12434/4303098d

Applying quantization to such a texture imposes a harmonic character upon it. Media 33.14 presents a single quasi-granular cloud quantized to four different scales: pentatonic, whole-tone, octatonic, and Bohlen–Pierce.

Media 33.14 Harmonic quasi-granular clouds via pitch quantization.
https://hdl.handle.net/20.500.12434/d3477587

Conclusion

Xenos implements and extends DSS in a modern virtual instrument. It aims to:

- Preserve the original sounds and behaviors of DSS.
- Simplify DSS by implementing perceptually informative parameters.
- Enhance DSS with a pitch quantizer that enables xenharmonic exploration.
- Provide access to DSS in a convenient plugin format.
- Facilitate composition and sound design with DSS through an intuitive GUI and standard interfaces.

Although the version of Xenos described here is a viable instrument that realizes these fundamental aims, it can also be considered a starting point, as Xenakis regarded his own work,[33] as there remain several directions for continued development that would enhance its creative potential.

One future goal should be further adaptation of traditional synthesizer elements. A general framework for parameter modulation, e.g., the inclusion of supplementary envelopes, low-frequency oscillators, and a matrix for managing their routings to synthesis parameters, would greatly augment the instrument's sound design capabilities by enabling an additional layer of deterministic, time-variant timbre modification.

The initial state of the wave cycle is another area of interest. A Xenos voice starts with its breakpoints randomized, but since DSS is sensitive to initial conditions, other configurations may yield effective behaviors.[34] Alternatively, Dynamic Stochastic Wavetable Synthesis offers a promising method for exploring DSS with complex waves. This technique applies DSS to arbitrary sample data, e.g., the classical waveforms or fragments of recorded audio, enabling the deformation of recognizable timbres by DSS.[35]

Additionally, visualization should play a larger role in the instrument's future. While the Xenos GUI aims to present parameters in an appealing and informative layout, it would be enhanced by visualizations of, e.g., the waveform, the random walks, or the stochastic distributions. Visualization presents a real opportunity to create new insight into this unconventional algorithm, its parameter space, and its musical applications.

Finally, Xenos could be made to adapt to multichannel output. Xenakis proposed duplicating the same DSS parameters in multiple voices, using unique random seeds

33 Xenakis, 1992, p. 293.
34 Beginning with the breakpoints zeroed, for example, induces an initial fade in.
35 Radna, 2023, p. 343.

to produce perceptually equivalent but nonidentical waves.[36] The ability to route these voices to individual loudspeakers would have compelling implications for spatial electronic music composition.

In *Formalized Music*, Xenakis criticizes early electronic music for its reliance on the "simplistic sonority" of "pure" electronically generated sound.[37] These timbres are deficient, he contends, due to their spectral stasis, unnatural transients, and resistance to pattern recognition. His contrasting approach, which led him to invent Dynamic Stochastic Synthesis, starts from chaos and creates order by introducing constraints. By imposing discrete pitch onto DSS, Xenos takes this principle one step further; in this sense, it proceeds in the same spirit.

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36 Xenakis, 1992, p. 298.
37 Ibid., p. 243.

34. Light Tectonics: The New Aesthetics in Iannis Xenakis's Work

Yin Yu and Conrad Harris[1]

The Encounter between Xenakis's Work and his Students

I (Yin Yu) studied for a Master's degree in Interior Architecture at the University of Oregon with a background in electronic engineering and information technology. I was very motivated by an interdisciplinary approach to architectural design. Around the early 2010s, open-source hardware became affordable. It instantly grabbed my attention and motivated me to experiment with new technologies in interior design projects. My Master's dissertation, "Open-Source Community," was deeply influenced by this software movement.[2] After architecture school, I returned to China and started practicing in architectural design firms in Beijing. During my spare time, I built an open-source 3D printer at home and experimented with digital design and fabrication.

While in architecture school, I became aware of a Beijing-based musician and poet, Yan Jun (b. 1973), who works with field recordings of building sounds. I listened to "*One*" from the debut album, *Ceremony* (2012), by the Tea Rockers Quintet, which comprises Yan Jun, folk artist Xiao He, Guqin master Wu Na, multi-instrumentalist Li Daiguo, and tea master Lao Gu.[3] The electronic sounds entwining traditional Chinese instruments and culture amazed me. Yan Jun created the Subjam label and organized a series of indie concerts called Miji. I met Yan Jun on 12 May 2015, during a Miji concert at the Meridian Space in Beijing. It was, of course, not a commercial concert. Only

1 The authors wish to thank Sharon Kanach for her guidance and advice around *The Shape of Light* project initiated by the Xenakis Project of the Americas. We are thankful to Carey Lovelace and Barbara Dobbs Mackenzie for leading and organizing the New York session of the Meta-Xenakis Global Symposium. Special thanks to Pauline Kim Harris for her video documentations. We thank Juan Manuel Esclante for his feedback on user interface design. The performance trip was supported by the School of Art and Design at the San Diego State University.

2 Yu, 2013.

3 See EnT-T (label), "Tea Rockers Quintet – One" (17 April 2012), *YouTube*, https://www.youtube.com/watch?v=dOTSAbQEQyg. See also "The Tea Rockers Quintet," *Bandcamp*, https://thetearockersquintet.bandcamp.com/

 https://doi.org/10.11647/OBP.0390.36

five people were in the audience (Beijing has a population of twenty-one million). After introducing myself as an architectural designer, Yan Jun mentioned a name that changed my life: Iannis Xenakis. Although I studied many works of Le Corbusier (1887–1965), Xenakis was not on my radar, nor was he for my architectural colleagues or teachers. Half a year later, to thank Yan Jun, I designed a 3D-printed object of his label Subjam (Figure 34.1), inspired by Xenakis's *Polytope de Montréal* (1967).[4]

Fig. 34.1 The 3D-printed design for the music label Subjam (2015). Photo by Yin Yu.

Through the book *Music and Architecture* and the publication *Iannis Xenakis: Architect, Composer, Visionary*, Xenakis's work immediately resonated with me.[5] His theory and vision, and his works across art, architecture, music, and mathematics motivated me to do research and practice with new technologies.

4 Xenakis's drawing which inspired my object can be seen in: Kanach and Lovelace, 2010, p. 66.
5 Xenakis, 2008; Kanach and Lovelace, 2010.

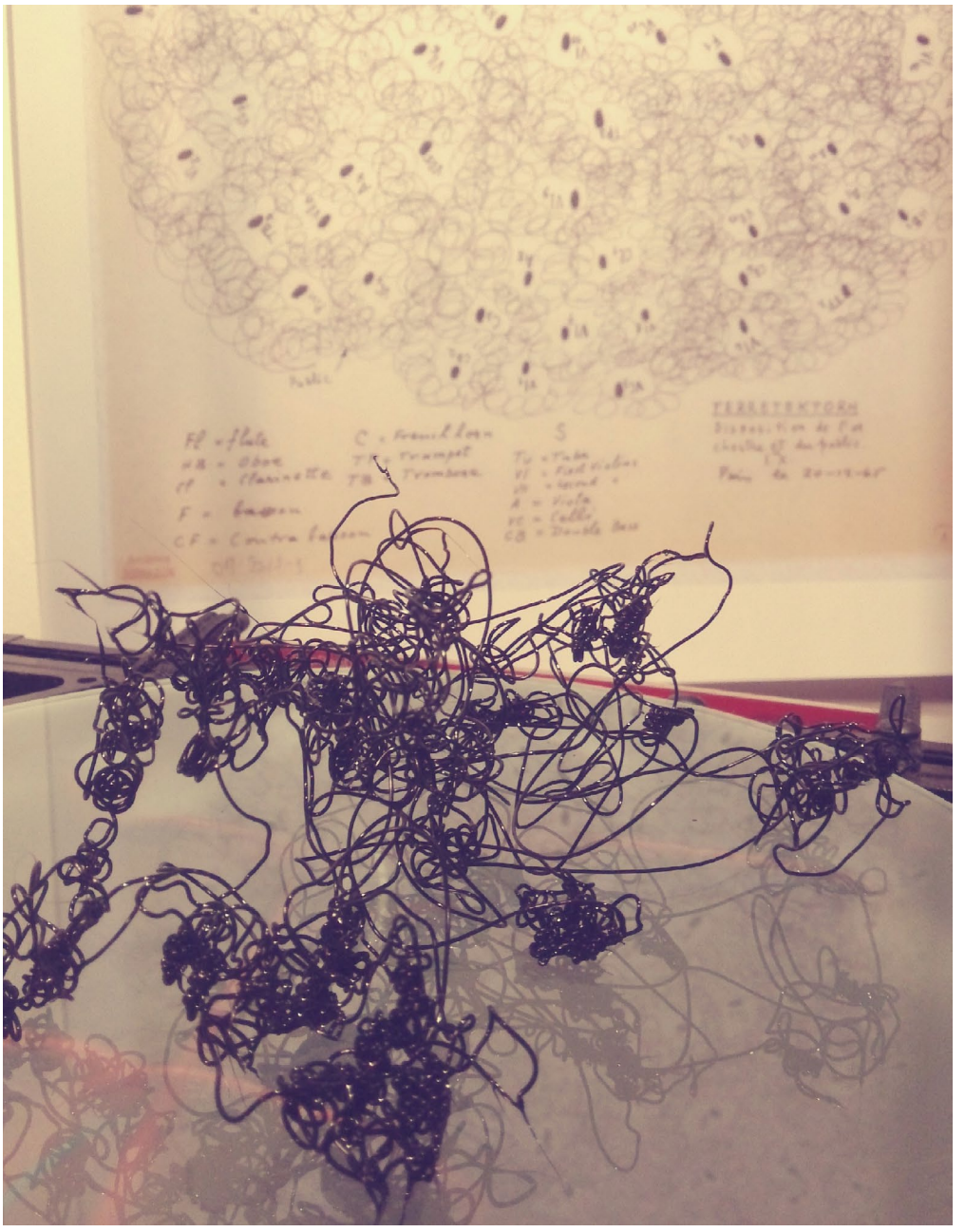


Fig. 34.2 An unexpected 3D-printed black object, in front of Xenakis's drawing of *Terretektorh* (distribution of musicians) (2015). Photo by Yin Yu.

I started studying Xenakis's work and began a few design experiments with a hobby 3D printer at home. An unexpected printing result (Figure 34.2) made me wonder how computers create "stochastic fabrication." Soon, I realized that my independent research was extremely limited by the resources I could access. I started to consider a

research path that focused on architecture and technology. However, I needed to figure out which program or institute to pursue it in. I reached out to Sharon Kanach (b. 1957) for advice on my career in 2016 (see below). Kanach, who later became one of my mentors, introduced me to Xenakis's student, Curtis Roads (b. 1951), and the graduate program in Media Arts and Technology (MAT) at the University of California, Santa Barbara (UCSB). MAT has a strong interdisciplinary research culture. In addition, the program has the expertise and facilities in electronic music, which perfectly matched my desired research direction. After leaving Silicon Valley in 2010 as an engineer, I never thought I would return to California for art.

My PhD studies started in Fall 2017.[6] I completed my dissertation, "*Sound Morphogenesis: A Theory and Methodology of Architecture and Design informed by Sound and Music*"[7] in 2022.

My first encounter with Xenakis's friends and students was actually before my doctoral study. In the summer of 2016, the Centre Iannis Xenakis (CIX) organized an international conference: *From Xenakis to the Present: the Continuum in Music and Architecture*.[8] The first leg of this conference took place in Cyprus at the European University of Cyprus (Cultural Studies and Contemporary Arts research laboratory (CSCA)) and University of Cyprus (Architecture Department). During the two-day event, I met Sharon Kanach, co-director of CIX; David Lieberman (b. 1951), then a professor from The Daniels Faculty of Architecture, Landscape, and Design at the University of Toronto; Lori Freedman (b. 1958), a clarinettist, improviser, and composer; among many other inspiring musicians, architects, scholars, and Xenakis experts.

Another significant impact during the *Continuum* conference trip was the border crossing experience in Nicosia—a divided capital city in two countries (the Turkish side being only recognized by the Turkish state, the Cypriot side being a member of the European Union). Coming from China, I have experienced the digital border's (the Great Firewall of China) disregard for human rights. Xenakis, a Greek political refugee who settled in France, inspires me from his work and life.

Xenakis's Works Involving Light

My understanding of architecture evolved through researching Xenakis's work and field studies. In December 2015, I hoped to see some of Xenakis's drawings at the Centre de Documentation de la Musique Contemporaine (CDMC, Documentation Center for Contemporary Music). I did not find his drawings; however, some books collected in the library (Figure 34.3) at the CDMC became my first source. As an

6 I was advised by Curtis Roads (chair), Sharon Kanach, Jennifer Jacobs (UCSB professor, researcher in computational fabrication, b. 1984), and Yitang Zhang (UCSB professor, mathematician, b. 1955).

7 Yu, 2022a.

8 *Continuum2016*, https://continuum2016.wordpress.com/

independent researcher who was outside of academia at that time, accessing this public library became extremely valuable. In May 2016, I visited several iconic buildings in France by Le Corbusier: *Cité radieuse/Unité d'Habitation* (Radiant City/Housing Project) in Marseille, the church *Notre-Dame du Haut* in Ronchamp, and the exterior of La Tourette convent outside of Lyon (Figure 34.4). I appreciated the aesthetics of these buildings more after learning that Xenakis designed or influenced some of their architectural elements. In March 2019, I visited the Roman baths' Frigidarium at the Musée de Cluny in Paris, where Xenakis showcased his *Polytope de Cluny* between 1972–4. Curtis Roads shared with me that he experienced this twenty-seven-minute sound and light performance eight times! Xenakis's *Polytope de Cluny* marked this ancient Roman architecture with special memories for people who had attended the performances. The Frigidarium, however, was dark and quiet during my visit (Figure 34.5). It left a sense of emptiness, but also motivated me to reimagine the Frigidarium as a legacy venue for future performances. My last field study before the COVID-19 pandemic took place in September 2019. I drove to the archaeological site at Mycenae, where Xenakis's *Polytope de Mycènes* took place in 1978. The thirty-two-hectare site overwhelmed me with its massive scale.

Fig. 34.3 A section of the book collection about Iannis Xenakis at the Centre de Documentation de Musique Contemporaine (CDMC), Paris (2015). Photo by Yin Yu.

Fig. 34.4 The author at the entrance of La Tourette with Xenakis's design of light "machine guns" behind her (2016). Photo by Yuanming Hu.

Fig. 34.5 A personal sketch in the Roman baths' Frigidarium at the Musée de Cluny (2019). Photo by Yin Yu.

At MAT, my research explored Xenakis's work through various media, such as virtual reality (VR), laser light performance, audio-activated digital architecture, and audio/visual performance. In 2018, I created a VR piece called *Polytope de Giza* (Figure 34.6) which virtually represents a light composition at the Great Pyramid in Egypt. The virtual location of the project was inspired by Xenakis's drawing of Cosmic City (1964), where the scale is much larger than Giza.[9] The sound playback speed in the VR is based on the user's walking speed.[10] I was able to experience the change of sound speed through a virtual walkthrough.

In 2019, I did my first laser performance. Inspired by the hanging "mathematical object" both inside and outside of the Philips Pavilion, *Laser Architecture* was a light and sound performance converting digital Platonic solid geometry into sound waves and laser vectors (Figure 34.7). As I was not formally trained as a performer, this public performance was an encouraging steppingstone.

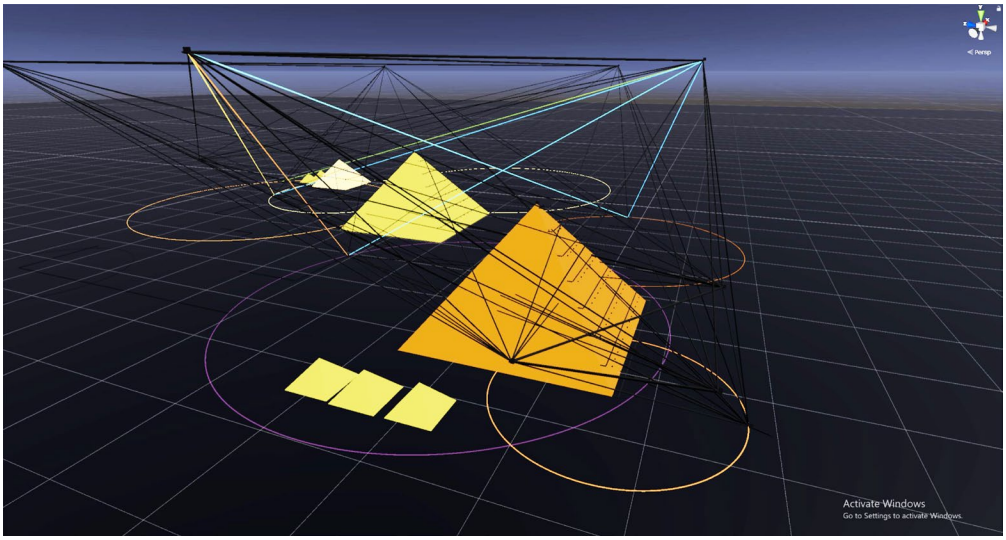


Fig. 34.6 A screen capture of the *Polytope de Giza* (2018). Figure created by Yin Yu.

9 Xenakis's drawing of the "Cosmic City" can be seen in Kanach and Lovelace, 2010, p. 86–7.

10 For the soundtrack, I used an audio file I downloaded from the internet. A male voice read ancient Egyptian poetry in Arabic. Since the project's virtual site is in Giza, I wanted to use local cultural sounds as the audio background. Back in 2018, I had just started to learn digital audio processing. Downloading an audio file and reworking it was one of my early experiments.

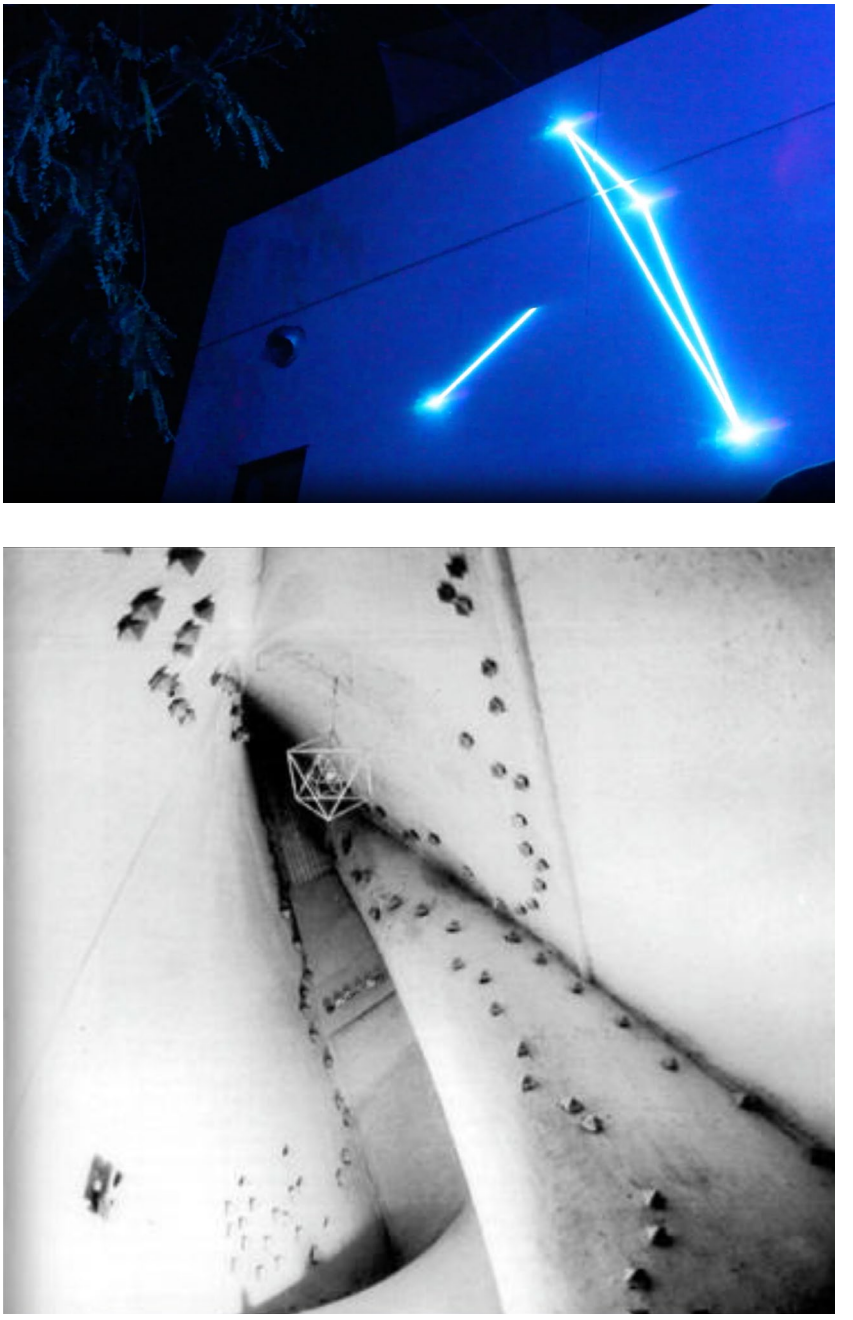


Fig. 34.7 (a) The performance of *Laser Architecture* at the Santa Barbara Center for Art, Science and Technology, March 2019 (Photo by Sihwa Park).[11] (b) The Platonic mathematical object hanging on the ceiling of the Philips Pavilion. © F.L.C./ADAGP, Paris/Artists Rights Society (ARS), New York, 2024.

11 Yin Yu, "Laser Architecture" (19 March 2019), https://w2.mat.ucsb.edu/yinyu/projects/LaserArchitecture.html

Light as the Bridge Between Music and Architecture

After visiting some architecture sites, and practicing as a multimedia artist and architectural designer, I came to the realization that light is the bridge between Xenakis's music and his architectural work. Not only artificial light in his polytopes, but also natural light in his architectural work. Light manifests form in architecture through direct and indirect lighting; light embodies time in music via period and frequency of lighting. Light connects Xenakis's two vocations: architecture and music.

One can trace Xenakis's light work back to the 1950s when he worked at Le Corbusier's studio. From his early study on light and the calculation of a sun path for the Assembly Building in Chandigarh, then "light canons," "machine guns" in the chapel of La Tourette, to the "streetlight" at the Unité d'Habitation in Marseille, as well as his famous and ubiquitous "undulating glass panes."[12] From the 1960s, Xenakis's light work expanded to computer-controlled artificial light, such as the flashing lights in *Polytope de Montréal*, laser lights in the *Polytope de Cluny*, and so on.[13] Light, in Xenakis's oeuvre, is a material that creates space, generates patterns, changes colors, evolves forms, and composes movement.[14]

Light Tectonics: Points, Lines, and Vectors

To celebrate Xenakis's centenary, in 2022, the Xenakis Project of the Americas commissioned Conrad Harris and me to collaborate on a piece we titled *The Shape of Light: A Visual Composition for Xenakis's Mikka and Mikka S*.[15] It is a performance of solo violin and audio visualization of Iannis Xenakis's composition *Mikka* (1971) and *Mikka S* (1976). The goal was to bring a new perspective on Xenakis's music and architecture through light study and digital technology. I call this approach light tectonics, which describes Xenakis's light phenomena. He used architectural elements, spatial location, computers, and light sources to compose visual performances in his work. The architectural elements include ceilings, walls, windows, and so on. For example, in the undulating glass panes, Xenakis designed a glazing system where light enters to create a performative space that changes throughout the day. Spatial location is the relative location of light. For instance, in the *Polytope de Cluny*, each laser beam was placed on a scaffold at a specifically designated location. In the *Polytope de Mycènes*, torches were carried around paths on the archaeological site.

Computers were used in many of Xenakis's polytopes. For example, in the *Polytope de Montréal*, Xenakis used computers to control the sequencing of the flashing lights.

12 Xenakis, 2008, Chapters 1.06 and 1.10; Chapters 1.14 and 1.16; p. 15; Chapters 1.11–1.13.
13 Xenakis, 2008, Chapters 4.03–4.06; Chapter 4.11.
14 Yu, 2022b.
15 "Xenakis Project of the Americas," *The Brook Center*, https://brookcenter.gc.cuny.edu/projects/xenakis-project-of-the-americas/

Like ingredients to a chef, Xenakis combined a variety of light sources in his work, such as direct/indirect light, flashing lights, searchlights, etc. In *The Shape of Light*, I selected six light tectonics "scenes" inspired by Xenakis's work.

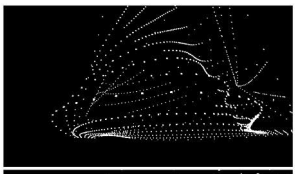
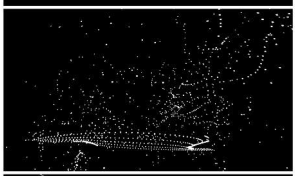
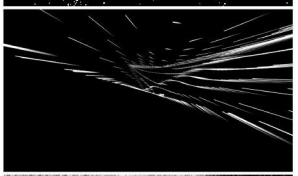
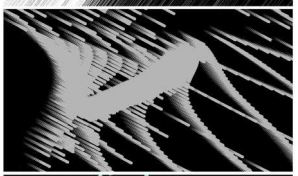
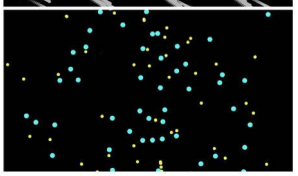
Scenes	References	Light Tectonics	Digital Light	Image
Scene one	The Philips Pavilion	Architecture envelope	Point	
Scene two	Walking through the pavilion	Spatial location	Point	
Scene three	Hyperbolic paraboloid	Architecture element	Point/line	
Scene four	Flashlights	Light source	Line	
Scene five	Laser light	Light source	Vector	
Scene six	Light cannons	Architectural element	Point	

Table 34.1 A table of light tectonics in *The Shape of Light*.

The first scene is the iconic Xenakis structure—the building envelope of the Philips Pavilion. I transform the continuous surfaces of the Philips Pavilion's digital model into a group of points. Each point represents a digital light source (e.g., LED light). Because of the density of the points, one can quickly identify the shape of the points based on the form of the Philips Pavilion. The second scene adds a spatial location element based on the first scene, bringing the viewers into the Pavilion. For the third scene, I focus more on detail. Since the hyperbolic paraboloid is an essential architectural element

of the pavilion, a single surface of the Philips Pavilion was selected. I transform this single surface into light beams. In this scene, digital lines represent the light beams. The fourth scene is a light phenomenon that transitions from the lights in the hallway at La Tourette to the flashing lights of the *Polytope de Montréal*. Continuing to the fifth scene, inspired by Xenakis's light trajectory design for laser beams and searchlights in his later works, vectors were used to represent light directions. Finally, the sixth scene highlights the "light cannons" at La Tourette and Xenakis's passion for cosmology. The colored circles represent the white, red, and black "light canons" at La Tourette. The circles then transform into many small dots that represent stars in the sky. Table 34.1 summarizes the content of each of the six scenes, the design decision, the form of the digital light, and the image visualization.

During our collaboration, Harris stated that *Metastasis* (1953–4) "gave birth" to the Philips Pavilion. The selection of these six scenes focuses on digital light transformations based on the form of the iconic structure, coupled with the live solo violin performance of *Mikka* and *Mikka S*. Harris's performance of the *glissandi* makes the digital light transformation represent a new aesthetic of Xenakis's work.

The Shape of Light: A Visual Composition for Xenakis's *Mikka* and *Mikka S*

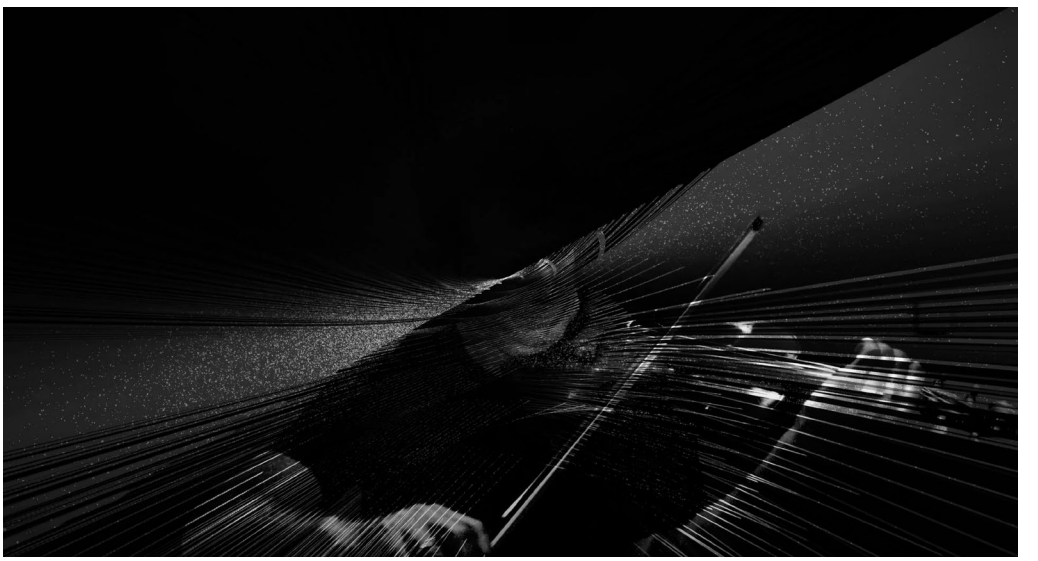
There are two versions of *The Shape of Light* (Media 34.1 and 34.2) performance. The first version was a pre-recorded performance for online screening, premiered on Xenakis's 100th birthday (29 May 2022) through the Meta-Xenakis consortium's website.[16] The second version was a live performance that premiered on 30 September 2022 at the Graduate Center of the City University of New York (CUNY) during the USA leg of the Meta-Xenakis Global Symposium Marathon. The pre-recorded version was also shown during coffee breaks in all five venues of the Marathon (Rouen (France), New York, Nagoya (Japan), Athens (Greece), and Mexico City (Mexico)).

The first version of the *Shape of Light* contains eight minutes of unedited live music recording and audiovisual composition. Harris's article on *Mikka* and *Mikka S* in *Xenakis Matters* is insightful and inspiring, along with his numerous performances of the work.[17] We wanted to take this opportunity to reenact a live performance by Harris with a visual representation that I would produce. Since it was for an online event, we decided that a pre-recorded video would be the best way to show the work. I recorded Harris's live performance on 20 April at the Karl Geiringer Hall UCSB, with assistance from sound engineer Connor Long. The black and white video intended to focus on

16 *Meta-Xenakis*, www.meta-xenakis.org

17 Harris, 2010; Kanach, 2012; see Brian Sawicki, "Conrad Harris - *Mikka* and *Mikka S* - Xenakis Matters" (1 March 2013), *YouTube*, https://www.youtube.com/watch?v=gQ0qDmr8j1s. This live performance was filmed at The Drawing Center on 28 February 2013 at The Drawing Center, NYC, during a book launch of Kanach, 2012.

the music and light. With a dark gray background, the white color represents light forms. The visual contains two layers. Harris's performance is one layer—recorded by a static camera from one direction. The audio visualization is another layer—which was generated by the software TouchDesigner (see below), based on the music. The final result is an edited visual composition of these two works, back-to-back. Sound artist Juan Manuel Escalante (b. 1982) mastered the sound. Figure 34.8 illustrates three different moments from the video.



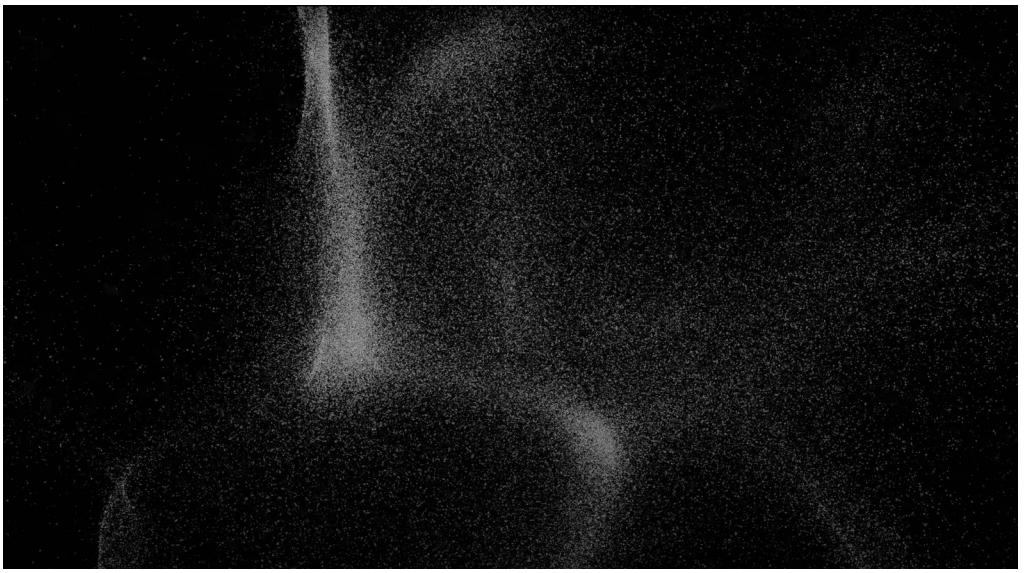


Fig. 34.8a–c Three scenes from version I of *The Shape of Light* video (2022). Figure created by Yin Yu.

The second version of *The Shape of Light* was a live performance in which Harris played solo violin, and I projected the visualization in real time. The live performance took place in the Skylight conference room sponsored by the Brook Center for Music Research and Documentation at the Graduate Center of CUNY in New York City during the USA tranche of Meta-Xenakis Global Symposium Marathon on 30 September 2022. Continuing from the first version, I brought in three additional visual elements for this live performance. They were inspired by Xenakis's light work, including laser lights, flashing lights, and light cannons. While Harris was playing, the string sounds were captured by the computer's microphone, which triggered the audiovisual software to project visual interpretations to two screen monitors (Figure 34.9). From a visual artist's perspective, the challenge of the live performance was the time measure. I sketched a provisional performance score on a paper after a few rehearsals. Figure 34.10 is a digital version based on the original sketch.

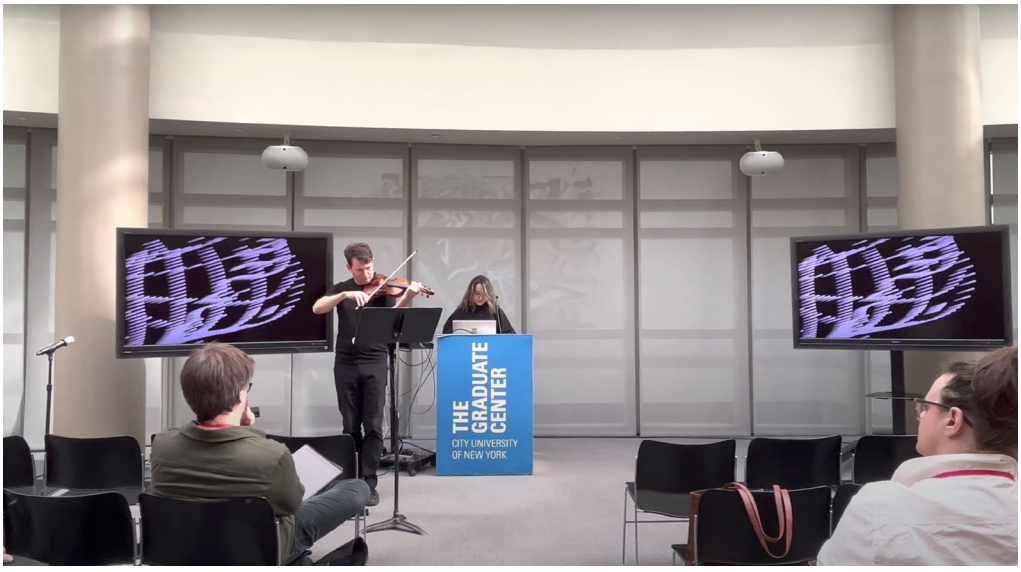


Fig. 34.9 Live performance of *the Shape of Light* (version II) at the Brook Center, CUNY (2022). Photo by Pauline Kim Harris.

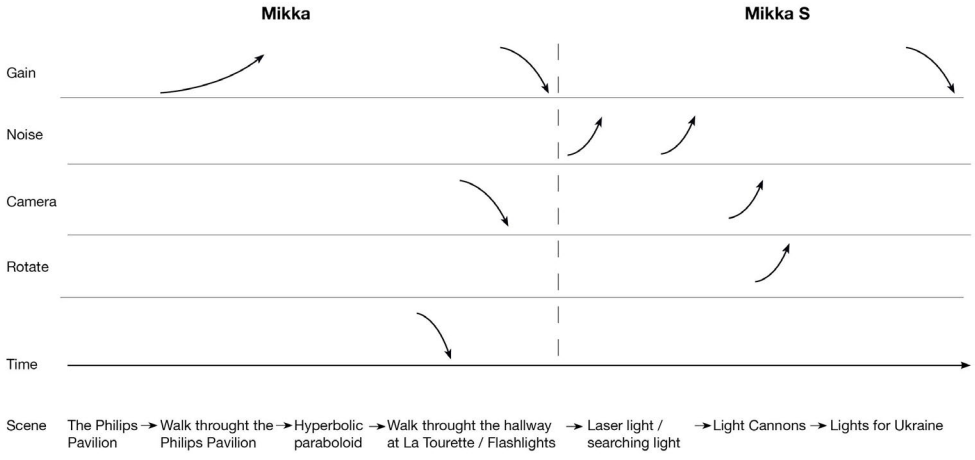


Fig. 34.10 A visual performance score for *The Shape of Light* (2022). Figure created by Yin Yu.

As Xenakis stated, "seen from the point of view of art, all of our knowledge and our actions are but aesthetic expressions of forms and their transformations."[18] The two versions of *The Shape of Light* echo this idea. They express light forms and reinterpretations of music into digital light visualizations.

18 Xenakis, 2008, p. 271.

System Interface and Detail Design

The project was realized using TouchDesigner (TD), a real-time, interactive, multimedia software. I developed a user interface (UI) for the live performance (Figure 34.11). On the right side is a list of manual controls, such as a scene switcher, gain controllers, and camera orientation. On the left is a real-time screen monitor. With this console, focusing on the sound and visuals is possible without entering each scene's visual setting. The UI provides a critical tool for a live performance setting.

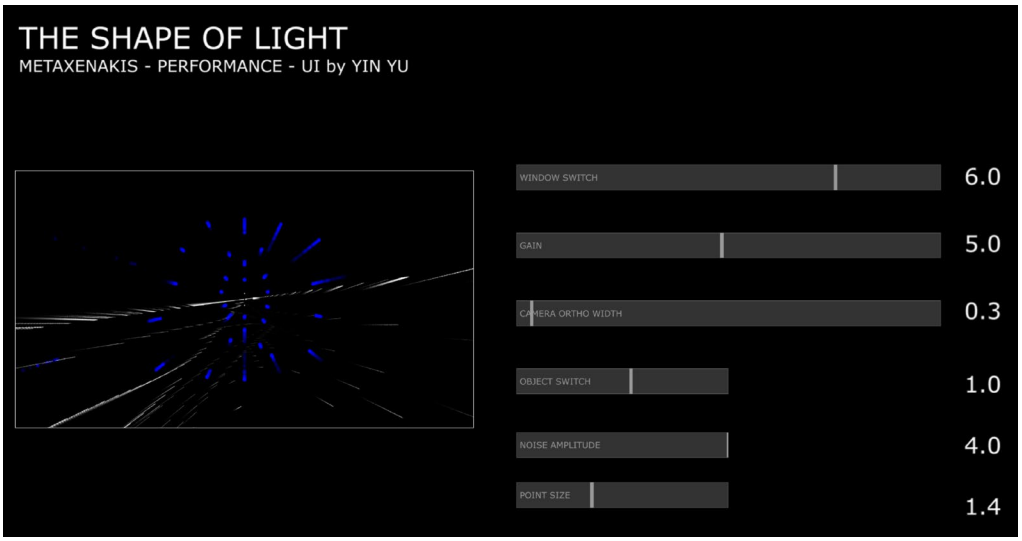


Fig. 34.11 The customized interface for the live performance of *The Shape of Light* (2022). Figure created by Yin Yu.

Seven TD networks were developed for the live performance. For example, Figure 34.12 gives an example of the hyperbolic paraboloid scene network. First, I built a surface of a hyperbolic paraboloid using a 3D modeling software. After importing the 3D model into TD, the TD network transformed the surface into a group of points, and then, to lines. Frequency range (Low pass f= 1000 Hz , High pass f= 2000 Hz , and Bandpass f= 1500 Hz), amplitude, and beat detection were integrated for the audio detections. After the first rehearsal for the live performance, Harris suggested incorporating colors for the visual design. As a result, the frequency range was mapped to the color range in the last two scenes.

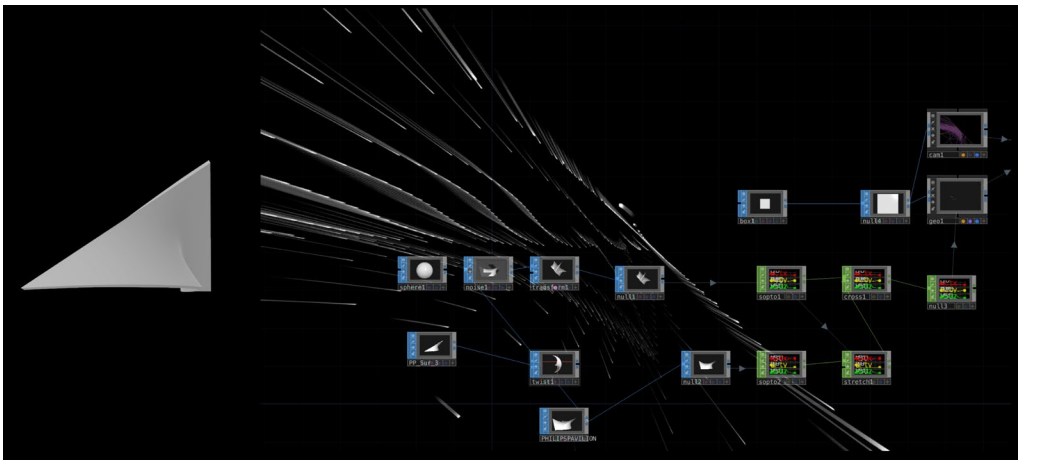


Fig. 34.12 The TouchDesigner network of hyperbolic paraboloid for audiovisual interpretation (2022). Figure created by Yin Yu.

Although Xenakis's light did not directly inspire the last scene, I was motivated by Xenakis's life from a political aspect. Questioning what I can do to respond to the 2022 Russian invasion of Ukraine, the scene of *Lights for Ukraine* (Figure 34.13) uses the blue and yellow colors as a support of Ukraine and reminds us of the ongoing wars in the world.

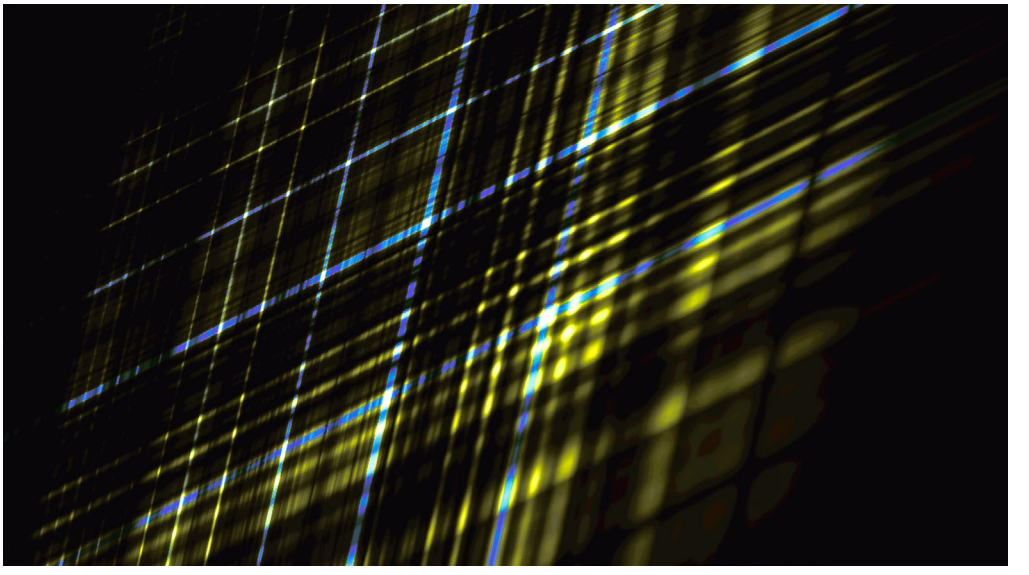


Fig. 34.13 The scene of *Lights for Ukraine* (2022). Figure created by Yin Yu.

Future Work

As mentioned above, the live performance of *The Shape of Light* premiered in the Skylight room at the Graduate Center of CUNY. As an audio-visual performance, we were limited by the acoustic properties of this room and the size of the presentation screens. Multi-cameras live projecting, large projector screens, and an immersive sound system could enhance the live performance experience. In the future, this project could develop into a multimedia installation or VR/AR piece. For each scene, I would like to overlap more elements and details in the design. Finally, with new lighting technologies, I would like to reimagine and produce new types of polytopes with multimedia software.

Media 34.1 (a) Live performance, *The Shape of Light: Mikka* (2022). Video by Pauline Kim Harris. https://hdl.handle.net/20.500.12434/17d4d981

Media 34.1 (b) Live performance, *The Shape of Light: Mikka S* (2022). Video by Pauline Kim Harris. https://hdl.handle.net/20.500.12434/074be057

Conclusion

Light in Xenakis's work is poetic, dramatic, emotional, and powerful. Xenakis not only created a new aesthetic of light art but also projected a future direction for the role of light in art at large, especially in transdisciplinary encounters. Xenakis's aesthetic for light as an artistic medium connects music and architecture. With new digital technologies, we may rediscover Xenakis's work, and pursue research on the many possibilities for the future of art and science as alloys.

Coda

I (Conrad Harris) was first introduced to the music of Xenakis in music school, when a composer I was taking a class from loaned me some recordings. I had not heard anything like it! Around the same time, I was taking a class in art and architecture. and chose, as my final project, to make a model of the Philips Pavilion. It was crudely constructed out of paper, wood, and glue. Needless to say, I did not save it, nor are

there any photographs of it. Nevertheless, I found it fascinating how closely Xenakis's piece *Metastasis* resembled the architecture of the Pavilion. It immediately gave me the impression of a different type of music, with its roots in the three-dimensional. Since then, I think of musical performances as filling a specific space, visualizing sound extending into all corners of the concert hall.

My approach to learning *Mikka* and *Mikka S* was a methodical one.[19] It seemed necessary to begin this way before becoming free to focus on the music's sonorities, subsequent overtones, and sound projection.

I began to imagine, when playing Xenakis's music, the laser beams, flashes of light, etc., that he used to create his polytopes.

Working with multidisciplinary artist Yin Yu on *The Shape of Light* provided an opportunity to explore further the possibilities of performances. A listener can "see" the music being played in space.

Media 34.2 Pre-recorded performance, *The Shape of Light* (2022). Video by Yin Yu.
https://hdl.handle.net/20.500.12434/93785dfa

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19 See Harris, 2010.

35. *Phoenix-Albatross*: An Approach to Iannis Xenakis's Work on Game Theory through Live Coding and Networked Dance

Iannis Zannos and Takumi Ikeda[1]

Introduction

In this chapter we present an attempt to reinterpret aspects of Xenakis's work in the context of twenty-first century performance practice using live coding and embodied performance or dance with sensors. Xenakis worked at a time when live interaction with computers was just starting. He worked mostly with non-interactive computer systems, but at the same time he launched the visionary project UPIC (Unité Polyagogique et Informatique de CEMAMu (Centre d'Études de Mathématique et Automatique Musicales)) to develop technology that enabled interactive sound design. His experiments with game theory had pioneer character also in terms of performance practice, and led to works that placed exceptionally high demands on the performers, as noted by Benny Sluchin and Mikhail Malt.[2] Thus, we view creating interactive works based on Xenakis's vision as a natural and necessary continuation of his legacy. In fact, the present project takes a radical stance toward this idea. It engages at the same time with three current challenging aspects in the field of contemporary computer music and performance. These are:

1. Live coding: executing code during the performance in order to generate the event sequences and the sound generating processes that produce the music.

1 The implementation of the work for this paper was supported by the research project Hub of Art Laboratories (HAL) of the Department of Audiovisual Arts of the Ionian University.

2 Sluchin and Malt, 2011, and Chapter 15 in this volume.

 https://doi.org/10.11647/OBP.0390.37

2. Linking human body movement to sound generation ("embodied performance"): in our case, dancers use sensors to influence the parameters of the sound generating processes and thus to fundamentally modify the qualities of the sound during the performance. Dancers become almost like instrumentalists interpreting the piece, with one important difference: they in fact enter into dialogue with the live coders, by modifying what they specify with their code in real time
3. Enabling a distributed mode of performance worldwide through the internet: performers play the piece in different venues in different locations at the same time, sharing control data and code over the internet to communicate and create one distributed performance.

The work which is presented here is based on the part of Xenakis's work which is by far less performed than any other. These are works based on game theory, namely *Achorripsis* (1956–7), *Duel* (1959), *Stratégie* (1962), and *Linaia-Agon* (1972) which incorporate a live simulation of a game within the performance itself.[3] As a result, these works are extremely difficult to perform instrumentally on stage, because they involve the making of live choices by the performers, based on complex game rules. On the other hand, such a setting is naturally more suitable for performance in a setting involving computers in real time. Computers could in fact perform a simulation of the game in real time without the intervention of humans, as is often done in game simulations for both peaceful and non-peaceful conflict scenarios. In our piece, we re-introduce the human performance factor by relying on the performers to make the choices based on live calculations and spontaneous action, using the computer to track the score and to provide visual cues about the state of the game.

Theoretical Background: Heteronomous Music and Musical Battles

In his introduction to the chapter on "Musical Strategy," Xenakis describes the idea of "Heteronomous Music," as a way to introduce a concept of external conflict between opposing orchestras or instrumentalists.[4] The sonic discourse which arises in this setting is seen by Xenakis as "a very strict, although often stochastic, succession of sets of acts of sonic opposition." We regard this setting as a fundamental aspect of the aesthetic and musical goals of the works discussed here. Xenakis explains that this kind of heteronomy is present in traditional musical forms as for example in Indian classical music, where two instrumentalists engage in playful competitive musical dialogue. In fact, there are also references to this genre in classical western music, in the

3 Arsenault, 2002, p. 58–72; DeLio, 1987, p. 143–64.
4 Xenakis, 1992, p. 111–13.

genre of "Battaglia" mainly in the seventeenth and eighteenth century. A prominent example inspired by this genre is the work by Claudio Monteverdi (1567–1643) *Il Combattimento di Tancredi e Clorinda* (1624), based on Canto 12 from Torquato Tasso's (1544–95) *Gerusalemme Liberata* (1581).[5] In a way, Xenakis's work in this field coincides with major events in geopolitics on the one hand, and with budding developments in computer and telecommunications technology on the other. In geopolitics, the Cold War conflict between the USA and the Soviet Union was a decisive factor in the development of game theory. The biography of mathematician John Nash (1928–2015)[6] illustrates in a dramatic way the mutual interdependence between the theoretical work of a mathematician and the geopolitics of the Cold War Period. John Nash's work on game theory, that won him the Nobel Prize, addressed problems of Game Theory at a time when the USA were engaged in a conflict for world domination with the USSR. The USA government and particularly their realized the importance of understanding the mathematics of game play for developing a strategy within the context of global politics. This context was rendered particularly complex, because it involved many players, i.e. the member states of the two opposite blocks of the western and the communist sides, and the points of view or specific intentions of each partner were hidden from the other partners. John Nash attempted a mathematical definition of the relative merits of trust and cooperation in a game of absolute conflict between players. [7] Another characteristic event in this context is the Cuban Missile Crisis of 1962, which happened in the same year as the composition of *Stratégie* by Iannis Xenakis. In computer technology, the development of computer games coincides with the birth of interactivity in computing and has become a driving factor in the field. Computer games are now interlinked with development of virtual reality (VR) and so-called virtual worlds such as the Metaverse. Our work approaches the potential of this field from the grassroots or rhizomatic perspective of open source and DIY (do it yourself). In this way, we want to point out an alternative, playful, and creative approach to technology, that emphasizes empowerment of the artist and independence from large multinational gaming, social media, and VR corporations. In parallel, we are aware of other performance forms that employ the battle-paradigm in popular culture, such as dance battles, as well as the hacking marathons of the "Demoscene" subculture, which open alternative creative approaches to mainstream gaming technology.[8]

5 Monteverdi, 1638.
6 Nicholson, 1991, p. 643.
7 Nasar, 1998.
8 Seifert, 2012.

Project Background: A Framework for Telematic Dance Performance and Computer Music

The background for this project is provided by a telematic dance project started by Iannis Zannos in 2018 as part of a sabbatical residency at the University of Arts of Tokyo, which resulted in a series of collaborations with Japanese dancers and composers. The online live coding framework that enabled the collaboration was developed by Zannos with the help of senior undergraduate students and post-doctoral students at the Department of Audiovisual Arts of the Ionian University, where he works. This framework does not rely on streaming audio over the network. Instead, only program code and sensor data are streamed over the network, using the UDP-based protocol Open Sound Control (OSC).[9] The sound is then synthesized on SuperCollider locally at each venue. In other words, one may say that the score as well as the movements of the interpreters are broadcast over the network, and the instruments that render this score are the computers at each venue. This method requires the minimum amount of data to be sent over the network and is therefore very fast. The delay between coders and dancers at each location and the reaction of the computers at remote locations is very small, as small as a fast internet connection permits (usually less than 1/5 or 1/10 of a second between Greece and Japan).

In 2021, Zannos approached the composer Takumi Ikeda, who is an experienced SuperCollider programmer and performer, and proposed a collaboration along these lines. The collaboration gradually developed into the present project in the course of several online as well as face-to-face meetings. Ikeda quickly became familiar with this framework and contributed sound processing algorithms that formed the main skeleton for the present piece and performances. Starting early in 2022, we rehearsed these algorithms in live coding sessions with dancers in Greece, with Ikeda joining us remotely live coding over the network. In parallel, we worked on models of the game described by Xenakis in Chapter 4 of *Formalized Music*, which were implemented mainly by Ikeda.[10] In early September 2022 we performed the first full version of the piece in Tokyo, while the Greek dancer Tasos Pappas-Petrides joined us from Athens over the network. This session has been recorded and is available for viewing on YouTube.[11]

9 Wright, 2005, p. 193–200.

10 Xenakis, 1992, p. 110–30.

11 Videos of *Phoenix-Albatross* by Ikeda and Zannos are available on YouTube, as follows: Iannis Zannos, "Phoenix-Albatross Part 1: Prelude" (19 September 2022), *YouTube*, https://www.youtube.com/watch?v=3bpukYHt8YM&list=PL1yHvCYr9BvbQc9A_1ZZUNNAjDKLum4-I&ab_channel=IannisZannos; Iannis Zannos, "Phoenix-Albatross Part 2: Duo" (19 September 2022), *YouTube*, https://www.youtube.com/watch?v=EWkqTDcEk9A&list=PL1yHvCYr9BvbQc9A_1ZZUNNAjDKLum4-I&index=4&ab_channel=IannisZannos; and Iannis Zannos, "Phoenix-Albatross Part 3: Trio" (19 September 2022), *YouTube*, https://www.youtube.com/watch?v=AurcuVQoBfM&list=PL1yHvCYr9BvbQc9A_1ZZUNNAjDKLum4-I&index=3&ab_channel=IannisZannos

The Score

Xenakis's orchestral work *Duel* (1959) is a "game for 56 musicians divided into two orchestras with two conductors" based on game theory, or in other words, the mathematical theory of game play.[12] The players of the game are two conductors, and the orchestras play "tactics," chosen by the conductors. Tactics correspond to individual cards in a card game. In the score of the piece, tactics correspond to score sections which have clearly distinguishable sonic characteristics. Xenakis describes the characteristics as follows:

- Event I: A cluster of sonic grains such as *pizzicati*, blows with the wooden part of the bow, and very brief arco sounds distributed stochastically.
- Event II: Parallel sustained strings with fluctuations.
- Event III: Networks of intertwined string *glissandi*.
- Event IV: Stochastic percussion sounds.
- Event V: Stochastic wind instrument sounds.
- Event VI: Silence.[13]

The two conductors take turns choosing tactics in a similar way as players in a card game choose playing cards to achieve a high score. The performance is formed by playing the sections from the score which are assigned to each chosen tactic. As a result, the music is generated as a byproduct of playing a game, and the aesthetic intentions of the piece are encoded as rules of the game in the assignment of matrix cells ("cards") to sections of the score. In this sense, it may be said that the music is the result of at least partly extra-musical rules, which is what Xenakis calls "Heteronomous Music," as opposed to "Autonomous Music" or "musique pour la musique."[14]

As a means of directing the performance towards the general direction of a desired aesthetic goal, Xenakis examined the desirability of sound combinations as a basis for the game rules, which he then encoded as a payoff (game) matrix. Therefore, the execution of the game automatically generates music that he generally finds favorable. Also, different music is generated each time the game is played. In Ikeda's view, this is an effort to create a humanized version of algorithmic composition through computers.

Xenakis's game theory works, *Duel, Stratégie*, and *Linaia-Agon*, are rarely performed due to their extreme technical complexity to prepare and to perform. *Linaia-Agon*, in particular, requires the performers to choose their own tactics while playing an extremely difficult score, forcing them to decide what to play in advance, which is a realistic approach. Ikeda believes that the lack of these performance opportunities

12 Xenakis, 1992, p. 110.
13 Xenakis, 1992, p. 113–14.
14 Xenakis, 1992, p. 110–13.

has led to a lack of validation of the game itself. The *Duel* rules themselves can easily be written in a programming language. Running it as a simulation or game program, rather than with an orchestra or musical score, would facilitate the refining of Xenakis's idea of the musical game he envisioned. After receiving a proposal from Zannos for a remote performance based on *Duel*, Ikeda created a version of the game matrix described by Xenakis in *Formalized Music*. After running several simulations of games on a computer he discovered that the rules of these matrices do not result in a fair game, but are biased to let the first player win more often than the second player. Xenakis also mentions this property and the need to create a fair game.[15]

In the quest to create such a fair game, Ikeda created a seven-by-seven game matrix, which was first performed live by two improvisers with Ikeda himself as referee. In Figure 35.1 we show the game matrix, represented as the score for Ikeda's piece *Laysan Albatross* (2022). The symbols at the top and left margins of the matrix frame approximate the character of the textures that the improvisers are asked to produce, namely as indicated in the legend, repetition, random movement, and static sound. Furthermore, the tactics include two types of instruments: a Japanese instrument (shakuhachi) and a Western instrument (either trumpet or violin depending on the player). This is thus at the same time an experiment in western-eastern sonic sensibility.

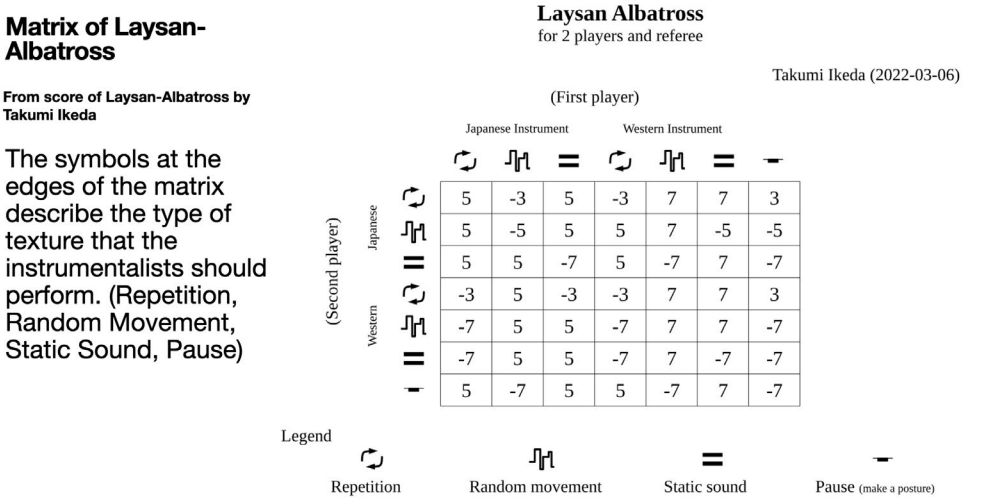

Fig. 35.1 Score of *Layan Albatross* by Takumi Ikeda (2022).

Ikeda-Zannos formed a collaborative duo to realize a new piece called *Phoenix-Albatross*. The idea of East–West dialogue from *Laysan Albatross* led to the formulation of the new piece's title, *Phoenix-Albatross*, namely "Phoenix" in reference to the mythical bird of

15 Xenakis, 1992, 116.

Chinese mythology (Houou, 鳳凰)[16] and "Albatross" in reference to the Albatross in "The Rime of the Ancient Mariner" by Samuel Taylor Coleridge (1772–1834).[17] This seemed fitting as the piece was conceived to be performed telematically from Greece and Japan at the same time. In the version which is presented here, the piece was performed in the dance studio Omikron3 Art Space in Athens, Greece by a third interpreter, the dancer Tasos Pappas-Petrides. The dancer used wireless wearable inertial measurement unit (IMU) sensors to control and modulate the textures defined in SuperCollider by the two performers in Tokyo. This performance is thus true to the name of the piece, *Phoenix-Albatross*, even if the musical performers were both situated in Suidobashi, Tokyo at the time of the performance at the location of the independent venue Ftarri.

Ikeda created a model of the game logic in SuperCollider as well as a graphic display of the matrix which both players consult at each move (see Figure 35.2). We call the two players x (Phoenix) and y (Albatross). Player x chooses moves from the columns of the matrix and player y chooses moves from the rows of the matrix. At each move, the matrix display updates to show which row or column has been chosen by the move of the last player. The other player has the responsibility to choose from that row or column one cell which maximizes the possibilities of winning the game. Player x must choose the greatest value from the column indicated by the most recent choice of player y, and player y must choose the smallest value from the row indicated by the most recent choice of player x. This approach corresponds to an interpretation of the *Duel* score as a zero-sum game, in which a positive number in the matrix is a profit for X, and a loss for Y, and conversely a negative number is a loss for X and a profit for Y. Consequently, the Y preferably chooses the cell with the smallest (negative) value, while X choose the cell with the largest (positive) value. This manner of playing the game corresponds to playing the game with a strategy of maximum gain using the minmax strategy, as shown in Figure 8 of Sluchin and Malt.[18]

Ikeda applied a simplified genetic algorithm (GA) to derive a fairer version of the original game matrix written by Xenakis; i.e., a version which would tend to result in an equal number of wins and losses for each of the two players when playing multiple games. The basic idea of the algorithm was to subject variants of the original matrix to one hundred game simulations and select amongst them the one that resulted in the fairest (most equal or balanced out) game result. This variation and selection process was iterated thirty times, to obtain an even fairer matrix within the limits of available computation time. The algorithm for obtaining variants from the original matrix at each iteration was to add and subtract the integer value 1 to one of the cells of the original matrix in turn, iterating over all cells in the original matrix. (Note: adding 1 and subtracting 1 to each of the 36 cells of the original matrix results in 72 matrices, each of whom differs from the original matrix by an integer value of 1 or –1 at a single cell.) The algorithm can be outlined as follows:

16 Nozedar, 2006, p. 37.
17 Coleridge, 1921, p. 186–209.
18 Sluchin and Malt, 2011.

1. Start with a selected or given game matrix m0 (input matrix).
2. Obtain the set v of all variant matrices of m0 which differ from m0 by a value of 1 or -1 at one single cell only. (Iterate variants +1, -1 over all 36 cells of m0 to obtain a set v comprising 72 matrices.)
3. Play the matrix game on each of the 72 matrices vn in v for 100 times, and collect the resulting score set sv containing 72 scores, one for each matrix, summing the results of the 100 games played with this matrix.
4. From the scores of step 3, select the matrix m1 which in which the number of wins and losses for each player differs the least. (50 wins and 50 losses is the best outcome, 100 wins and 0 losses is the worst.)
5. Repeat steps 1 to 4, using the matrix m1 output by step 4 as input matrix m0.
6. Repeat steps 1–5 thirty times. The matrix m1 selected by step 4 at the thirtieth iteration is the matrix to use for the *Phoenix-Albatross* game.

The matrix obtained from the above algorithm was used in our performance of *Phoenix-Albatross* and resulted in a draw of 2-2, which confirmed our sense that it is a fair matrix.

Phoenix-Albatross Matrix

From Display Programmed in SuperCollider by Takumi Ikeda

Phoenix corresponds to player X and Albatross to player Y.

The yellow colour indicates the player who is expected to make the next move.

display

PHOENIX \ ALBATROSS	0	1	2	3	4	5
0	-1	-1	3	1	1	-1
1	-1	-1	3	-1	1	-1
2	3	-1	-3	3	1	-3
3	1	3	2	-2	-3	1
4	-1	-1	1	-1	1	-1
5	-1	-1	-5	-4	-2	3

PHOENIX ALBATROSS

Fig. 35.2 The game matrix of *Phoenix-Albatross* (2022). Figure created by authors.

Contrary to *Laysan Albatross*, *Phoenix-Albatross* does not involve a referee. Instead, the two performers choose the best move by consulting the points written on the game matrix. It would be easy to create a function that chooses the best move for each player and suggests it or plays it automatically. We decided however to leave this task to the players themselves to increase the demand for concentration and create a sense of suspense, which is part of the human and musical aspect of the performance.

The sonic realization of the piece is based on prototypes of sound textures written

in SuperCollider by Ikeda, employing the infrastructure for accessing sensor data via OSC written by Zannos. The piece was performed in a three-movement form, as follows:

- "Prelude": free improvisation by Ikeda and Zannos with dance by Tasos Pappas-Petrides modulating the sounds from SuperCollider through wearable sensors.
- "Duo": game play in two rounds by Ikeda and Zannos (without dance).
- "Trio": game play in two rounds by Ikeda and Zannos, with dance by Tasos Pappas-Petrides modulating the sounds from SuperCollider through wearable sensors.

Discussion

Phoenix-Albatross is a radical re-interpretation of the game-theoretical and heteronomic music ideas of Xenakis in the new medium of dance-driven music, telematic dance, and live coding. This performance context is radically different from that of the orchestral music setting for which Xenakis wrote *Duel*. Control of sound structures through "dance" represents a departure from the classical instrumental paradigm in terms of the relationship of the performer to the sound structure, which is more fluid and direct but at the same time less predictable and more complex. In fact, while a professional dancer performed the piece, this type of performance is not dance in the traditional sense, but a new hybrid and experimental performance medium. This piece explores the nature and potential of the medium through a dialogue with the musical thought of Xenakis. The dynamics of sound control through movement connected to live coding of synthesis algorithms created a new way of interaction and interpretation during the performance; a kind of hybrid between dance, gestural music expression, and instrumental performance. The design of the sound synthesis algorithms must take into account the dynamics and constraints of this kind of performance, and especially consider the cognitive affordances of the dancer/performer, e.g. how causality between bodily movement and sound is perceived, and what types of movements are preferred or perceived as suitable. To this already complex situation is added the fact that the flow and balance of sound is affected by the code choices made by the two live coding musician interpreters (Ikeda and Zannos) prompted by the decisions of the game-matrix algorithm. The interventions of the live coding performers into the sound flow act as extraneous disturbances in the causal context established by the interdependence between the dancer's movements and the resulting sounds. It can be argued that the interplay between causality and non-causality could be a decisive formal factor, and that in fact interactive dance performances need to explore this interrelationship in depth in order to give rise to new aesthetics or performance art forms involving sound and movement. Furthermore, while the design of the sound algorithms took into

account the generic descriptions of sound textures in *Duel*, the requirements of body-sound interaction favored building algorithms from scratch, rather than building on transcriptions of the event textures found in the orchestral score of *Duel*. It should be mentioned that Stefano Kalonaris created a different live-coded version based on *Duel*, which emulates more closely textures found in the score, while eschewing gestural interaction and relying entirely on live coding.[19] A comparison of these two approaches could be fruitful for future research.

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19 The piece by Kalonaris, called *Duel Revisited*, was performed on 17 December 2022 at the Xenakis Networked Performance Marathon 2022, with Zannos as one of the live coders. A link to a video recording is included in Chapter 40 of the present volume, which presents this Marathon event.

36. Mapping the Influence: Iannis Xenakis's GENDYN Algorithms as a Means for Creative Explorations in Live Improvised Feedback Music

Thanos Polymeneas-Liontiris[1]

Introduction

This chapter is written following an autoethnographic perspective.[2] It presents one of my most recent creative research projects, aiming to contextualize it within my previous and overall creative practice, while drawing a link between it and its historical relation to Iannis Xenakis's *Generation Dynamic* (GENDYN) algorithm.

Previous Feedback Works

My creative practice ranges from composition to performance, as well as sound art. Since 2014, the *idée fixe* in most of my works has been the notion of feedback, a concept I have not ceased to explore in its many different possible manifestations. For example, I have made acoustic and acousmatic compositions based on material deriving from audio feedback processes, such as *Sun Bleached* (2019), a work for baroque ensemble (flute, violin, viola da gamba, harpsichord) and tape.[3] In *Sun Bleached*, most sounds of the tape were results of feedback processes.

For my live performance practice, I hack acoustic instruments to convert them to feedback instruments (see Figure 36.1). More specifically, through explorations in this

1 I would like to thank Stelios Manousakis for his help on the SuperCollider code, Sergio Luque on the discussions we had regarding the two different methods and the *Gendy* implementations in SuperCollider and Nikos Ioakeim for the ongoing conversations on aesthetics and the work of Iannis Xenakis.

2 Adams et al., 2014.

3 Polymeneas-Liontiris, 2014.

 https://doi.org/10.11647/OBP.0390.38

field I have made different versions of acoustic feedback resonating double basses.[4] The model of feedback in this case is relatively simple: electromagnetic pickups transfer the sound of the instrument's strings to loudspeakers mounted on the body of the instrument itself, thus exciting the strings, and so on. The concept of feedback in this context might seem simple, but the acoustic and musical results of it are aesthetically extremely rewarding.

Fig. 36.1 Feedback Augmented Acoustic Double Bass. Photos by M. Eugenia Demeglio (2018).

I use these feedback instruments either as a solo performer, or to play with other musicians in a variety of line-ups. Very often, I use the feedback double bass to play in feedback music ensembles. Such ensembles are comprised either by musicians playing on other feedback instruments, such as the Feedback Musicianship Network Ensemble (see Figure 36.2), or by musicians who are interested in the conceptual and creative potential of the notion of feedback, and who employ it in a variety of ways in their practices. In certain cases, these ensembles do operate as larger scale feedback systems, as the audio produced by one instrument might feed into other instruments and vice versa, such as the Brain Dead Ensemble (see Figure 36.3).,[5]

4 Polymeneas-Liontiris, 2018.
5 Polymeneas-Liontiris et al., 2018; Brain Dead Ensemble, 2019.

Fig. 36.2 The Feedback Musicianship Network Ensemble. Photo by Dimitris Kyriakoudis (2022).

Fig. 36.3 The Brain Dead Ensemble. Photo by Matthew Garland (2018).

A very prominent part of my creative practice consists of devising music theater performances. There, the notion of feedback is central, as it takes place between audience, technology, and performers and thus becomes responsible for the musical and dramaturgical development of the work (see Figure 36.4).,[6] In these cases, the notion of feedback might extend to human behaviors since it might be manifest as an

6 Polymeneas-Liontiris et al., 2022a; 2022b.

exchange of information between audience and performers. Feedback processes might include technological interaction, which may cause the production of audio and visual information (sound and/or moving image); or, in other cases, the feedback processes might reside merely in an interpersonal level between audience and performers.

Fig. 36.4 A scene from the performance of my work *Quicklime* (2016), the design of which was based on feedback processes. Photo by Erin McKinney (2016).

My most recent experimentation in the broad field of feedback, and the one I will present in here, is data feedback using Dynamic Stochastic Synthesis, implemented in the programming language SuperCollider, a process that I use for my live, free improvisation, and noise music performances.[7]

Coding Feedback

The simplest type of audio feedback happens when one turns a microphone toward the loudspeaker which amplifies it and in turn emits the signal that the same microphone picks up. In this case, the result is a very characteristic high-pitched noise that becomes exponentially louder. A similar effect occurs when one turns an electric guitar towards its own amplifier. Most often the frequency we listen to in these cases is either the resonance frequency of the space or, it is related to the self-resonance, self-noise, and spectral specifications of the equipment used or, a combination of both.

Audio feedback within a computer though may happen in many different manners, and in order to control that feedback and obtain interesting results without letting it get out of hand in terms of loudness, one needs to design "when" feedback will happen, "how" it will happen ("what" will feed back "where"), and "how much" of

7 For more on Dynamic Stochastic Synthesis see Hoffmann, 1996; Hoffmann, 2000. For more on SuperCollider see Wilson et al., 2011.

the original signal will be fed back into the system. The SuperCollider code example written below will reproduce the sound of a sine wave, the frequency of which will be controlled by the mouse cursor within the boundary of 20 Hz to 20 KHz:

```
Ndef(\osc, {`(freq: MouseX.kr(20, 20000, 1), phase: 0, mul:
1)}).play;
```

Code 36.1 sine wave example.

Media 36.1 Sine wave example in SuperCollider.
https://hdl.handle.net/20.500.12434/e0c6d5a8

If we wanted to add feedback in the above line of code, then one possible way to do it is to modulate the oscillator's phase parameter by using the audio output of that same oscillator. We therefore modulate the oscillator of a synthesizer not with another oscillator, but with the synthesizer itself:

```
Ndef(\osc, {SinOsc.ar(freq: MouseX.kr(20, 20000, 1),
phase:Ndef(\osc) , mul: 1)}).play;
```

Code 36.2 Controlled feedback example.

Media 36.2 Controlled feedback example in SuperCollider.
https://hdl.handle.net/20.500.12434/38e50bc1

The sounding result resembles Frequency Modulation and it is a process called Phase Modulation. The peculiarity though of this case is that the modulator in this process is fed by the output of the entire synthesizer, hence the feedback.

It is most likely that the more composite sounds one creates in the initial process of sound synthesis design, more complex results will be generated once feedback is added to it. For example, in the sound synthesis algorithm below there some reverberation is added, as well as panning for spatialization; and the overall amplitude of the synthesizer is randomly controlled by a low frequency noise generator. These simple additions contribute greatly to the making of a much richer and more intriguing sound result.

```
(SynthDef('osc', { arg freq =1300, rate =1, vol=1, gate =1,
panRate=0.1;
  var sound, env;
  sound = Gverb.ar(Pan2.ar(SinOsc.ar(freq, 0, LFNoise2.
ar(rate)).fold2(Line.kr(0,1.01,8)),SinOsc.ar(panRate)), 100,
5, 0.1);
  env =EnvGen.ar(Env.asr(10, 1, 10), gate) ;
    LocalOut.ar(sound);
  Out.ar(0, sound *env);
}).add; );
a=Synth('osc');
```

Code 36.3 Low frequency noise modulation example.

Media 36.3 Low frequency noise modulation example in SuperCollider
https://hdl.handle.net/20.500.12434/b71262ba

When one adds feedback to the above sound synthesis algorithm, in a manner similar to the way feedback was added in the first example—by controlling the phase parameter of the oscillator using the sound of the synthesizer itself—one gets a more intricate and interesting result than before. The output of this synthesizer may begin with a sound that resembles the previous example, but very soon, it tends to "break" into noise explosions, surprising the listener. The synthesized sound resembles a sort of walk on a cliff-edge or a tight-rope; it gives the impression of a certain type of unpredictability and fragility. While listening to it, one cannot tell "when" and "how" such loss of "equilibrium" will happen, causing the sound to explode.

```
(SynthDef('oscfeedback', { arg out=0, in=0, freq =1300, rate
=1, vol=1, feedbackVol =1, gate =1, panRate=0.1;
  var input, sound, env;
    input = InFeedback.ar(1) * feedbackVol;
  sound = GVerb.ar(Pan2.ar(SinOsc.ar(freq, input, LFNoise2.
ar(rate)).fold2(Line.kr(0,1.01,8)),SinOsc.ar(panRate)), 100,
5, 0.1);
  env =EnvGen.ar(Env.asr(10, 1, 10),gate) ;
```

```
    LocalOut.ar(sound);
  Out.ar(out, sound *vol *env);
}).add; );

b=Synth('oscfeedback');
```

Code 36.4 Feedback example.

Media 36.4 Feedback example in SuperCollider.
https://hdl.handle.net/20.500.12434/99cead12

Feedback music has often been described as the type of music based on the notion of Metacontrol—a process within which one might give away control, to benefit from the influence that the algorithm might reward them with.[8] Music making and performing with feedback can also be described as a process of tango dancing, where the two dancers have a dynamic relation of leading and following the cues between them. In that respect, the feedback performer/music maker is required very often let herself be led by the cues of the feedback algorithm. Therefore, feedback music is often a non-linear way of music-making, and it is a matter of playing "with the algorithm" rather than playing "the algorithm."

Dynamic Stochastic Synthesis

My latest explorations in feedback involve the use of Dynamic Stochastic Synthesis algorithms. Stochastic synthesis emerged in the Centre d'Études de Mathématique et Automatique Musicales (CEMAMu; Research Center for Mathematical and Automated Music) in Paris by Xenakis, assisted by Gérard Marino, Marie-Hélène Serra, and Jean-Michel Raczinski.[9] It was first computed by a program called GENDYN (standing for Génération Dynamic) written in BASIC programming language. To write the music generated by such program, Xenakis developed another program called PARAG. The result of the combination of these two programs was first presented to public in October 1991 at the Computer Music Conference, in Montreal as *Gendyn301*; however, Xenakis subsequently withdrew this work from his catalogue.[10] A month later, in November

8 De Campo, 2014.
9 Marino et al., 1993.
10 Luque, 2009.

1991, the work *Gendy3* was premiered at the Rencontres Internationales de Musique Contemporaine in Metz. After *Gendy3*, Xenakis added the possibility of modulating the parameters of the Dynamic Stochastic Synthesis algorithm. With this extended version of GENDYN, in 1994 Xenakis composed *S. 709*, which was premiered at the Journées UPIC à Radio France that same year.

It is widely recognized that Dynamic Stochastic Synthesis was first used by Xenakis in certain sections of his work *La Légende d'Eer* (1977), and the process used there may be called the 1977 method. Contrastingly, the composer used the 1991 method for the making of *Gendy3* (1991) and *S. 709* (1994).[11] The difference between these two methods is described in detail in the 2009 article of Sergio Luque: "The Stochastic Synthesis of Iannis Xenakis."[12]

Essentially, both Dynamic Stochastic Synthesis methods (1977 and 1991) allow composers to design their music on a sample level using a breakpoint interpolation synthesis method. The positions in time and the amplitude of the samples in such digital sound processing are specified by a process of a probabilistic perturbation called "random walks" (see Figure 36.5).[13] The main difference between the two methods is that the 1991 method has two orders (two levels) of random walks, while the 1977 one has only one order.

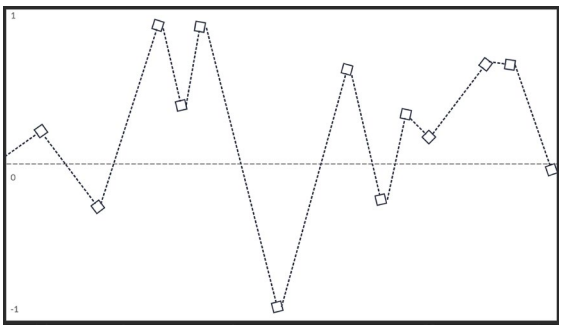

Fig. 36.5 A "random walk" probability perturbation with linear interpolation between the steps © Thanos Polymeneas-Liontiris (2023).

Dynamic Stochastic Synthesis in SuperCollider

In my explorations in SuperCollider I came across few Unit Generators that aim to reproduce—or at least are based on—Xenakis's Dynamic Stochastic Synthesis algorithms.[14] The first three Dynamic Stochastic Synthesis Unit Generators were made

11 Ibid.
12 Ibid.
13 Collins, 2011.
14 Unit Generators in SuperCollider are (among other things) sound processing and sound generating engines within the SuperCollider Server (the signal processing unit of this programming language).

by Nick Collins.[15] Unit Generator *Gendy1* is based on the thirteenth chapter of *Formalized Music* that describes the 1977 method, while *Gendy2* is based on the 1991 algorithm, as it is described in the fourteenth chapter of the same book and in Hoffmann's 2000 article "The New GENDYN Program."[16] The third stochastic synthesis Unit Generator is called *Gendy3* in which, according to Collins, "a desired frequency can be specified and achieved exactly; breakpoints are perturbed, and durations fixed proportionally within the current period."[17] Two more Stochastic Synthesis Unit Generators are to be found in SuperCollider: *Gendy4*, a cubic-interpolated version of *Gendy1*; and *Gendy5*, a non-interpolating version of *Gendy1*.

Feedback Using *Gendy1*

Coming across the Gendy Unit Generators in SuperCollider, exploring them and learning to understand them, I was intrigued to find ways to use feedback to drive them. However, the Gendy Unit Generators do not take audio input; therefore, it is not possible to do audio feedback with them. Nonetheless, they have input parameters; therefore, one can do data feedback instead. To do so, I started by analyzing the signal output of a *Gendy1* Unit Generator to retrieve its fundamental frequency and its overall dynamics. Then I took these values, I scaled them down to match the range of its input parameters, and finally fed them back to it. The results were immediately rewarding. It was as if one controlled a probability "noise" generator, by its own output: as though one organizes chaos by using chaos to do it. In these explorations I have been using feedback to control different parameters within *Gendy1*. In other cases, I fed back these values to control external effects applied on *Gendy1* such as the parameter of the overall sampling rate of the synthesizer.

Often, the audio results retrieved by these feedback processes resembled sounds characteristic of the original GENDYN, such as "bee-like" sounds, "insect swarms," etc.; at other times though I came across relatively harsh metallic sounds and uncontrolled noise explosions. A very characteristic sound often produced by this algorithm is a noise with a clear central frequency that moves rapidly and erratically in the spectrum. A sort of classic feedback-like sound, giving the impression that the algorithm is striving to identify itself and trying to imitate it, but then gets lost before it gets back into it.

For demonstration's sake, the following audio example is the beginning of Xenakis's work *Gendy3* (1991) with the original GENDYN algorithm audio example (Media 36.5), and after that, a short improvisation that I did using data feedback with Gendy1 (Media 36.6), the code of which can be found below.[18]

15 Collins, 2011.
16 See Xenakis, 1992; Hoffmann, 2000.
17 Collins, 2011, p. 2.
18 See Contemporary Classical, "Iannis Xenakis—Gendy3 (1991)" (29 May 2019), *YouTube*, https://www.youtube.com/watch?v=5qS5lqbx9H0

Media 36.5 Beginning of *Gendy3* (1991) by Iannis Xenakis.
https://hdl.handle.net/20.500.12434/771ba956

```
(SynthDef(\GendyI, {
  |inbus =0, outbus = 0,
  ampdist = 0, durdist = 1,
  adparam = 0.5, ddparam = 0.4,
  minfreq = 0.095, maxfreq = 0.98878,
  ampscale=0.5, durscale=0.5,
  numcps=24,
  maxdel = 0.5, del= 0.0, pmul = 1,
  pos = 0, bits =24,
  mix = 0,
  vmix = 0.333, vroom = 0.5, vdamp = 0.5|
  var pan, pitch, input, out, crush;
  input = InFeedback.ar(inbus, 1);
  input = DelayC.ar(input, maxdel, del);
  pitch = Pitch.kr(input)[0] * pmul; //we track the pitch
  pitch.poll;
  pan= Pan2.ar(Gendy1.ar(ampdist, durdist,
    adparam, ddparam,
    minfreq * pitch, pitch * maxfreq,
    ampscale, input.fold(0,1),
    numcps), LinLin.kr(pitch, 0, 44100, -1, 1), 0.3);
//we feedback the pitch value here
  crush=Decimator.ar(pan, pitch*10, bits);
  crush = XFade2.ar(pan, crush, mix, 1);
  crush=FreeVerb.ar(crush, vmix, vroom, vdamp);
  out = Out.ar(outbus, Limiter.ar(crush, 0.995, 0.1));
// we feedback the pitch value also here
}).add;);
```

```
y = Synth(\GendyI);
y.set(\ampdist, 5, \durdist, 0.001, \adparam, 0.1,\ddparam,
0.1, \minfreq, 200, \maxfreq, 1000, \ampscale, 0.1, \
durscale, 0.1, \numcps, 10, \pmul, 0.5, \pos, 0, \bits, 2);
y.set(\ampdist, 1, \durdist, 0.1, \adparam, 0.1,\ddparam,
0.1, \minfreq, 500, \maxfreq, 5000, \ampscale, 0.1, \
durscale, 0.1, \numcps, 24, \pmul, 1, \pos, 0, \bits, 24);
y.free;
```

Code 36.5 Data feedback example.

Media 36.6 Data feedback example in SuperCollider.
https://hdl.handle.net/20.500.12434/b447e54e

The combination of feedback and *Gendy1* Unit Generator offers a great variety of quite harsh, often unstable, and unpredictable spectra of tonal and noisy sounds that call for interaction and playfulness in the context of live improvised music. I have not made an acousmatic piece yet, as I am still experimenting with it and slowly discovering it. Nevertheless, free-improvisation music events are the perfect context to try my ideas and experiment with their potential.

Controlling *Gendy1* with Machine Learning

The control parameters of the SuperCollider Unit Generator *Gendy1* (the algorithm based on the 1977 method, and the one I use above) are written below, as designed and described by Nick Collins. These parameters control the probability distribution of amplitude, duration, the random walk barriers for amplitude and duration, the minimum and maximum frequency of oscillation, etc… In detail:

- The first parameter is defined as "ampdist" and controls the type of probability distribution that will define the perturbation of the amplitudes' breakpoints.
- The second parameter is called "durdist" and defines the probability distribution for the duration of random walks.
- The third parameter is called "adparam" and is the coefficient for the probability distribution of the breakpoint amplitude; it requires values in the range 0.0001 to 1.

- The fourth parameter is "ddparam" and is the coefficient for the probability distribution of the breakpoint duration; it requires values in the range 0.0001 to 1.
- The fifth parameter is "minfreq" and is the minimum allowed frequency of oscillation for the Gendy1 oscillator, therefore it gives the largest period, hence the maximum duration of the first random walk.
- The sixth parameter is "maxfreq" and is the maximum allowed frequency of oscillation for the Gendy1 oscillator, therefore it gives the shortest period, hence the minimum duration of the first random walk.
- The seventh parameter "ampscale" defines the primary random walk barriers for amplitude and takes values from 0.0 to 1. An ampscale of 1.0 allows the full range of -1 to 1 for a change of amplitude.
- The eighth parameter "durscale" defines the primary random walk barriers for durations.
- The ninth parameter "numcps" defines the initial number of breakpoints in the buffer.
- The tenth parameter "knum" regards the current number of utilized control points.
- The eleventh parameter "mul" defines the overall amplitude of the Gendy1 algorithm.
- And the twelfth parameter "add" defines its DC offset.

As one can see, there are plenty of parameters for even one instance of the algorithm, something that makes the process of controlling them quite hard, let alone if there are more instances of Gendys within one algorithm. To control so many parameters, I often use a MIDI controller, yet as I need drastic changes in the sound qualities and the materials generated by the processes, I had to find a way to control many parameters at once. I therefore started using a custom trained machine listening application Wekinator, a feed-forward artificial neural network that consists of three layers: the input layer, the hidden layer, and the output.[19] It uses a technique called backpropagation to get trained. With it, I gained more control over the different parameters of the algorithm and managed to interact more easily with it during my performances. Essentially, Wekinator gave me the possibility to instantly control many parameters of the synthesizer without having to input all these parameters by myself. In other words, just by operating four MIDI controllers, I was able to instantly control ten parameters of the synthesizer. Lately I have been experimenting with two *Gendy1* Unit Generators playing together in SuperCollider. It is important to say here that

19 Fiebrink et al., 2009.

Hoffmann, in his 2000 article *The New GENDYN*, explains how the 1991 method was based on sixteen layers of GENDYN algorithms for the making of *Gendy3*, a level of complexity I have not managed to reach yet with this version of feedback I am using.[20] The next step of my experimentation in this domain will be cross feedback between two *Gendy1*s. Basically, in such experiments, the data output of one *Gendy1* Unit Generator will be fed to and therefore drive another *Gendy1* Unit Generator, and *vice versa*.

The Compositional Influence of Xenakis's Inquisitive Nature

I admit that I am at the beginning of exploring something very interesting and I have the feeling that I have not even scratched the surface of the possibilities offered by such processes. However, if there is one thing that I am aiming to contribute with this article, it is not the results of my explorations, nor the processes *per se*, but the desire and urge for experimentation that drive these processes and offer these results. I am aiming to celebrate the spirit of Xenakis, his interest in experimenting and in trying old (and new) processes in new contexts—as he did with stochastics, with cellular automata, with game theory, and with so many other theories and processes that were initially considered "non-musical," changing the way we understand music computation and music making. Therefore, my essential argument here, aside the technical or aesthetical aspects of it, is that Xenakis's overall *oeuvre* has primarily influenced my practice in being musically curious, explorative, daring to try, daring to borrow processes from different practices, and daring to combine concepts, techniques, and technologies to travel to new shores of aesthetics and musical expression.

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37. Notes on *A Catalog of Difference*

Andrew Lucia

Introduction[1]

I present here a long-term research and analytic design project whose origins date back to roughly 2008, titled *A Catalog of Difference*.[2] The *Catalog*, published in 2017, is the culmination of my tenure as the Cass Gilbert Visiting Fellow in the School of Architecture at the University of Minnesota, during which time I had the fortune and resources to refine and collate years of research to date. Intellectually, *A Catalog of Difference* is an ongoing analytic project in pursuit of two overarching questions:

1. How is the material world around us organized?
2. How is the information contained within its images structured?

1 The following chapter is largely based on *Notes on A Catalog of Difference* as it was presented for the occasion of the Meta-Xenakis Global Symposium on 30 September 2022 in New York City. This chapter is dedicated to the memory of Peter Lloyd Jones (1965–2022). Footnotes will be used for expanding on the original presentation, either for the purposes of re-introducing content that had been edited for time, or for additional comment and elaboration that came about as a result of conversation during the symposium.

2 Lucia, 2017. The research conducted for this 2017 instantiation of the project was undertaken and supported through the Cass Gilbert Visiting Fellowship in the School of Architecture, University of Minnesota and generously funded therein. A very special thanks to Zhetao Dong, Samantha Kowalke, and Mohsin Khokhar, my undaunted research assistants without whom this would not have been possible.

 https://doi.org/10.11647/OBP.0390.39

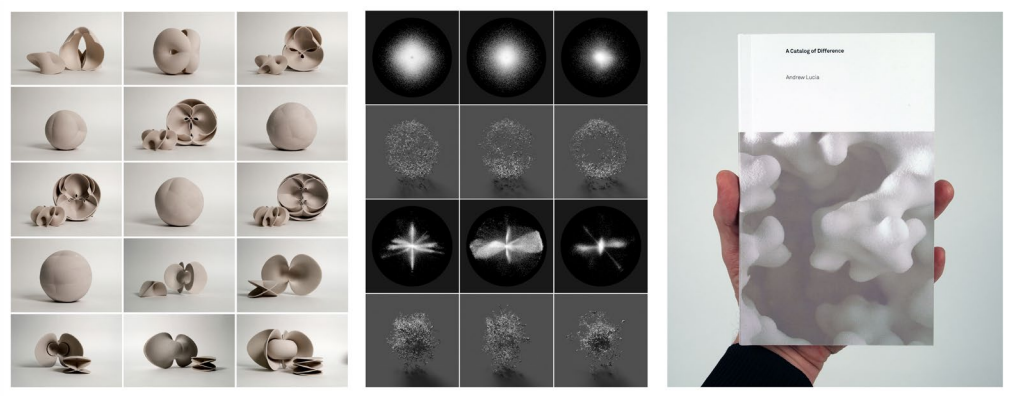

Fig. 37.1 Select representations from *A Catalog of Difference*, 2017. Printed ceramic models of surface curvature (left), scatter plots of planar and spatial image gradients (middle), and the exhibition catalog (right). © Andrew Lucia (2017).

Physically, the *Catalog* is a collection of over one thousand studies that survey and analyze degrees of difference across images, objects, and environments. The outcome of these studies is a collection of artifacts comprising a range of representational types including 3D-printed ceramics, digital photography and moving image, 2D-printed renderings and drawings, and speculative texts (Figure 37.1). To date, only a fraction of the entire *Catalog* has been produced for exhibition, which has been shown in Minneapolis, New York, and Paris.[3]

The roots of this project are indebted to the theories and writings of Iannis Xenakis, and it is herein that those influences are reflected. For this I humbly give thanks to Xenakis, for opening the door to an expanded way of thinking, and to a group of people with whom I share through theory and practice.

3 Showings have included the premiere exhibition at the Goldstein Museum of Design, HGA Gallery, Rapson Hall University of Minnesota, February through April, 2017; at usagiと_newyork, October, 2017; and as part of a group show with Young and Ayata for *DRAWBOT #2: Post Digital Drawing in Architecture and Art*, 9 February through 3 March 2018 at the AA[n+1], curated by Emmanuelle Chiappone-Piriou and Leslie Ware.

Fig. 37.2 *A Catalog of Difference* premiere exhibition at the Goldstein Museum of Design, HGA Gallery, Rapson Hall University of Minnesota, February through April 2017. Top image © Andrew Lucia (2017), and at usagiと_newyork, October 2017; lower image © Yuriy Chernets (2017), with permission.

Origins

The origins of the *Catalog* date back more than a decade, first as a series of questions formulated during my Master of Architecture thesis, *Form Between Matter*.[4] Namely, how do the representational tools we employ impact the way we create and design? I would also extend this question to the model spaces of creation we routinely inhabit, those in architecture being almost exclusively geometric.[5] And while there is much we are indebted to in this legacy, one must also ask to what extent its dominance has inhibited alternate modes of conception and expression. This challenge is akin to Xenakis's pursuits beyond the traditions of Western music.[6]

The tools (the difference machines) that comprise the *Catalog* have been implemented and deployed across a range of data throughout the arts and sciences, while challenging assumptions within those disciplines (Figure 37.3). Throughout 2008–11, many of the initial concepts were formalized in LabStudio, a multidisciplinary collaborative spearheaded by Dr. Peter Lloyd Jones and Jenny Sabin, an initiative spanning the arts and sciences housed within the Schools of Design and Medicine at the University of Pennsylvania. It was here that many of the initial tools were developed, albeit in an agnostic manner, ones that could peer equally across scales and subjects into the worlds of biology and architecture.[7]

4 Lucia, 2008. My graduate architecture thesis, presented in 2008 at the University of Pennsylvania, School of Design, was largely informed by my research into particular twentieth century avant-garde music composition and theories including those of, among others, Morton Feldman (1926–87), Karlheinz Stockhausen (1928–2007), John Cage (1912–92), Steve Reich (b. 1936), Alvin Lucier (1931–2021), György Ligeti (1923–2006), and importantly Iannis Xenakis. Specifically, I found inspiration in Xenakis's production of new compositional methods, which required invention towards the pursuit of novel aural material rooted in systems and information theory, and a way of thinking about the material world in a granular manner.

5 See, for instance, Xenakis, 1992, p. 242–54. The whole of Chapter IX, "New Proposals in Microsound Structure" is concerned specifically with the inherited system of Fourier harmonic analysis, its inherent biases and limitations.

6 Ibid., p. 5–8, 192, 207–8 for Xenakis's critique of serialism.

7 As a member of LabStudio I questioned issues inherent to the biological sciences that I had been similarly critical of within architecture; many of the adopted (and trusted) quantitative and qualitative visualization tools deployed in the biological sciences were similarly born of geometry (cell segmentation, for example), a tool unfit for the noisy, non-bounded and non-fixed biological material in question. See, for example, Lucia, 2013 and especially Lucia, 2018.

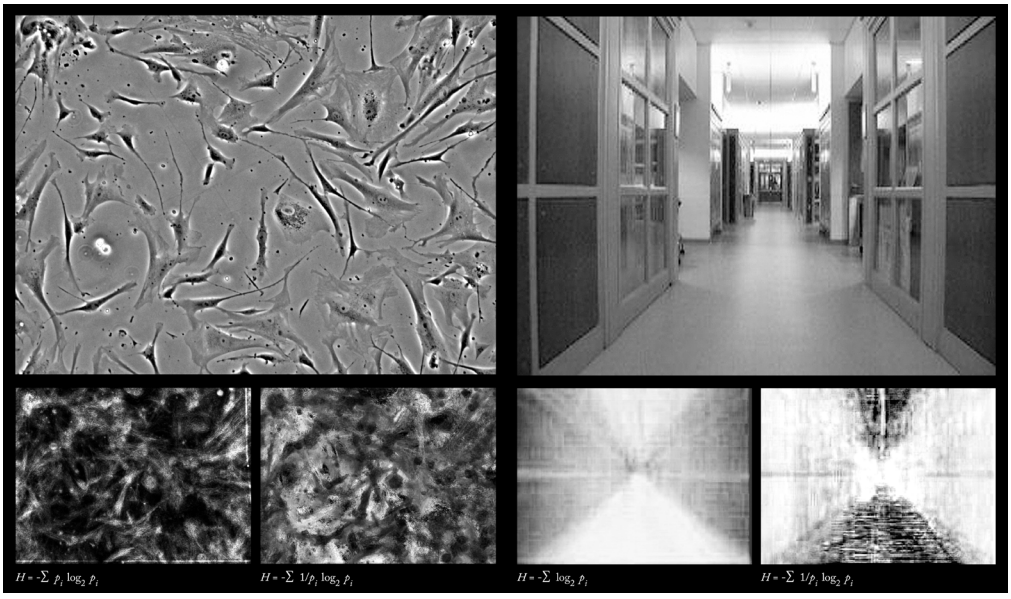

Fig. 37.3 Information calculations across scale and discipline. Information calculations based on the rate of change through moving images of smooth muscle cells under a microscope (left) and as a camera is tracked through a hallway (right). This figure was adapted from the original by Lucia et al., 2013, p. 187–90. © IEEE (2013). Reprinted, with permission, from *Proceedings of the 15th International Conference on Information Visualisation (IV)*, 2011.

Xenakis

As mentioned, my background is in architecture, and it is through that avenue that I discovered Xenakis's work. Yet it was not Xenakis's architectural contributions that struck me, though no doubt significant. While one cannot decouple the conceptual thinking behind the development of his architectural and musical outputs (Figure 37.4), I want to stress that it was his sonic works and compositional theories that had an indelible impact on my thinking, particularly as they would relate to the perceptual world of material, its organization, and ultimately its appearance.[8]

8 See Lucia et al., 2014. This conference paper, presented at the Music in Architecture-Architecture in Music symposium at the University of Texas at Austin, was the first, and to date only, text to explicitly outline the connections between the material-spatial theories of Xenakis and the tools that would eventually form the basis of *A Catalog of Difference*.

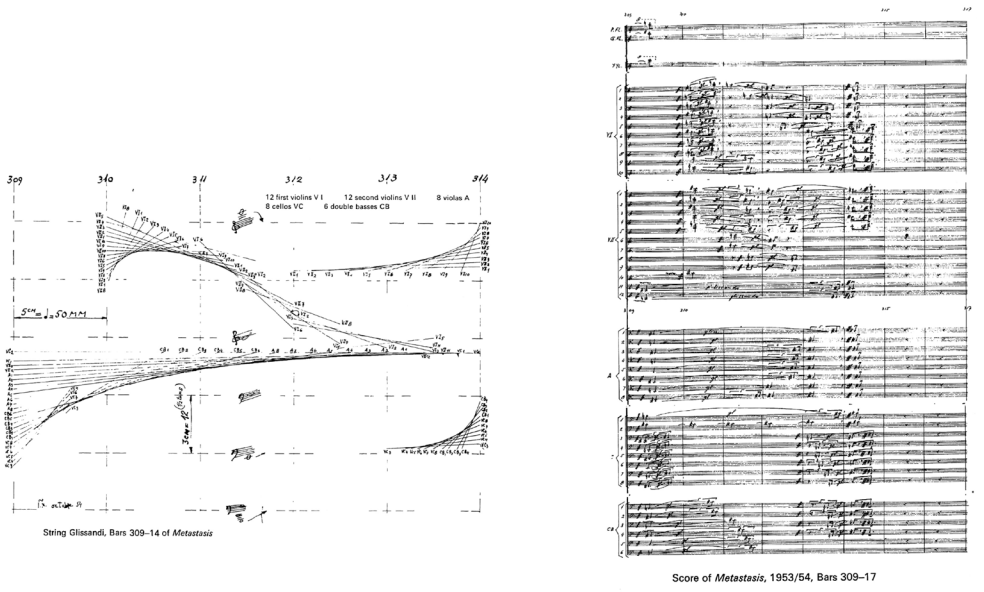

Fig. 37.4 *Metastasis*: notation of string *glissandi*, bars 309–14 (left), reprinted courtesy of Pendragon Press; and score (1953/54), bars 309–17, © 1967 by Boosey & Hawkes Music Publishers Limited, with kind permission of Boosey & Hawkes Bote & Bock, Berlin.

Of all Xenakis's musical works, *Metastasis* is unique in its overlap with his architectural output, notably in the *glissandi* diagram's relationship to that of the ruled surfaces present in the geometry of the 1958 Philips Pavilion.[9]

It was Xenakis's writings and approaches to composition (and more broadly *sound* as a material), rooted in statistics and information theory that was, for me, revolutionary. *Pithoprakta*, for example, borrows from James Clerk Maxwell (1831–79) and Ludwig Boltzman's (1844–1906) kinetic theory of gasses (Figure 37.5).

9 Reproduced in Xenakis, 1992, p. 2–3.

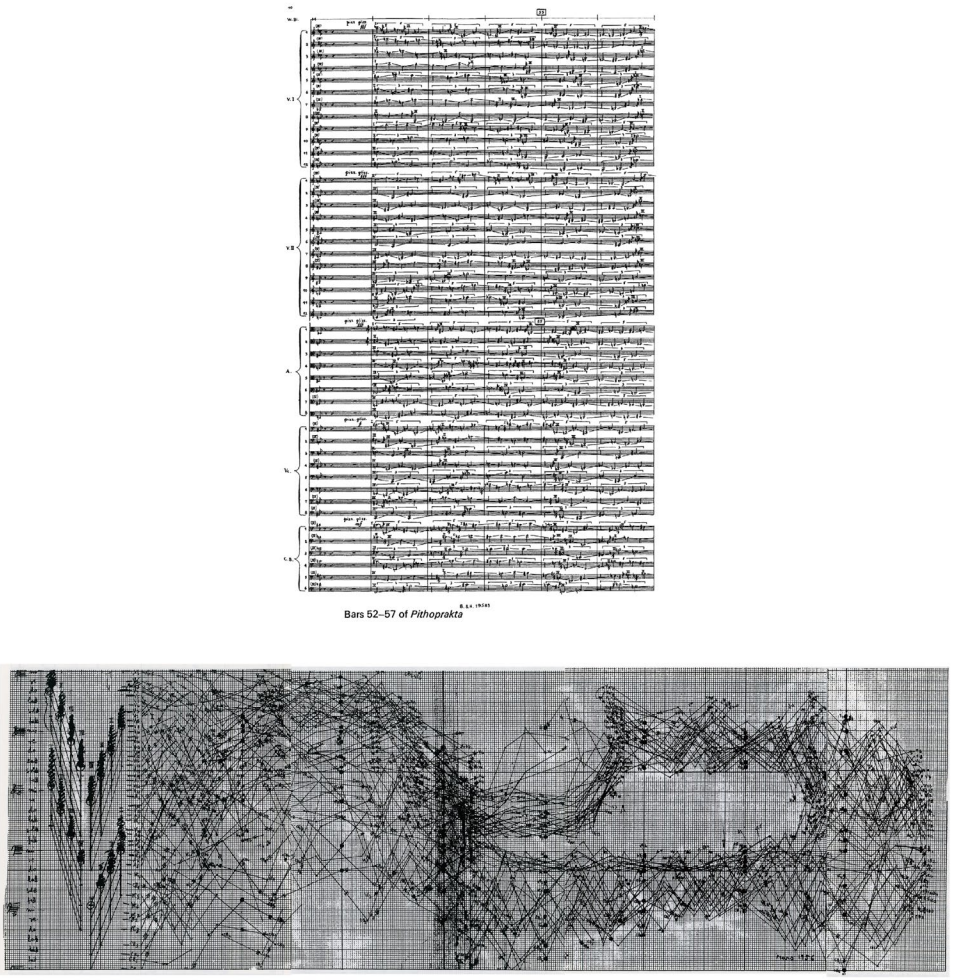

Fig. 37.5 *Pithoprakta*: score (1955/56), bars 52–7 (top) © 1967 by Boosey & Hawkes Music Publishers Limited, with kind permission of Boosey & Hawkes Bote & Bock, Berlin. Graph (bottom), reprinted courtesy of Pendragon Press. The graph represents a set of "speed temperatures" relating to the distribution of sonic elements, borrowing from Maxwell and Boltzmann's kinetic theory of gasses. The score makes evident the body of simultaneous discrete elements, as if a gaseous mass. Reproduced in Xenakis, 1992, p. 17–21.

The approaches to a complex material world outlined in Xenakis's *Formalized Music* opened a window that was undeniably prescient, one which could not be ignored. If, for Xenakis, *sound* was material, my parallel material-perceptual world in architecture was *light*.[10] The query embedded at the core of *A Catalog of Difference* shares Xenakis's way of thinking in a granular manner, in a way that considers the organization of material as probabilistic and cloud-like (Figure 37.7).

10 This differs from Xenakis's design of light through the Polytopes in that *The Catalog of Difference* comprises the analysis of existing structures rather than their generation.

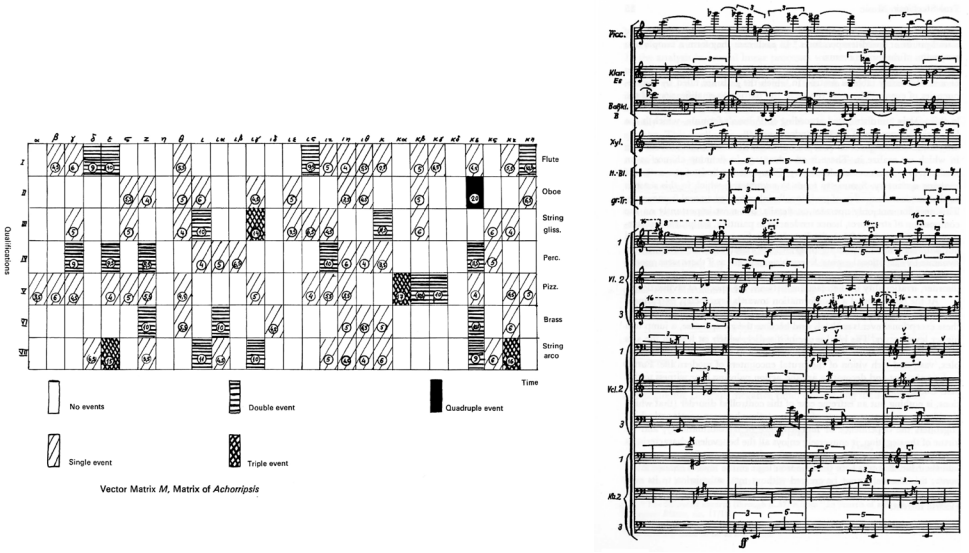

Fig. 37.6 *Achorripsis*: Vector Matrix M (left), reprinted courtesy of Pendragon Press; and (right) bars 104–8 (1956/57), © 1967 by Bote & Bock Musik- und Bühnenverlag GmbH & Co., with kind permission of Boosey & Hawkes Bote & Bock, Berlin. The likelihood of sonic events considered in a stochastic manner. Reproduced in Xenakis, 1992, p. 26–8.

Achorripsis (1958) offers one such example whereby the density and likelihood of sonic events were considered in a stochastic manner (Figure 37.6). Xenakis offered a model of the material and perceptual world in which things are not treated as finite "things," but rather as flows of informational events; flows that have an order (*taxis*), organization (*systasis*), structure, and probability of occurrence (*tyche*).[11] In short, a world of perception that is composed of discrete micro-events, in aggregate comprising a macro-event; events whose quantization is a consequence of the limits of the perceptual body encountering those flows of information.

11 Xenakis, 1992, p. 4.

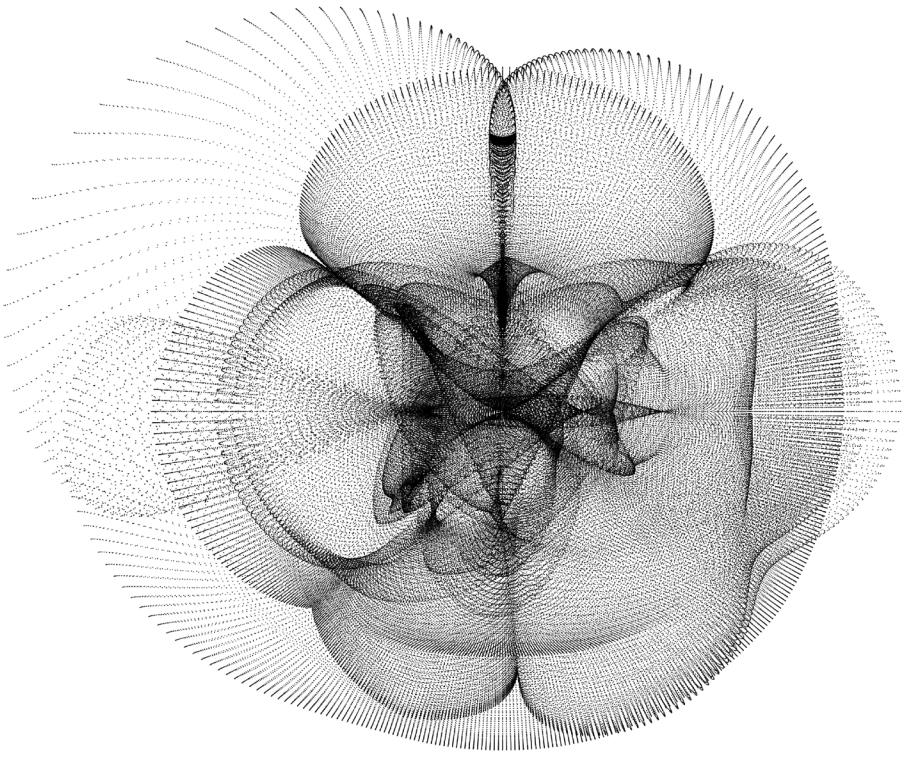

Fig. 37.7 Intrinsic Curvature Study of a Deformed Torus #2 from *A Catalog of Difference*, 2017. © Andrew Lucia (2017).

Xenakis's *Formalized Music* was transformative in demonstrating approaches to my own questions concerning more stable matter and its ephemeral image.[12] Like Xenakis, the methods of the *Catalog* were developed as a means of questioning inherited formal legacies, those in architecture spanning centuries to the foundations of the discipline—namely those of descriptive and projective geometry (Figure 37.8). Alternatively, how might we reframe this discussion in an informational, rather than geometric, understanding of space and its perception?[13]

12 While all matter is, in a sense, non-stable, the use of the term *stable matter* here refers to that which would be so in relation to human perceptual time scales, i.e. architecture and other "fixed" environments, etc.

13 The legacies questioned by Xenakis in *Formalized Music* directly paralleled conversations in which I was surrounded in 2008 during my graduate architecture education, namely those involving discussions of the novel production of affect. These 2008 discussions were occurring amidst an onslaught of newly developed geometric playgrounds made possible by radical advancements in architectural computation. While on the one hand these new computational capabilities were able to generate novel tools, methods of production and formal outcomes, they were simultaneously

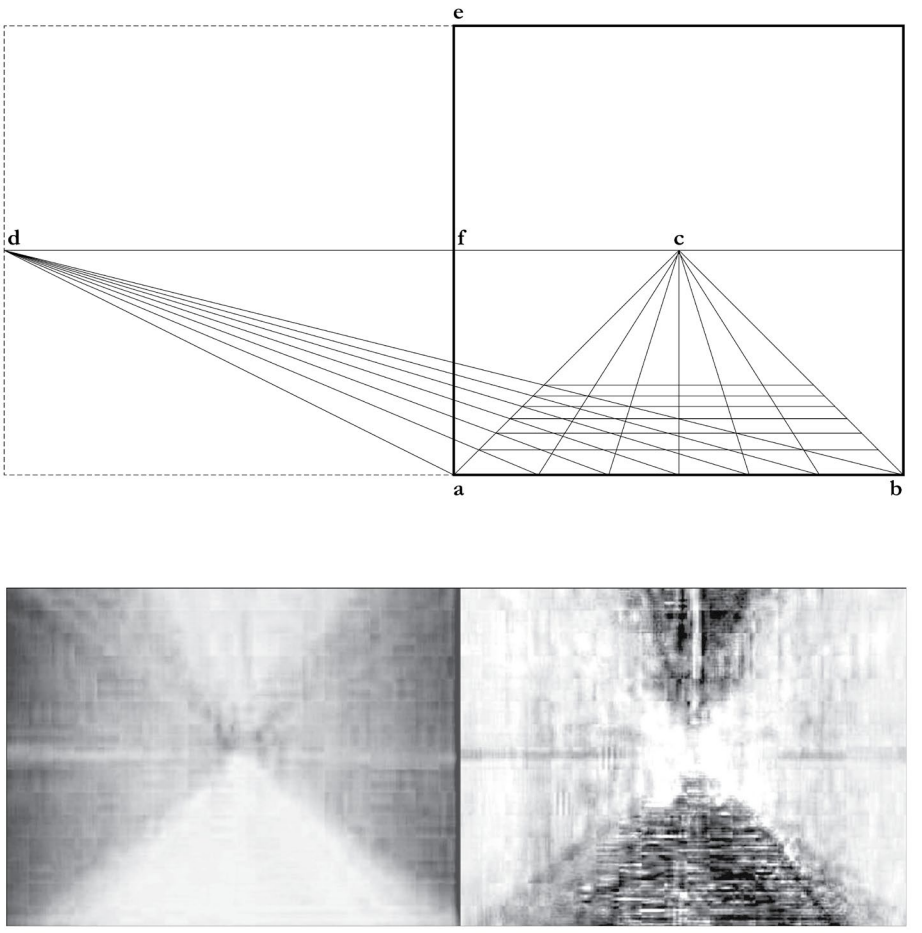

Fig. 37.8 From geometry to information. *Diagram of Perspective Construction* (top) after Leon Battista Alberti: *De Pictura* (conceived 1435–6): (ab) ground plane; (c) vanishing point (centric); (d) viewer's eye; (abe) picture plane; (df) viewing distance; (dfc) horizon line. Cumulative summation value for information derived from a video as a camera is tracked down a corridor (Bottom). Weighted "moderate" and "rare" event information (left and right). Portions of the bottom figure were adapted from the original by Lucia et al., 2013, p. 190. © IEEE (2013). Reprinted, with permission, from *Proceedings of the 15th International Conference on Information Visualisation* (*IV*), 2011.

Difference

As the tools and theories behind *A Catalog of Difference* began to evolve and expand, so too did the cast of referents. No doubt, the application of information theoretic ways

mired in centuries old languages of architectural legacy—namely those of descriptive and projective geometry—and thus not free of their inadequacies.

of thinking were not exclusively the purview of Xenakis, although he was certainly the foremost revolutionary of these concepts in music.[14] It would be beyond the arts that the works of others began to enter into my thinking, one notable figure and the namesake behind the *Catalog* being the anthropologist Gregory Bateson (1904–80).[15] Like Xenakis, his ability to synthesize disparate realms of knowledge under one umbrella echoes strongly. Importantly, Bateson is remarkable for his embrace of information theoretic principles more broadly into the evolutionary sciences, anthropology, perception, linguistics, biology, aesthetics, and design. It was from here that parallels can be drawn to Bateson's usage of the term *difference*, specifically his notion that it is those *differences that make a difference* that matter in so many aspects of our conscious and unconscious lives.[16]

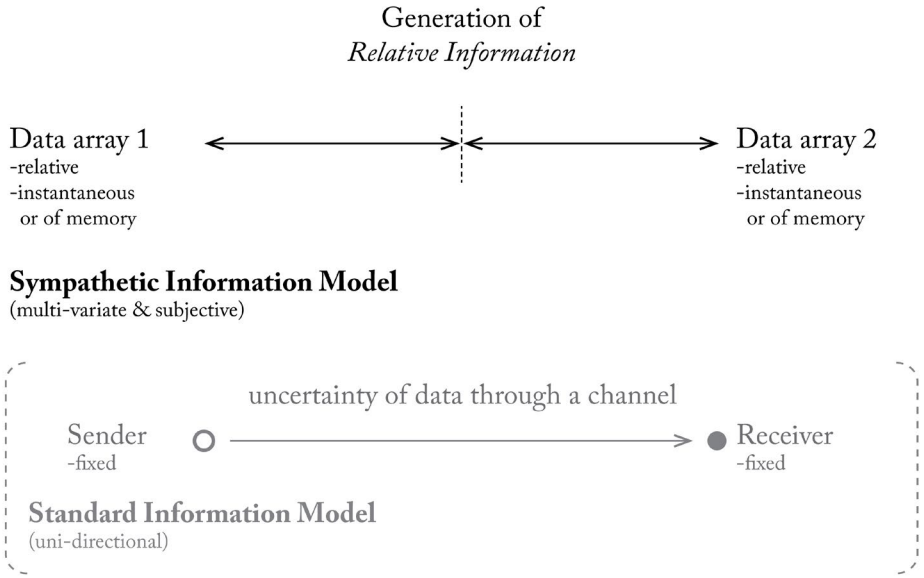

Fig. 37.9 From standard to sympathetic information models through a fusion of relative data. Note the distinction from the classic standard model of information with that of the sympathetic model proposed here. The latter relies on the comparison of two relative data arrays while the former describes a unidirectional flow of information through a discrete channel. Lucia, 2017, p. 104. © Andrew Lucia (2017).

14 I am thankful to Olga Touloumi and Anton Vishio who, during the discussion portion of the symposium, reminded me of the pioneering works into cybernetics and perception by Abraham Moles (1920–92), with whom Xenakis was known to have been introduced and held discussions concerning information and aesthetics. The notes on these meetings, according to Touloumi, reside in Paris. (Moles, 1968).

15 I am thankful for my introduction to Bateson that came at the insistence of David Salomon, who had been familiar with my line of research into difference and information theories through Xenakis.

16 The phrase *differences that make a difference* is adapted from the original, "...what we mean by information—the elementary unit of information–is a difference which makes a difference..." (Bateson, 2000, p. 459).

Bateson states, "To produce news of difference, i.e., *information*, there must be two entities (real or imagined) such that the difference between them can be immanent in their mutual relationship."[17] Bateson similarly notes, "[…] perception operates only upon *difference*. All receipt of information is necessarily the receipt of news of difference, and all perception of difference is limited by threshold. Differences that are too slight or too slowly processed are not perceivable."[18] Ultimately, for all of the many figures that have embraced information theoretic principles, it is difference that underlies the generation of information, particularly perceptual information.[19]

For Xenakis, these perceptual and informational principles were inherently embedded within his theories and methods. Here we see his diagrams describing how one might embed the limits of perception into sonic compositional material (Figure 37.10). These exist at the upper and lower thresholds of audible perception, and durationally as the just-noticeable difference.[20]

17 Bateson, 2002, p. 64.

18 Ibid., p. 27.

19 Another notable figure of importance to this discussion, and whose theories also influenced the development of the *Catalog*, is the perceptual psychologist James J. Gibson (1904–79). Gibson's *Ecological Approach to Visual Perception* posited ambient optic arrays of visual information. Again, for Gibson, a notion of difference is fundamental to the production and perception of visual information, "Only insofar as ambient light has structure does it specify the environment. I mean by this that the light at the point of observation has to be different in different directions (or there have to be differences in different directions) in order for it to contain any information. The differences are principally differences of intensity." (Gibson, 1986, p. 51).

20 I am thankful to James Harley who, during the discussion portion of the symposium, encouraged a revisiting of Xenakis's later writings that concern one's being inside or outside time, and its perception. These concepts are notably elaborated on in Chapter 10 of *Formalized Music*, "Concerning Time, Space and Music." In one especially relevant passage concerning difference and one's being "inside or outside" of time Xenakis speculates, "What is the flux of time which passes invisibly and impalpably? In truth, we seize it only with the help of perceptive reference-events, thus indirectly, and under the condition that these reference-events be inscribed somewhere and do not disappear without leaving a trace." He would continue, "[…] if events were absolutely smooth, without beginning or end, and even without modifications or 'perceptible' internal roughness, time would likewise find itself abolished. It would seem that the notion of separation, of bypassing, of difference, of discontinuity, which are strongly interrelated, are prerequisite to the notion of anteriority. In order for anteriority to exist, it is necessary to be able to distinguish entities, which would then make it possible to 'go' from one to the other. A smooth continuum abolishes time, or rather time, in a smooth continuum, is illegible, inapproachable." (Xenakis, 1992, p. 262).

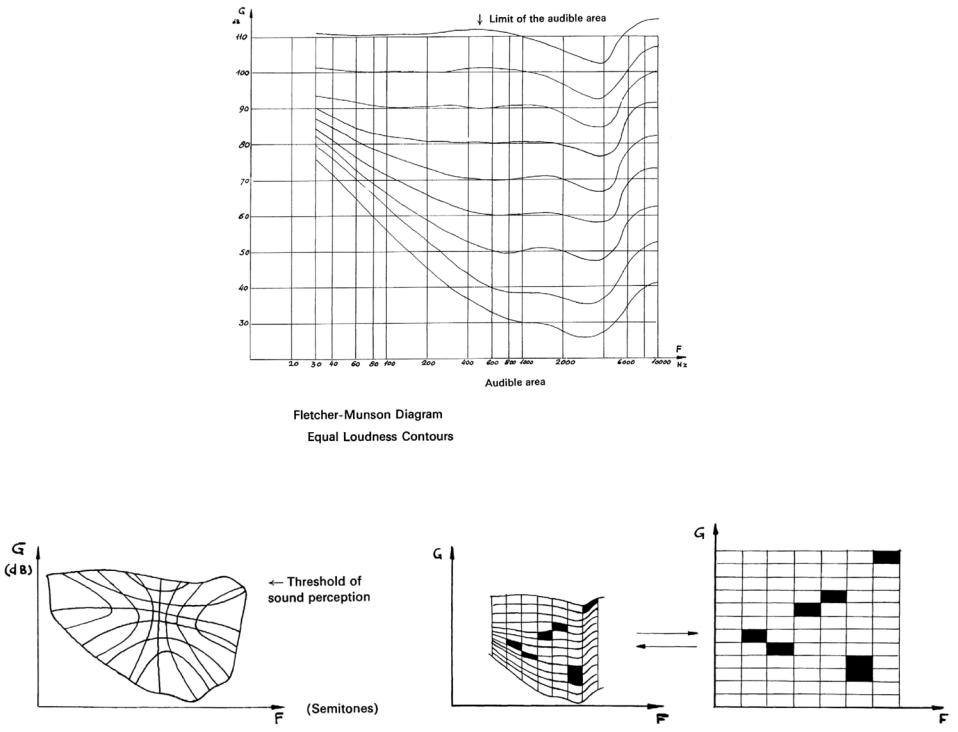

Fig. 37.10 Fletcher-Munson diagram of equal loudness contours (top) and their remappings based upon the sensitivity of human perception to the density of sonic events (bottom). Reproduced in Xenakis, 1992, p. 48–9. Images used with permission of Sharon Kanach and Pendragon Press.

Image in Motion: The Probability of Change across Images Through Time

The various tools and processes embedded in the representations of the *Catalog* were developed in parallel over the course of several years. Before discussing the static representations comprising the 2017 and 2018 exhibitions of the work, it is necessary to cover the dynamic studies and tools underpinning their creation—those whose origins are directly influenced by Xenakis's Markovian stochastic theories of composition outlined in *Formalized Music*.[21]

Xenakis would conceive of his sonic materials existing as grains of sound composed of duration, frequency, and intensity that were "adequately disposed in time" and could be "resolved into elementary acoustic signals of very short effective durations, whose amplitude can be divided equally into quanta in the sense of information theory."[22]

21 Ibid., p. 1–78.
22 Ibid., p. 373.

Xenakis devised a vector space for the life of all sonic events, whereby grains of sound were disposed on conceptual "screens," or "time-sheets," whereby a "book of screens equals the life of a complex sound."[23] Xenakis's "book of screens" is an abstract space depicting the quality and organization of sonic events through time (Figures 37.11 and 37.12). Albeit not a 1:1 translation, taking license with this abstraction, one can equally consider the moving image in a similar manner. An individual sheet of visual material (i.e., an image) inherently contains many of the same variables as Xenakis's granular sonic materials, and even more so when considered through time.

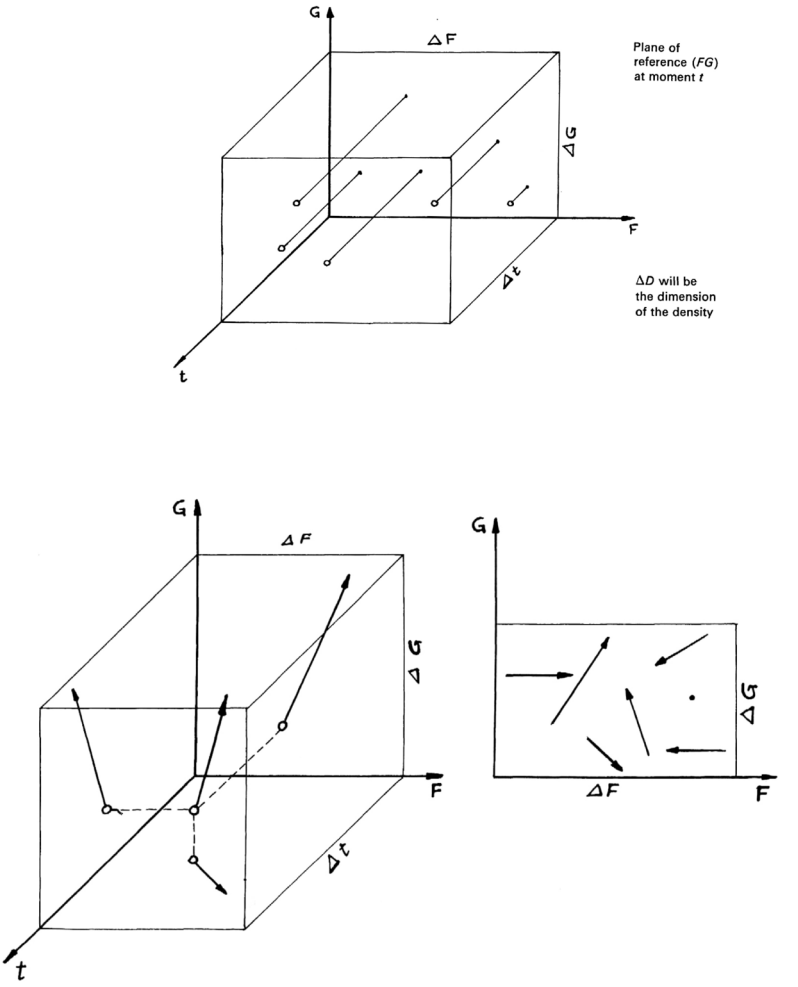

Fig. 37.11 Distribution of elementary sonic grains as vectors disposed along a frequency (f) and intensity (G, dB) axes through time (t), with the top diagram demonstrating continuous tones and the bottom depicting *glissandi* events. Reproduced in Xenakis, 1992, p. 50, 55. Images used with permission of Sharon Kanach and Pendragon Press.

23 Ibid., p. 51.

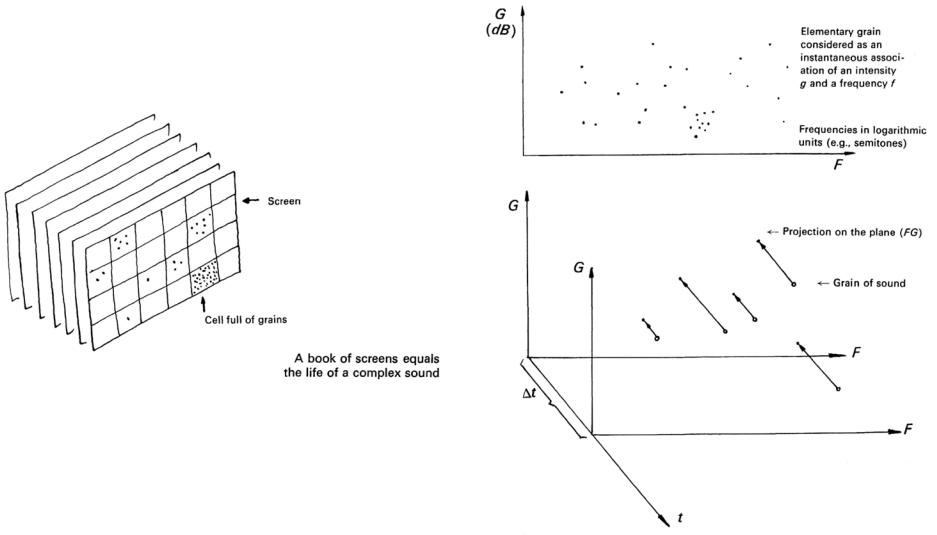

Fig. 37.12 A "book of screens" upon which granular sonic elements are distributed; a series of discrete temporal planes for the life of complex sounds. Reproduced in Xenakis, 1992, p. 46, 51. Images used with permission of Sharon Kanach and Pendragon Press.

c_a = timbre or instrument family

h_i = pitch of the sound

g_j = intensity of the sound, or dynamic range

u_k = duration fo the sound

$H_{i,j}$ = hue of the pixel (color)

$S_{i,j}$ = saturation of the pixel

$B_{i,j}$ = intensity of the pixel brightness

$p_{i,j,t}$ = probability the pixel will change

Fig. 37.13 Variables of sound and moving image. Xenakis's definition of sonic entities (left), "represented in a first approximation by vectors of four usually independent variables" (adapted by author from Xenakis, 1992, p. 23). By comparison, variables associated with moving images are defined by hue, saturation, and brightness of pixel values, with the probability of a pixel's change being substituted for its duration.

By the very nature of digital consumer image technology, a static image comes ready-made and composed of individual elements in the form of pixels, whose variables include intensity and color rendered within the limits of human visual perception (hue, saturation, and brightness), with the probability of change being a variable through time (Figure 37.13). I want to take a moment to walk through an example, one that considers these variables.

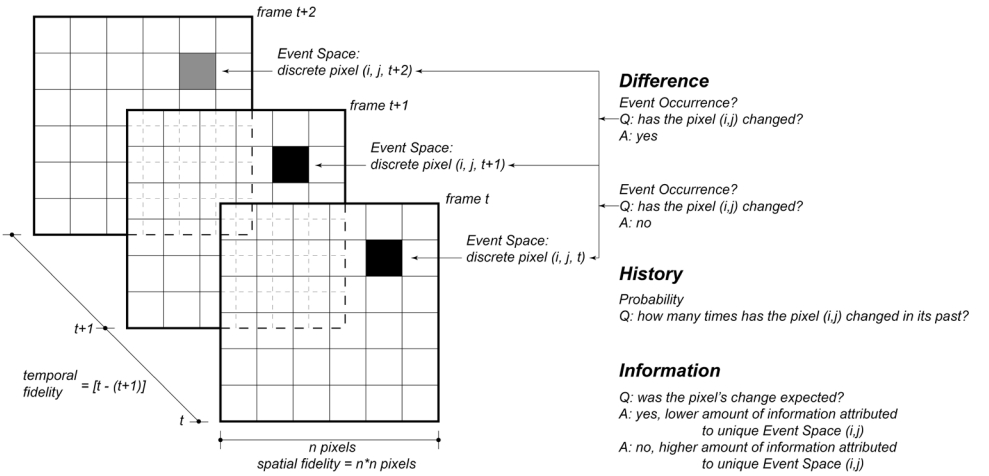

Fig. 37.14 Schematic diagram of pixel event space; difference, history and information. Original figure by Lucia et al., 2013, p. 188. © IEEE (2013). Reprinted, with permission, from *Proceedings of the 15th International Conference on Information Visualisation (IV)*, 2011.

In this schematic diagram (Figure 37.14), every pixel is queried as to whether its state has changed within a given brightness threshold. This is a question of difference. Next, its history is examined for the probability of its likelihood to change. Based on its current state (change or no change), its information may be tabulated. For this the general equation utilized by Xenakis and developed by Claude Shannon (1916–2001) and Warren Weaver (1894–1978) is used, $H = -\sum p_i \log_2 p_i$, whereby H is the amount of uncertainty in the occurrence of an event, p is the probability of an event occurring.

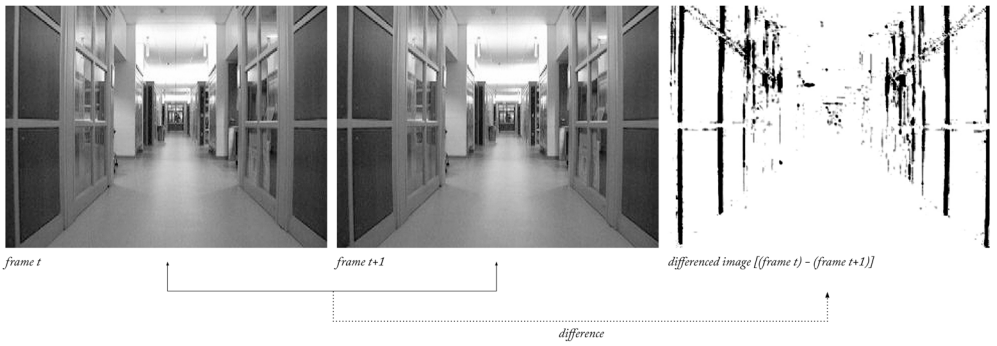

Fig. 37.15 Image differencing. Difference in pixel contrast (right) between consecutive digital video images (left and middle) as a camera is tracked down a hallway. This figure was adapted from the original by Lucia et al., 2013, p. 187. © IEEE (2013). Reprinted, with permission, from *Proceedings of the 15th International Conference on Information Visualisation (IV)*, 2011.

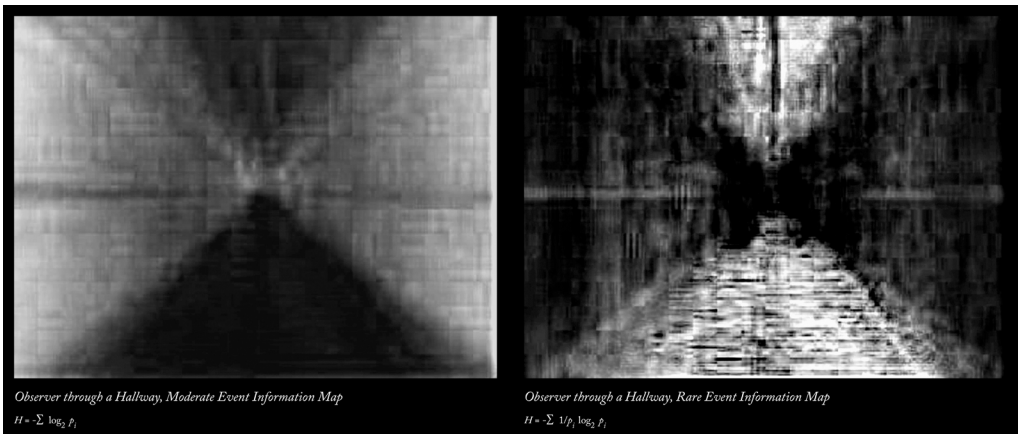

Fig. 37.16 Information maps. Cumulative summation values for information maps derived from a video as a camera is tracked down a corridor demonstrating weighted moderate and rare event information for an observer traversing a hallway. This figure was adapted from the original by Lucia et al., 2013, p. 190. © IEEE (2013). Reprinted, with permission, from *Proceedings of the 15th International Conference on Information Visualisation (IV)*, 2011.

In Figures 37.15 and 37.16, we take the example of a recording device traversing a hallway. The brightness intensity of sequential images is subtracted from one another, resulting in their difference. As the difference is calculated, the cumulative summation of information is tabulated and weighted in a manner that favors common or rare events in the pixel field.[24]

Xenakis's compositional methods were developed in abstract mathematical spaces, or vector spaces. In doing so, he was operating one step removed from the direct material at his disposal, one of several means utilized to break from Western traditions. These information mappings now describe visual material in probabilistic terms, yet as a static image they are not situated in an abstract vector space describing their changing disposition. The second half of this chapter focuses on this phenomenon while asking: "How *different* am I from my neighbor?", which makes up the foundational question of *A Catalog of Difference*.

A Catalog of Difference (2017)[25]

While the tools that comprise the *Catalog* have found application to data across an array of disciplines and scales, I present here the instantiation of the project that exclusively examines human-scaled spaces, surfaces, and their images. The research is divided into three distinct yet related subsets, examining the order and organization of planar ambient light, spherical ambient light, and surface curvatures. The studies in each of

24 Modifications to the standard equation for information $[H = -\sum p_i \log_2 p_i]$ are made in order to give priority to moderate $[H = -\sum \log_2 p_i]$ and rare $[H = -\sum 1/p_i \log_2 p_i]$ events within the pixel field.

25 Portions of the following were adapted from Lucia, 2017.

these subsets questions form versus its appearance. An important translational goal of the *Catalog* was to render each entity removed from its outward metric image, to represent it in an abstract vector space in terms of its degrees of difference and order. Each representational artifact is an aggregate of micro-entities that in total suggests a cloud-like macro-form.

Analysis on the Order and Structure of Ambient Light Embedded within Planar Imagery

The first subset of the research begins with an examination into the structure of ambient light projected to a picture plane—as this is the historically dominant modality by which images have been constructed and transmitted.

Method and Analysis

For these studies, the gradient vectors within each image are calculated, extracted, and remapped to a polar coordinate system forming a scatter plot (Figure 37.17). The scatter plot of each image gradient depicts the changing intensity and direction of light within the image. To do so, each data point is measured locally within the image at every pixel in comparison to its neighbors. Alternately stated, every point in an image asks itself, "to what degree and in which dominant direction am I *different* from my neighbors?"

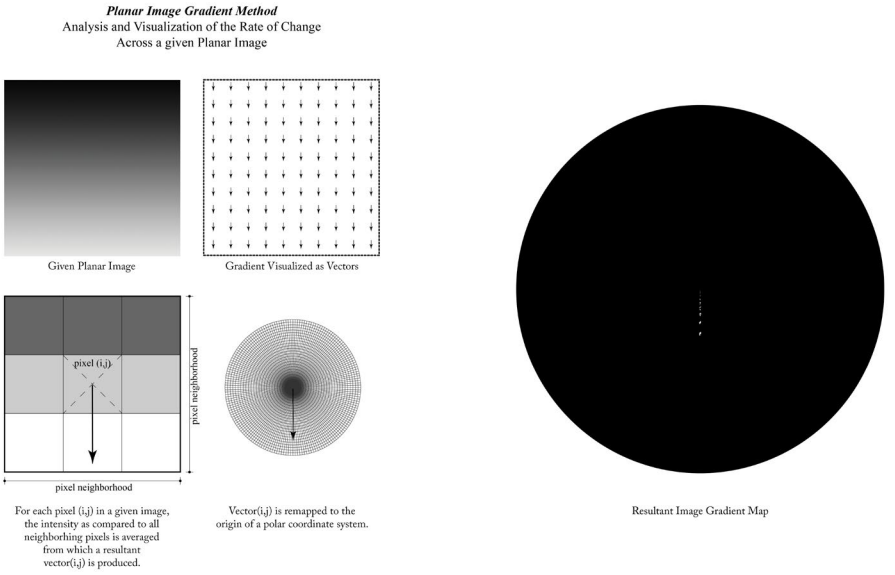

Fig. 37.17 Planar image gradient method from *A Catalog of Difference*, 2017. © Andrew Lucia (2017).

The result is a visualization of the structure of difference within the image. Removed from its respective appearance, this light-based signature is thus a qualitative and quantitative description of the order within a scene's image. Here, I present the scatter plots for images of clouds, flora, and urban scenes (Figures 37.18, 37.19, and 37.20, respectively). Additionally, the number noted for each study is a measure of the amount of redundancy within each gradient, an account of the redundancy within the spatial difference of light values across the entire image. These values are plotted logarithmically with higher values indicating less redundancy, more disorder, and thus more information. This type of difference ultimately underlies the spatial structure of ambient light-based information within a given scene.

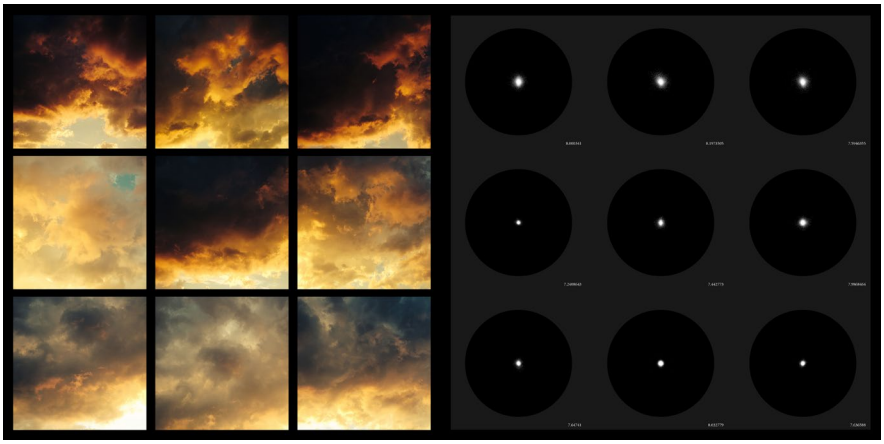

Fig. 37.18 Study of nine images of clouds (left) and their image gradients (right) from *A Catalog of Difference*, 2017. Each image gradients' information content is calculated as $[H = -\sum p_i \log_2 p_i]$ and noted numerically. © Andrew Lucia (2017).

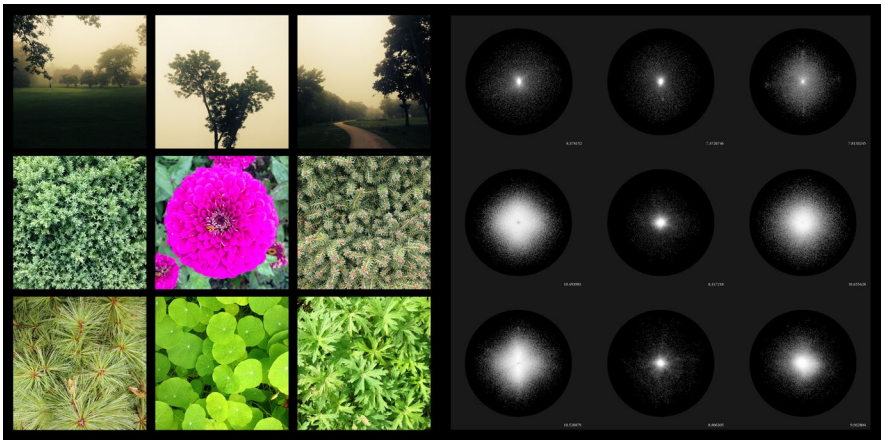

Fig. 37.19 Study of nine images of flora (left) and their image gradients (right) from *A Catalog of Difference*, 2017. Each image gradients' information content is calculated as $[H = -\sum p_i \log_2 p_i]$ and noted numerically. © Andrew Lucia (2017).

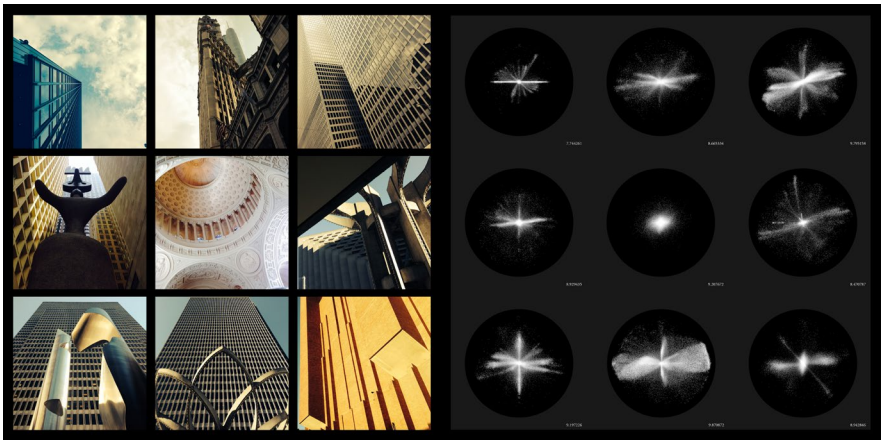

Fig. 37.20 Study of nine images of the built environment (left) and their image gradients (right) from *A Catalog of Difference*, 2017. Each image gradients' information content is calculated as $[H = -\sum p_i \log_2 p_i]$ and noted numerically. © Andrew Lucia (2017).

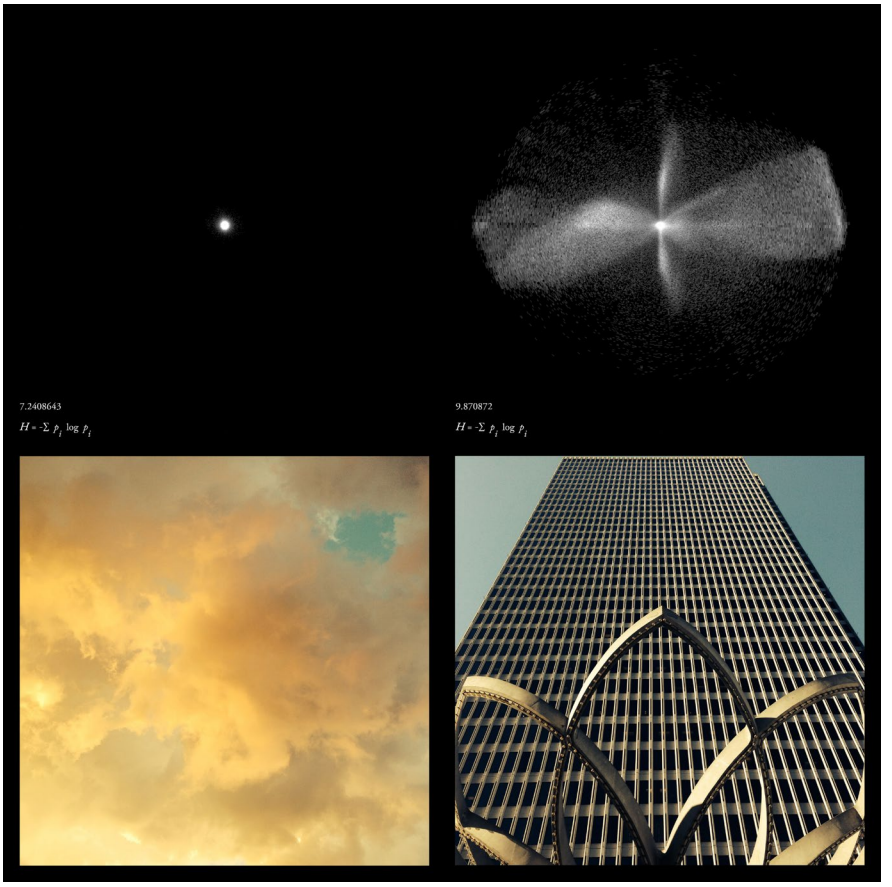

Fig. 37.21 Comparison of the image gradients of clouds and an urban environment, and their respective gradients' information content $[H = -\sum p_i \log_2 p_i]$. © Andrew Lucia (2017).

Lastly, it should be noted that the order of physical material within the original scene is not an indicator of the amount of order in the light-based *information* that is contained within that scene's image. For instance, the *information* in the appearances of many urban scenes' gradients exceeds that of the natural environments (Figure 37.21). Clouds in particular have a highly ordered ambient reflection and thus their images have a lower *information* content. Though static in nature, this type of measurement can be seen as akin to Xenakis's ideas of *ataxy*, allowing images to be categorized purely based on their structures' degrees of order or disorder, rather than by their symbolic or linguistic significance. Here, the images from Figures 37.19 and 37.20 are arranged according to the amount of order within their gradients (Figures 37.22 and 37.23).

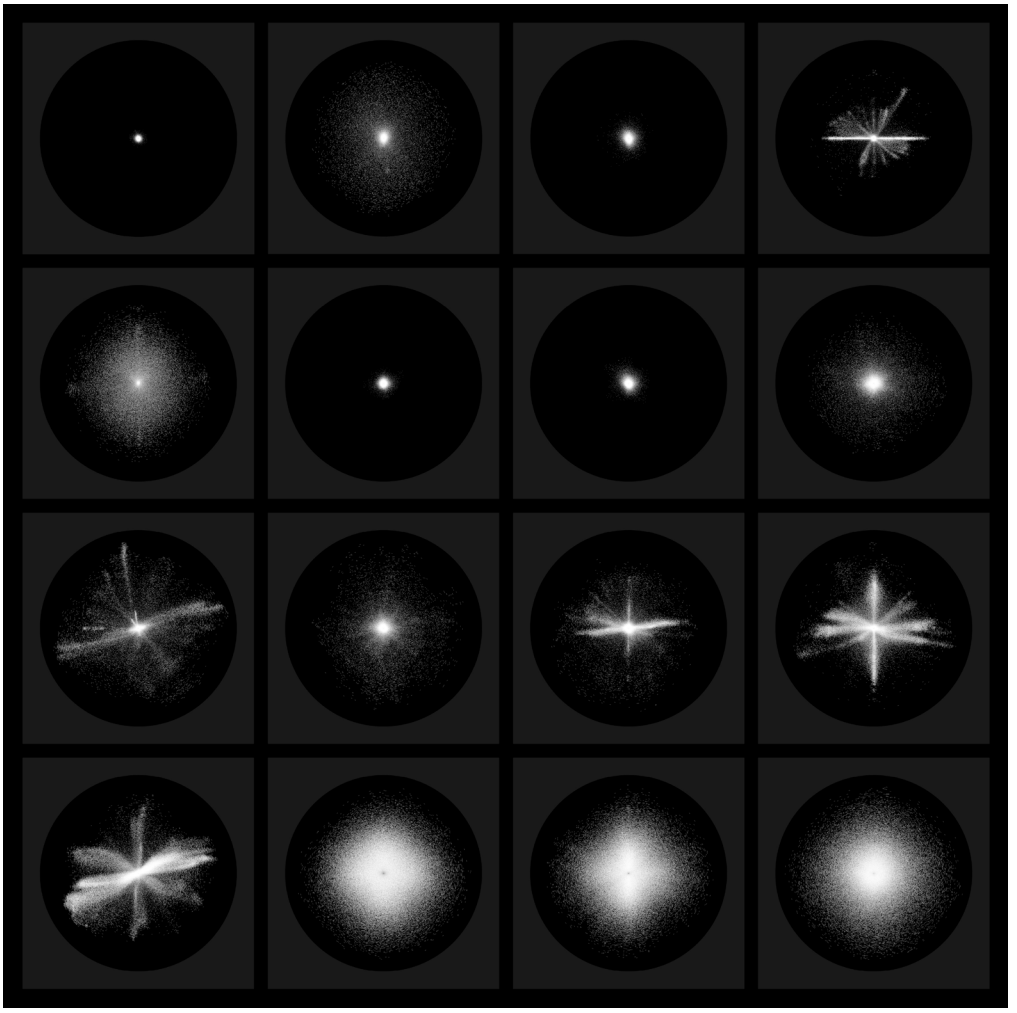

Fig. 37.22 Matrix of nine image gradients arranged according to their information content (lower, upper left to higher, bottom right). This type of arrangement can be seen as akin to Xenakis's ideas of ataxy, allowing images to be categorized purely based on their structures' degrees of order or disorder, rather than by their symbolic or linguistic significance. © Andrew Lucia (2017).

Fig. 37.23 Matrix of nine images arranged according to their gradients' information corresponding to the content in the previous figure. © Andrew Lucia (2017).

Analysis on the Order and Structure of Omni-directional Ambient Light

Here, a major two-fold shift occurring in modalities of visual representation is undertaken (Figure 37.24): the first is a transition from planar to spherical modes of projection, followed by an extrinsic to intrinsic reframing of an observer relative to their perceptual environments.[26] The light captured on a picture plane is but a subset of all the omnidirectional ambient light reaching an observation point within

26 This latter spherical type of projection has always physically existed but has largely been conceptually neglected at the expense of neatly framed and geometrically managed *windows to the world*—those mediating devices that separate us from our environments.

an environment. That limited subset, typically manifest as a framed planar image, is ultimately a fragment of a much larger spherical domain of light—a unique point of observation containing all light-based information about an environment—within a sphere of observation.

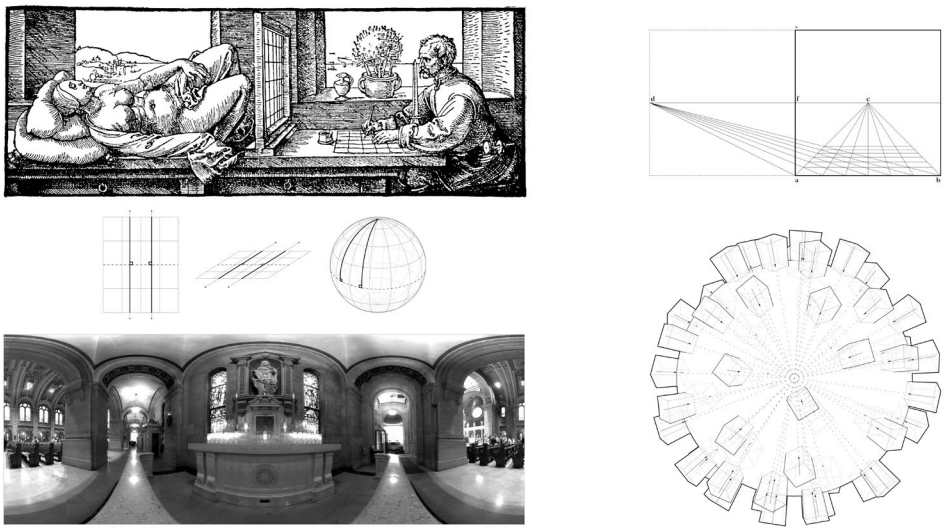

Fig. 37.24 From plane to sphere. *Draughtsman Drawing a Recumbent Woman*, Albrecht Dürer, 1525 (top left, public domain); violation of the parallel postulate in positively curved spherical-space (middle left); spherical image remapped to planar representation (bottom left); *Diagram of Perspective Construction* (upper right) after Leon Battista Alberti: *De Pictura* (conceived 1435–6); diagram of a spherical image subdivided by discrete picture frames (bottom right). Lucia, 2017, p. 76, 106. © Andrew Lucia (2017).

Method and Analysis

The gradient vectors for each environment's spherical image are calculated, extracted, and remapped to a common origin forming a spatial scatter plot in the form of a point cloud. The method used here, illustrated in Figure 37.25, is similar in nature to that of the planar image gradient extraction described earlier. Lastly, after remapping the vectors as points, for visualization purposes moments of density within the resultant point cloud are figured and solidified as a surface.

For demonstration, the light spheres for two interior scenes (Figure 37.26) are set against two scenes from an outdoor natural environment (Figure 37.27). We see here, again, nine studies on the structure of light embedded within human-made built environments (Figure 37.28), contrasted against nine demonstrating those of natural environments (Figure 37.29). In the former, discernible structure is evident, whereas the latter is far more evenly distributed.

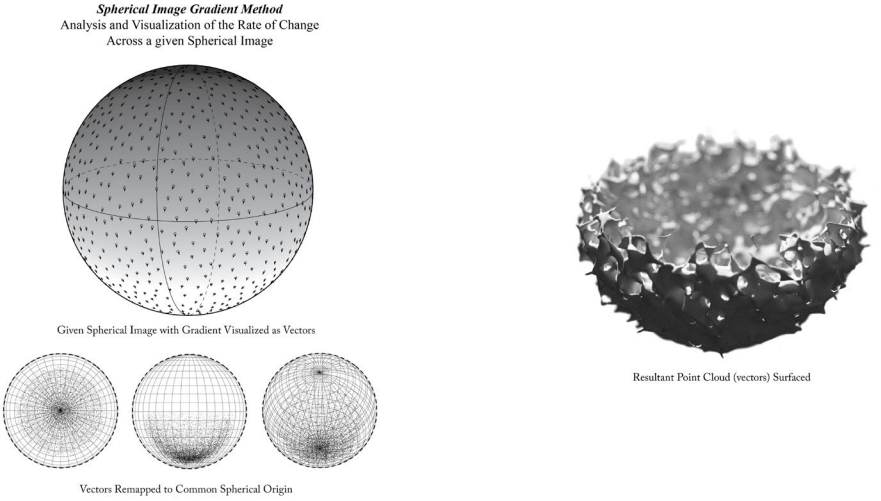

Fig. 37.25 Spherical image gradient method from *A Catalog of Difference*, 2017. © Andrew Lucia (2017).

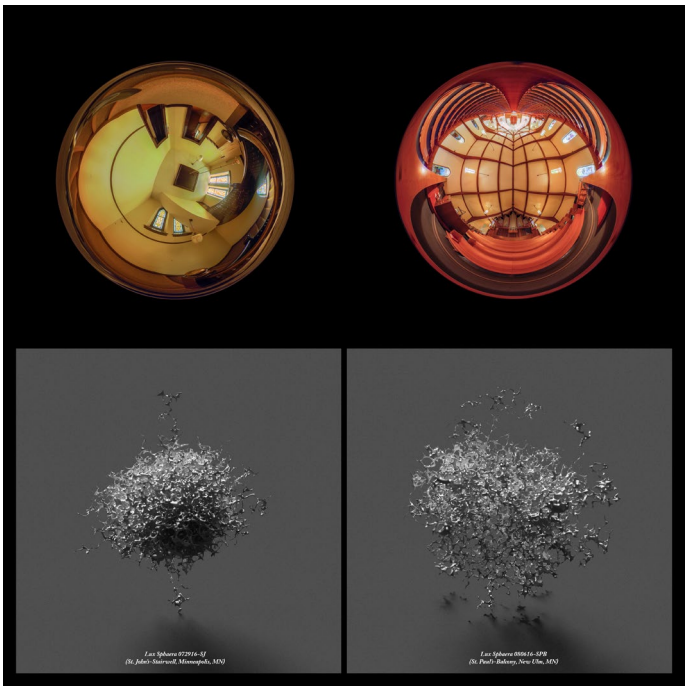

Fig. 37.26 Two studies on the structure of light embedded within human-made built environments from *A Catalog of Difference*, 2017. © Andrew Lucia (2017).

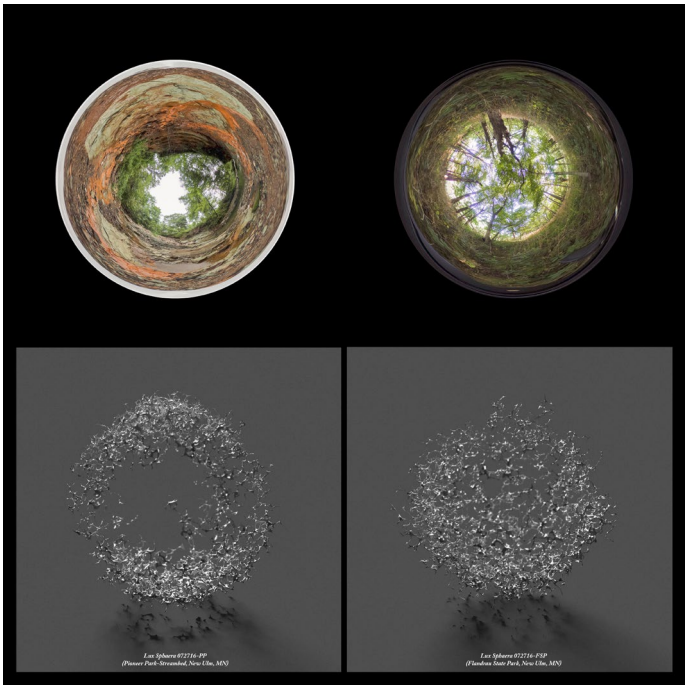

Fig. 37.27 Two studies on the structure of light embedded within natural environments from *A Catalog of Difference*, 2017. © Andrew Lucia (2017).

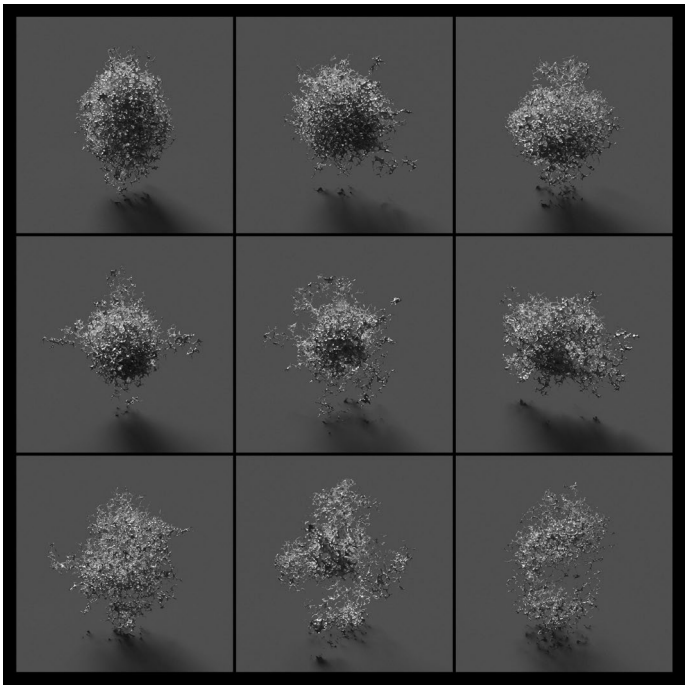

Fig. 37.28 Nine studies on the structure of light embedded within human-made built environments from *A Catalog of Difference*, 2017. © Andrew Lucia (2017).

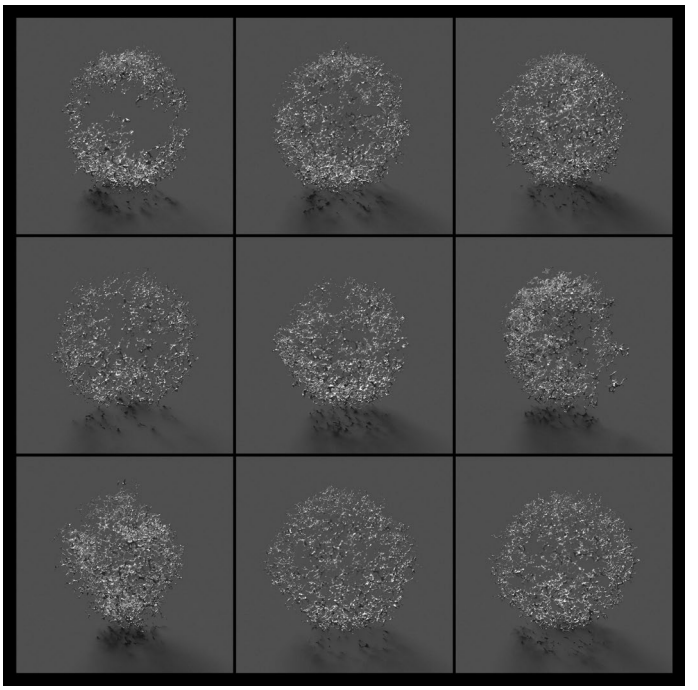

Fig. 37.29 Nine studies on the structure of light embedded within natural environments from *A Catalog of Difference*, 2017. © Andrew Lucia (2017).

Analysis on the Order and Structure of Surface Curvature

Similar to the prior studies in ambient light, these surficial inquiries challenge the notion of an object's underlying formal structure versus that of its appearance. Here, through a measure of intrinsic curvature (the Gaussian curvature), an object is represented as a description of the change across itself. One is no longer concerned with the object as a thing, but rather with how that thing is intrinsically changing. What would typically be a discussion of an object's shape and surface is now framed akin to the approaches undertaken throughout the light-based portions of this research—those asking how a system is changing across itself. These types of systems do not rely on external observation and depend entirely on local understandings of difference.[27]

Method and Analysis

Here, the rate of change across a given surface is evaluated, visualized as a vector, and remapped to a common origin producing a spatial scatter plot in the form of a point

27 Gaussian curvature is implicitly differential. That is, Gaussian curvature has embedded within its measure an intrinsic account of instantaneous rates of change at any discrete point along a given surface, defined as the product of the principal curvatures, $K=k_1 \cdot k_2$.

cloud (Figure 37.30). As with the image gradients, each point of evaluation upon the surface is taken and measured locally. Alternately stated, every point on the surface asks itself, "to what degree and in which direction am I different from my neighbors?"

Taken further, a point cloud of infinite density is ostensibly a surface (Figures 37.32 and 37.33). In that regard, I present five studies on the intrinsic curvature of Plücker's conoid, and five studies on the intrinsic curvature of annuli.

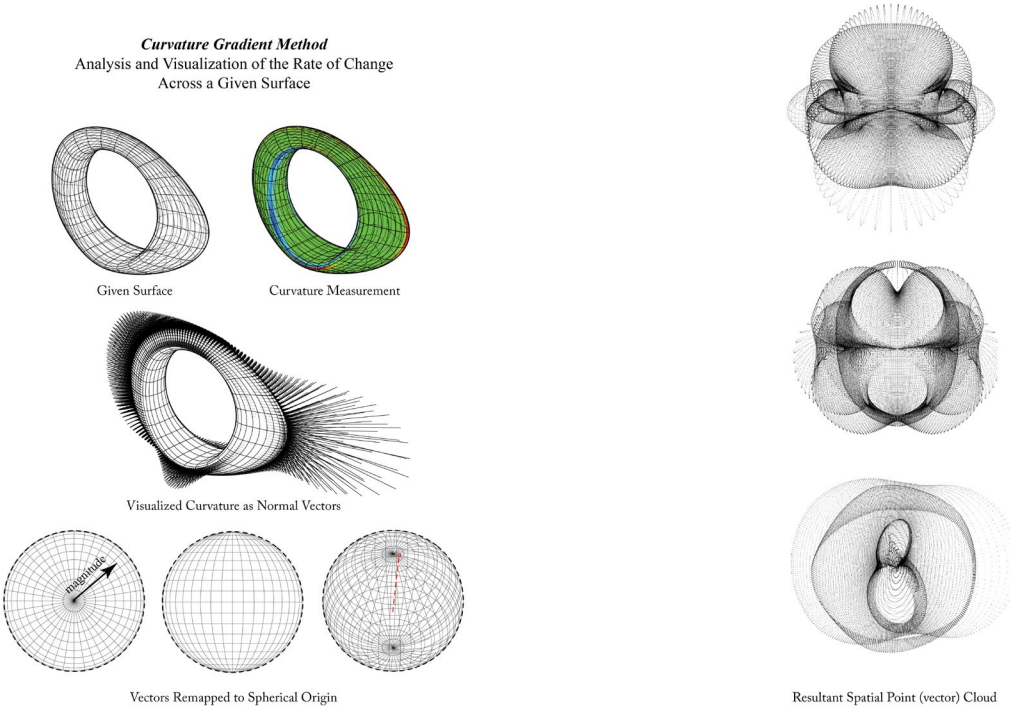

Fig. 37.30 Curvature gradient method from *A Catalog of Difference*, 2017. This figure was adapted from the original by Lucia et al., 2013, p. 194–5. © IEEE (2013). Reprinted, with permission, from *Proceedings of the 15th International Conference on Information Visualisation (IV)*, 2011.

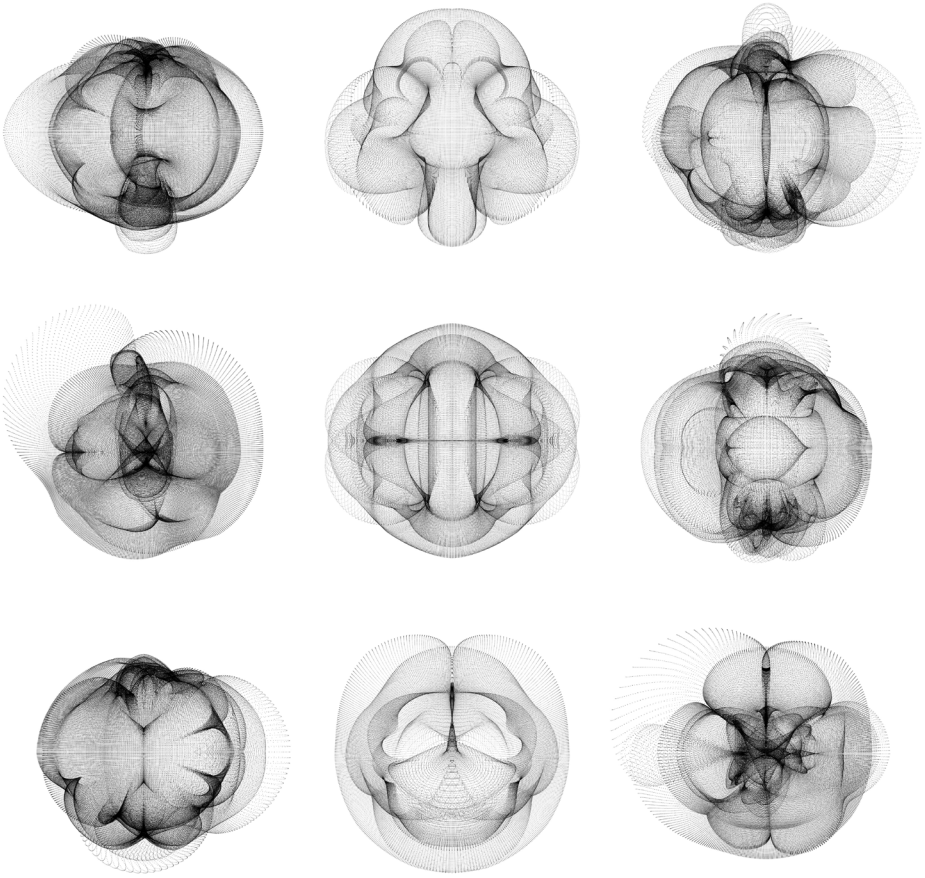

Fig. 37.31 Nine studies on the intrinsic curvature of deformed tori from *A Catalog of Difference*, 2017.

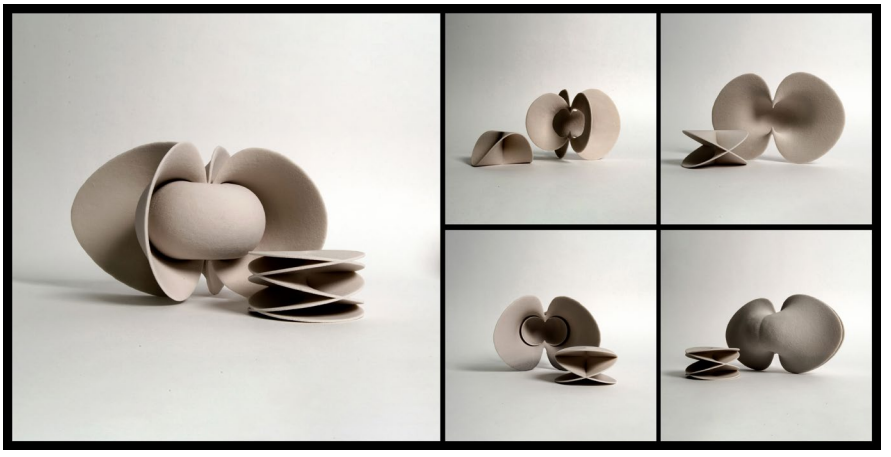

Fig. 37.32 Five studies on the intrinsic curvature of Plücker's conoid from *A Catalog of Difference*, 2017. © Andrew Lucia (2017).

Fig. 37.33 Five studies on the intrinsic curvature of annuli from *A Catalog of Difference*, 2017. © Andrew Lucia (2017).

Conclusion

The studies comprising *A Catalog of Difference* do not purport to be a direct translation of Xenakis's methods from the sonic realm into that of the visual. Rather, the difference machines elaborated on in the *Catalog* are a suite of methodologies that, in concert, ask questions of the visual world of matter akin to that in which Xenakis's generative methods operate sonically. This is but a moment along the journey of an ongoing adventure in perception.[28]

28 I would like to additionally and warmly thank Sharon Kanach for reaching out and inviting me to submit an abstract for consideration to this remarkable global symposium, and for her unflinching

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dedication to the legacy of Iannis Xenakis, of which her organization and leadership of this event is evidence. Many thanks, also, to Carey Lovelace, Barbara Mackenzie, and to the Xenakis Project of the Americas in helping to make this event a resounding success.

38. The Algorithmic Music of Iannis Xenakis—What's Next?

Bill Manaris[1]

Introduction

Iannis Xenakis was a pioneer in algorithmic composition of music and art. He combined architecture, mathematics, music, and performance art to create avant-garde compositions and performances that are still being analyzed, performed widely, and discussed.[2] The compositions and other artifacts created by him were primarily inspired by his deep appreciation and understanding of algorithms, mathematics, and the use of controlled randomness, i.e., stochastic processes.

Xenakis was awarded a doctorate from the Sorbonne in 1976, for previously published theoretical and creative works.[3] Since Xenakis was trained in mathematics, he viewed algorithmic computation through the lens of mathematics. Given the evolution of the field of computer science since that time, Xenakis's work now clearly falls within the field of algorithmic arts (AlgoArts). Xenakis's many musical contributions are deeply algorithmic in nature, and his rich and influential output

1 This work is partially co-sponsored by the US National Science Foundation and the US National Endowment for the Arts, under CNS-2139786, "Computing in the Arts—The Algorithm is the Medium," http://AlgoArts.org. It is partially based on a talk given at the Music Library of Greece, in May 2022. It also includes materials presented at the International Symposium on Electronic Art (ISEA) 2022 conference (Forgette et al., 2022), and the first Algorithmic Arts workshop (Manaris and McCauley, 2022). The author would like to thank Stephanie Merakos, Director, Music Library of Greece, for her invitation to give the talk upon which this paper is based. The author would also like to acknowledge Anna Forgette and Samantha Ramsden, for their contributions to design, computer programming, and execution of the performances reported herein. Andrew Brown contributed to the implementation of Concret PH in JythonMusic. Meghan Gillikin and Nick Moore helped with the design, programming, and testing of the experiences. Finally, the musicians, Yiannis Bafaloukas (piano), Daniel Brown (cello), and Devon Wyland (bassoon) traveled from the Netherlands, United States, and Germany, respectively, to be part of the performance of the *on the Fractal Nature of Being…* piece.

2 See Di Scipio, 1998; Kanach, 2008; Kanach, 2010; Kanach, 2012; Lombardo et al., 2009; Reynolds and Reynolds, 2021; Schafer, 1993; Solomos, 2008; Solomos, 2021; Valle et al., 2010.

3 Xenakis, 1985.

 https://doi.org/10.11647/OBP.0390.40

would not have been possible without the ability to implement his processes through different computer programming languages, such as Fortran and BASIC, and the formalization, standardization, and replicability that such programming languages provide.[4]

This chapter is based on an invited talk-performance for a general audience at the Music Library of Greece, in the context of "Meta-Xenakis"—a transcontinental celebration of the life and work of Iannis Xenakis.[5] It navigates the intersection of science and art, introduces some of Xenakis's computational and algorithmic techniques to a non-technical audience, and explores how the field of stochastic music has advanced in the twenty years since Xenakis's passing. While ideas and techniques pioneered and employed by Xenakis are now well-understood, today's music technology has evolved tremendously through the integration of artificial intelligence, advanced computing algorithms, and human-computer interaction—techniques and technologies that were unavailable to Xenakis.

This chapter discusses some of Xenakis's works in algorithmic and stochastic music, and reimagines the types of music that Xenakis could possibly be making today, having access to the modern technologies of smartphones and computing devices. It spans several of the topics from the Meta-Xenakis call for participation, including the blending of music, science and technology; a performance and retelling of one of Xenakis's early works, *Concret PH* (1958) through the use of smartphone technology; UPIC (a system he developed to compose music through the use of computers); Xenakis's compositional methods and tools, and how these can be enhanced with newer ideas in computational aesthetics and modeling of creativity; how musical gestures can be informed by advances in sensors, data mapping/translation, and human-computer interaction techniques; and how stochastic music and art can be enhanced through other mathematical methods and models that Xenakis did not use, to blend more traditional music theoretic ideas into the body of techniques introduced by him.

Meta-Xenakis—The Algorithm Is the Medium

The word "meta" stems from the Greek "μετά," which means "transcending" in a theoretical (or structural) sense, i.e., "higher-level"; and "after," in a temporal (or spatial) sense, i.e., "beyond."

Many sources on Xenakis are written by and for musicologists, music composers, and performers, and as such focus on the musical output that Xenakis created.[6] This is reasonable, as Xenakis was primarily known as a music composer. Fewer works have

4 Hoffmann, 2000; Xenakis, 1971.

5 *Meta-Xenakis*, https://meta-xenakis.org; "Iannis Xenakis and Algorithmic Music" (31 May 2022), *BLOD*, https://www.blod.gr/lectures/iannis-ksenakis-kai-algorithmiki-mousiki

6 See for example Solomos, 2008; Solomos, 2021; Roads, 2004.

been written on the meta-level, algorithmic side of Xenakis—i.e., the algorithms or processes he created to generate musical artifacts. However, there are some notable examples of such meta-level analyses.[7]

In this chapter, I interpret the prompt "Meta-Xenakis" in both senses: (a) by exploring his work at a higher, algorithmic-level, something Xenakis did extensively himself, and (b) by exploring how it is possible to move forward utilizing his algorithmic contributions and innovations, which are a rich part of his intellectual and artistic inheritance.[8]

The next section focuses on Xenakis's algorithmic process. It discusses an example of mathematical modeling, sonification, and computer programming he used in musical compositions.

Algorithms–A Brief Definition and History

An algorithm is a formalization of process, or a sequence of steps for performing a task. Algorithms have become prominent through their use in computer science within the last seventy years or so. However, they have existed at least for two thousand years (e.g., Euclid's algorithm), and possibly longer, e.g., Plimpton 322, the 3,700-year-old, Babylonian clay tablet depicting various Pythagorean triples—numbers that exemplify the Pythagorean theorem and imply a procedure for generating them.[9]

Another early algorithmic example is the Antikythera mechanism, an ancient computational device surviving at the National Archeological Museum of Greece, constructed approximately 2,100 years ago to replicate movement of celestial bodies.[10] The Antikythera mechanism employs gear ratios to implement mathematical relations, similarly to the nineteenth-century Difference and Analytical Engines, designed by Charles Babbage (1791–1871) and Ada Lovelace (1815–52).[11] The connection between early algorithms, these machines, and modern computing is undeniable.

In music and art, algorithms appear as early as Guido d'Arezzo (*ca*. 1000 AD), and in compositions of Johann Sebastian Bach (1685–1750), Wolfgang Amadeus Mozart (1756–91), John Cage (1912–92), and Iannis Xenakis, as well as in the visual works of M. C. Escher (1898–1972), Roman Verostko (1929–2024), Vera Molnár (1924–2023), and Ernest Edmonds (b. 1942), among others.

By focusing on the algorithms used to generate pieces, i.e., the meta-level analysis

7 Xenakis, 1971; Reynolds and Reynolds, 2021; Hoffmann, 2009.

8 Cf. Xenakis, 1971.

9 Plimpton 322 does not describe the actual Pythagorean theorem, which was named after the Greek philosopher Pythagoras (c. 570–495 BCE), and which was communicated to us through Book I of Euclid's *Elements* (see The Editors of Encyclopaedia Britannica, "Pythagorean Theorem," *Encyclopaedia Britannica*, https://www.britannica.com/science/Pythagorean-theorem). However, the existence of Plimpton 322 presupposes the algorithm, or process for generating such numbers. Cf. Robson, 2002.

10 Vallianatos, 2012.

11 Manaris and Brown, 2014, p. 4–5..

followed herein, we begin to see the true extent of possibilities that Xenakis introduced to us.

It is important to make the following distinction, between analyzing the music of a particular piece—such as *Pithoprakta* (1955–56) or *ST/10-1, 080262* (1962)—versus analyzing the algorithms created to generate such pieces. For instance, Damían Keller and Brian Ferneyhough (b. 1943) offer a notable meta-level analysis of *ST/10-1, 080262*:

> Xenakis employed his ST (Stochastic Music) program to compose a number of works, including ST/10. The program was coded by M. F. Génuys and M. J. Barraud in FORTRAN IV on an IBM 7090 [...] Xenakis utilized ST to generate data in text format which he later transcribed to musical notation. As he declared, the transcription was a delicate step, and required the making of several compositional decisions.[12]

Xenakis included the complete ST program in his seminal book, *Formalized Music: Thought and Mathematics in Music*.[13] By doing so, he indicated the autonomy, and significance of algorithms in his compositional approach. This program, written in Fortran, was used to compose a number of works, including *ST/10-1, 080262*.[14]

In some regards, this Fortran (or other programming language) notation is similar to reading a musical score, for people who are well-versed in it. However, to be precise, this notation is actually a meta-score, i.e., a score (or recipe) for generating musical scores, in a particular musical style. This important observation is usually sidestepped in many sources on Xenakis. This is probably due to the fact that the intersection of people who are well-versed in both notations—computer programming as well as common practice notation—is relatively small, compared to people who can only read/write computer code, and people who can only read/write musical notation.

Input → Process → Output

All artifacts surrounding us (chairs, computers, smartphones) may be analyzed in terms of:

- The *process* that created them.
- The *input* to this process.
- The *output* of this process.

In the case of music and art, the process is usually hidden (or protected) in a veil of mystery (or secrecy)—few artists share their process with the world. On the other hand, the inputs to the process, the source materials (or inspiration) are available to us, usually from conversations with the artists. For instance, Claude Debussy (1862–1918) created harmonic material from gazing at colorful landscapes. Finally,

12 Keller and Ferneyhough, 2004, p. 162.
13 Xenakis, 1971, p. 145–52.
14 Fortran was the state-of-the-art, high-level programming language, at the time.

the outputs of the process—the actual artifacts—are always available to experience, inspect, interpret, and evaluate. It is by experiencing these artifacts that people are attracted to a particular composer, or artist, or not—as the case may be with Xenakis, or, say, Jackson Pollock (1912–56).[15]

Xenakis used algorithms and mathematical models to create much of his music. For instance, he presents a thorough, eight-step process labelled "Fundamental Phases of a Musical Work," clearly influenced by early software development processes.[16]

Above, I discussed one of Xenakis's algorithms, written in the programming language Fortran. Given this algorithm, we can identify *input*, *process*, and *output*:

- The musical *output* is what most people experience first.[17]
- The *input* to the process consists of numerical data.[18]
- The *output* generated by the program is a sequence of numbers.[19]

However, given the program output, there are several possibilities for what to do next. One possibility is *data visualization*, i.e., take the numerical output and convert it to visual drawings, or charts. Such visualizations may be information preserving, or they may focus more on aesthetic or artistic outcomes, without necessarily preserving accuracy. Another possibility is *data sonification*, i.e., take the numerical output and convert it to sounds or a musical composition. This is mainly what Xenakis did in his *ST* works. Yet another possibility is *data materialization*. The term is relatively recent, and refers to something Xenakis did do, i.e., take the numerical output and convert it to physical form.[20]

Xenakis produced *sonification* designs, where he translated numerical data to sound. In the case of the ST program, he used solfege pitches on the Y (vertical) axis, and time on the X (horizontal) axis. The dots are actual numerical outputs, which are mapped to notes. Finally, he draws lines to connect the notes.[21] The *final output*—the musical score—is generated by transcribing the numerical output, using a sonification design, to musical notation. Xenakis chooses to sonify these numerical data as large masses of musical point-notes. There are other possibilities, as will be shown later in the chapter. These point-notes are mapped to string *pizzicati*, *glissandi*, and other aleatoric and stochastic microsound events, to be again interpreted by chosen orchestral instruments and performers. This mapping is stochastic, in that some aspects of the performance

15 Jackson Pollock's process generated artifacts with similar statistical properties to Xenakis's (Taylor et al., 1999).

16 Compare Xenakis, 1971, p. 22; Page and Didday, 1980, p. 248–9.

17 See first five measures of *ST/10-1, 080262* in Xenakis, 1971, p. 154.

18 Fortran, like most programming languages, allows embedding of external data in programs: see Xenakis, 1971, p. 152.

19 Xenakis, 1971, p. 153.

20 This is the case, for example, with the architectural design of the Philips Pavilion: see Kalff et al., 1958; Harley, 2004. For more on data materialization see Starrett et al., 2018.

21 Xenakis, 1971, p. 18–19.

are approximate (and may be unplayable); these aspects are left to be interpretated (or approximated by) the performers.[22]

The piece is eventually performed by musicians, who interpret (or approximate) the musical score, adding subtle layers of breathing, hesitation, movement, simplification, and micro-textures to the sonic outcome. This can be heard in specific performances or recordings of the piece.[23]

The challenging nature of Xenakis's musical scores is expressed well in the following:[24]

> Of the many pianists who have performed and discussed *Evryali*, dedicatee Marie-Françoise Bucquet perhaps best expresses the performance issues Xenakis raised, writing, "Supreme challenge: he asks us to take risks and overwhelming responsibilities. I find it wonderful that instead of saying to the performer 'I have written this piece for you, and you are going to play it,' he said to me 'Here is the piece. Look at it, and if you think you can do something with it, play it.'"[25]

Xenakis himself states:

> I do take into account the physical limitations of performers [...] But I also take into account the fact that what is limitation today may not be so tomorrow. [...] Then there are works, such as *Synaphai*, where it's up to the soloist whether he plays all the notes or leaves some out. Of course, I prefer it if he plays them all. [...] But as I've said before, for all their difficulty, the pieces can be performed. In order for the artist to master the technical requirements he has to master himself. Technique is not only a question of muscles, but also of nerves. [...] In music the human body and the human brain can unite in a fantastic, immense harmony. No other art demands or makes possible that totality. The artist can live during performance in an absolute way. He can be forceful and subtle, very complex or very simple, he can use his brain to translate an instant into sound but he can encompass the whole thing with it also. Why shouldn't I give him *the joy of triumph—triumph that he can surpass his own capabilities*?[26]

One may explore the value this rich interpretive space potentially adds, by listening to Xenakis's musical scores performed through a computerized (i.e., perfectly accurate) MIDI synthesizer. For instance, one such effort appears in Grossman's CD release comprising the pieces, *Herma* (1961), *Mists* (1980), *Khoaï* (1976), *Evryali* (1973), and *Naama* (1984), for solo piano or harpsichord.[27] However, according to Kanach:

> [This] recording of Xenakis's keyboard music realized by computer defeats the purpose

22 For instance, in *Evryali* (1973), Xenakis overlooks the fact "that the two hands and ten fingers of the pianist can only reach so far ... and even includes a high C#, beyond the range of any piano" (Harley, 2004, p. 75).

23 Ryan Power, "Iannis Xenakis—ST/10-1, 080262 (Audio + Full Score)" (09 Nov 2021), *YouTube*, https://youtu.be/Jtoge5GIa9o

24 One may argue that this contributes to why he is admired by some musicians, while avoided by others.

25 Harley, 2004, p. 74.

26 Kanach, 2010, p. xii.

27 Grossmann, 2008.

> of this human, self-surpassing, personal engagement in performance. But it does lift the veil on that which cannot—yet!—be easily performed by human hands. At most then, it could be considered a pedagogical tool.[28]

Finally, an important point here is that Xenakis chose the way his work sounds—he meticulously crafted his *sound aesthetic*, through his sonification choices. In other words, his particular sound aesthetic is mainly the result of the *second part* of his compositional process—the sonification design. The first part—his algorithmic approach—is mostly *style-agnostic*, and as such it can be used with other sonification choices, bringing possibly broader acceptance, and application of his techniques to other compositional spaces. This will be demonstrated below, through specific musical examples.

Algorithmic Music: Who Is the Composer?

Authorship attribution is a significant question, often arising in algorithmic music composition. Sometimes this may even confuse experts in computer science. So, given the above example (*ST/10—1,080262*), *who is the composer*? Possible answers include:

- Carl Friedrich Gauss (1777–1855), the German mathematician who created the probabilities used for input in Xenakis's work.
- The computer—an IBM 7090—which executed the ST program and produced the output numbers.
- Xenakis who created (a) the process, or algorithm, and (b) the sonification design used to generate the final music score.

In the original talk (upon which this chapter is based), with an audience of about 160 people, three identified Gauss as the composer, three identified the computer as the composer, but the majority identified Xenakis as the composer. Without doubt, the algorithm created the musical output. However, Xenakis wrote the algorithm, therefore, Xenakis is indeed the composer. This is a significant observation.

However, the question of authorship becomes more nuanced when the input to the process becomes statistical probabilities derived from other composers' musical works, such as those of Bach, Mozart, or Ludwig van Beethoven (1770–1827).[29] Recently, this has become a controversial topic, given the availability of software systems trained with statistical probabilities from large language models (LLMs), such as ChatGPT and DALL·E.[30]

Ultimately, though, this demonstrates the power of the algorithm as a creative medium, and strengthens our appreciation for Xenakis's vision and pioneering algorithmic work. In summary, algorithms are a powerful compositional tool, as Xenakis demonstrated.[31]

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28 Kanach, 2010, p. xii.
29 See Cope, 2001; Manaris et al., 2007.
30 Roose, 2022; Vincent and Li, 2023.
31 This raises a forward-thinking, corollary question: Since algorithms are such a creative medium,

What's Next?

Some Xenakis-Inspired Ideas and Examples

The following sections present algorithmic music examples, derived from Xenakis's work, as well as proposing some ideas on what might come next.

Concret PH (1958) —A Simplified Algorithm

```
# ConcretPH_Xenakis.py
#
# Generates a point cloud of sounds in the style of
# Iannis Xenakis's "Concret PH" (1958).

from music import *
from random import *

# constants for controlling musical parameters
cloudWidth = 64          # length of piece (in quarter notes)
cloudDensity = 23.44     # how dense the cloud may be
particleDuration = 0.2   # how long each sound particle may be
numParticles = int(cloudDensity * cloudWidth)   # how many particles

part = Part(BREATHNOISE)

# make particles (notes) and add them to cloud (part)
for i in range(numParticles):

   # create note with random attributes
   pitch    = randint(0, 127)   # pick from 0 to 127
   duration = random() * particleDuration  # 0 to particleDuration
   dynamic  = randint(0, 127)   # pick from silent to loud
   panning  = random()          # pick from left to right

   note = Note(pitch, duration, dynamic, panning)   # create note

   # now, place it somewhere in the cloud (time continuum)
   startTime = random() * cloudWidth    # pick from 0 to end of piece
   phrase = Phrase(startTime)           # create phrase with this start time
   phrase.addNote(note)                 # add the above note
   part.addPhrase(phrase)               # and add both to the part
# now, all notes have been created

# add some elegance to the end
Mod.fadeOut(part, 20)

View.show(part)
Play.midi(part)
Write.midi(part, "ConcretPh.mid")

```

Fig. 38.1 Algorithm for generating a simplified version of Xenakis's *Concret PH* (1958), in Python. Figure created by author (2014).

Xenakis coined the term *stochastic music* (from the Greek stochos, "στόχος," or target), to describe music that evolves over time within certain statistical tendencies and

when should algorithmic music composition, and computer programming, in particular, become part of a well-rounded music education curriculum, and begin to be taught broadly in conservatories?

densities, and has points of origin and destination. Xenakis created stochastic music to react to purely chaotic, random properties of twelve-tone, or serialist music.[32] He believed the listener may be aesthetically overwhelmed by the complexity of serialist music—which, although deterministic due to its rules of creation, by definition, over time sounds utterly chaotic (i.e., uniformly distributed). He proposed that statistical mathematics could be used to produce a compositional technique, whose musical outcome is more controllable. This could produce more aesthetically pleasing music, as he went on to demonstrate. His first electroacoustic composition, *Concret PH*, was composed intuitively (i.e., non-algorithmically, by ear) to demonstrate this.

We have constructed an algorithm to simulate a simplified version of Xenakis's *Concret PH*, in Python, as shown in Figure 38.1.[33] *Concret PH* is revisited later in this chapter, to include a probability density function that models more accurately Xenakis's original.

UPIC—Controlling Musical Parameters through Curves

Xenakis used computer programming to create musical compositions, but also tools to assist in the compositional process. One important example is the Unité Polygogique Informatique de CEMAMu (UPIC) computer system. UPIC was invented in 1977 by Xenakis and his associates to connect visual drawing (e.g., architectural drafting) with musical or sound design, in order to achieve "sonic realization of drawn musical ideas by a computer."[34]

UPIC allows a music composer to draw curves (or arcs) via stylus or mouse on a graphical user interface. Curves are converted to sounds automatically, using wave tables and envelopes to form individual sounds. This process can generate arbitrarily complex, evolving timbres, and thus offers immense compositional power to describe new sounds, whose texture unfolds over time.[35] UPIC's system design went through several iterations, over the years, to improve its functionality and usability.

UPISketch is a direct descendant of UPIC, initially developed by the Centre Iannis Xenakis (CIX) at the University of Rouen, and the European University of Cyprus (EUC) in 2018.[36] Similarly to UPIC, UPISketch is a drawing sound composition tool. However, it is more advanced technologically (e.g., runs on smartphones and modern computers), and has a more intuitive interface, being geared towards a general audience.[37]

32 Xenakis, 197, p. 8–9.
33 Manaris and Brown, 2014, p. 166–7.
34 Bourotte and Kanach, 2019, p. 252.
35 Marino et al., 1993.
36 Bourotte and Kanach, 2019.
37 UPISketch was developed under the Creative Europe program, Interfaces, whose goal is to explore innovative ways of introducing audiences to the work of cutting-edge musicians and sound artists (see *Interfaces Network*, http://www.interfacesnetwork.eu).

UPISketch follows Xenakis's original sonification approach of *pitch versus time*, and, like UPIC, extends it to the continuous (i.e., frequency) domain. Users draw curves, which then are mapped to frequency, or amplitude contours, used to generate complex sound timbres. Additionally, UPISketch supports importing arbitrary audio recordings, to be used as instruments, through pitch-shifting, and micro (or granular) sampling, which is a powerful feature. UPISketch runs on iOS (iPhones, iPads), Windows, and Mac OSX, making it widely available. As an educational tool, it further promotes Xenakis's music-pedagogic motivation for developing UPIC. As he stated in 1979:

> The pedagogical interest is obvious: with UPIC, music becomes a game for children. They draw. They hear. They have everything at their fingertips. They can correct things immediately. They are not forced to learn instruments. They can imagine timbres. And above all, they can immediately devote themselves to composition.[38]

My research students and I have also reconstructed a simplified version of UPIC, in Python. To do so, we used JythonMusic, an environment for developing interactive musical experiences, and systems for computer-aided analysis, composition, and performance in music and art.[39] JythonMusic has been used for research in music information retrieval and computational musicology, as well as in modeling aesthetics and creativity, sound spatialization, and telematics. It provides various libraries for music representation and composition, image manipulation, graphical user interface development, and interaction with external devices via MIDI and OSC (Open Sound Control), among others. Also, it works with other software, such as Ableton Live, PureData, Max/MSP, and Processing. JythonMusic's pedagogical goal is to provide a gentle introduction to the powerful medium of algorithms, and computer programming, to musicians and computational artists. It has been used to teach algorithmic music composition, dynamic coding (live coding), and musical performativity to university students for over a decade.[40]

Our UPIC implementation expands on the original to control various aspects of a musical piece through curves. Although we have implemented a simple graphical user interface for drawing curves and generating sounds in real-time, in our work, we find it more useful to simply output numerical sequences—x and y coordinates of graph points—and then incorporate them algorithmically in other JythonMusic programs. This algorithmic-based UPIC approach has been taught to first-year university students, in the context of introducing algorithmic thinking and computer programming to students with musical and artistic backgrounds and interests, for over a decade.[41] For example, here is an early (*ca*. 2010) implementation of the approach.[42]

38 Xenakis, 1979, p. 96, quoted in Bourotte and Kanach, 2019, p. 253.
39 *JythonMusic*, http://jythonMusic.org
40 Manaris and Brown, 2014; Manaris et al., 2016; 2018.
41 Manaris et al., 2014; Manaris and Brown, 2014.
42 "Sonifying images," *JythonMusic*, https://jythonmusic.me/ch-7-sonification-and-big-

After students were exposed to this approach, they were asked to create their own musical compositions, as semester final projects. Here are videos of these student projects.[43] Finally, these student projects were showcased in "Visual Soundscapes," a month-long exhibit at our university's library.[44]

One might argue that embedding UPIC-generated data back into programs reverts back to Xenakis's original, pre-UPIC approach. However—pedagogically and artistically—this is both desirable and effective, as it combines the best of both worlds: drawing (or capturing existing curves) to represent input data (like Xenakis did), with the readability, learnability, and expressivity of modern programming languages, such as Python, Processing, and Scratch.

Programming languages may be seen as actual user interfaces, and may be evaluated in terms of their usability, defined as specific attributes such as: their learnability, user efficiency, memorability, user error-proneness, and user satisfaction.[45] Also, given that some of these programming languages can now fully represent (and play back!) musical data, they have become *representationally equivalent* to common practice music notation, and can be used as alternative music notations.[46] In fact, such languages are *supersets* of common practice notation, because they may also represent algorithmic processes, and thus connect notation and compositional processes into one powerful and expressive representation.

In our approach, UPIC graphs may describe densities of pitch, dynamic, harmonic probability or consonance, timbre or different instruments, occurrence of arbitrary sonic events, as these unfold over time (or relative to each other). In fact, these graphs can model any musical attribute desired, as long as it can be controlled via algorithmic means. Since this is done in Python, such graphs can also control aspects of other algorithmic artifacts, including parameters of external sound engines (e.g., Ableton Live), visualizations, animation parameters, and arguments to arbitrary Python functions, thus tapping into the full power of a Turing Machine.[47]

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data/#Sonifying-images

43 It should be emphasized that these students had not programmed before (for the most part): "Computing in the Arts @CofC," *Vimeo*, https://vimeo.com/cofccita

44 This exhibit was funded in part by the US National Science Foundation, under grant "Computing in the Arts: A Model Curriculum" (DUE #1044861).

45 Manaris, 2007.

46 Something that might have given Xenakis immense joy, since this is precisely what he was trying to do with his Fortran and BASIC programs, i.e., represent musical data and processes. This is precisely the reason why programming languages like Max/MSP (and Pure Data) have been invented at Ircam (and elsewhere), and are being used widely by music composers, around the world, to create avant-garde music.

47 Another wonderful alternative, also inspired by UPIC, is the graphical environment IanniX, a sequencer for digital art and real-time control. See *Iannix*, https://www.iannix.org/

```
# probability values: y values from UPIC curve
upicProbabilities = [0, 1, 1, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 1, 1, 1,
                     1, 1, 1, 1, 1, 1, 1, 1, 0, 0, 1, 1, 1, 2, 2, 2, 2, 2, 2,
                     3, 3, 3, 3, 3, 2, 1, 1, 1, 1, 1, 0, 1, 2, 2, 2, 2, 2, 2,
                     2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2, 2,
                     2, 3, 4, 4, 5, 7, 8, 8, 8, 9, 9, 9, 10, 10, 10, 11, 11, 11,
                     11, 12, 12, 12, 12, 13, 13, 13, 13, 13, 13, 12, 13, 11, 11,
                     10, 10, 8, 7, 5, 6, 3, 4, 1, 2, 1, 0, 1, 1, 1, 1, 2, 4, 5,
                     6, 6, 7, 8, 9, 9, 9, 9, 9, 9, 9, 9, 9, 9, 9, 9, 10, 11,
                     11, 12, 12, 12, 12, 12, 12, 13, 14, 16, 18, 17, 16, 16, 16,
                     20, 23, 26, 34, 36, 33, 31, 32, 30, 31, 31, 30, 30, 29, 30,
                     28, 28, 29, 10, 11, 12, 13, 14, 16, 16, 18, 18, 19, 20, 22,
                     23, 26, 27, 38, 40, 44, 48, 48, 48, 48, 48, 48, 50, 53, 57,
                     60, 63, 63, 64, 65, 61, 50, 42, 38, 40, 45, 49, 61, 63, 63,
                     72, 81, 92, 108, 129, 145, 155, 164, 173, 176, 174, 169, 121,
                     121, 122, 133, 148, 159, 163, 112, 109, 106, 106, 109, 114, 115,
                     124, 137, 137, 161, 170, 170, 180, 190, 199, 209, 212, 213, 226,
                     234, 242, 253, 260, 263, 263, 256, 245, 229, 211, 203, 220, 249,
                     281, 301, 307, 308, 322, 345, 357, 370, 378, 380, 381, 382, 385,
                     385, 388, 390, 394, 396, 397, 397, 400, 400, 400, 401]

# generate a list of probabilities using the curve function

# values to reach at different time points (y-axis)
values = [1, .88, .97, .5, .85, .2, .75, .03, .001]

# points in time that corresponding values above should be reached (x-axis)
# (this creates a list of relative indices into the list of probabilities above)
timePoints = [0, int(len(upicProbabilities) * .10), int(len(upicProbabilities) * .25),
              int(len(upicProbabilities) * .35), int(len(upicProbabilities) * .5),
              int(len(upicProbabilities) * .65), int(len(upicProbabilities) * .75),
              int(len(upicProbabilities) * .8), len(upicProbabilities)]

# returns a list of integers interpolating the given value-point pairs
probabilityList = curve(values, timePoints)
```

Fig. 38.2 Code excerpt implementing a UPIC-generated probability list, in Python. Figure created by author (2022).

Concret PH—A Retelling (2022)

As mentioned above, *Concret PH* is an early and influential piece of stochastic music, composed by Xenakis intuitively, to capture mathematical probabilities he was deeply interested in. It was performed in the Philips Pavilion at the 1958 World's Fair, using approximately four hundred loudspeakers–arranged in five clusters, and ten channels, or sound routes. Special playback machines with a three-track sound tape, and a fifteen-track control tape were used for sound routing. Unfortunately, the Pavilion was demolished, so we cannot experience the piece as it was originally performed.[48]

Our reinterpretation of *Concret PH* utilizes speakers on audience smartphones, to recreate the multiplicity and apparent unpredictability of sound sources of the original, as well as audience movement through the performance space. We utilize our UPIC approach to control the density of sound events over time, in order to recreate the unfolding sound densities and textures of the original.

In the original, Xenakis used tape recordings of burning charcoal, partitioned into

48 Kalff et al., 1958; Lombardo et al., 2009; Valle et al., 2010.

one-second fragments, pitch-shifted and overlaid, to create granular, unfolding sound textures. Our recreation uses sounds from the original,[49] together with hammer-on-anvil sounds, to simulate individual charcoal sound events.

Our code distributes the required number of sound events across all participating audience smartphones. This works regardless of how many smartphones are participating. The piece may be reproduced using a single smartphone, as well as hundreds of them, always maintaining the desired density and sound texture. Participants are asked to move around freely, resembling people moving through the Philips Pavilion in 1958, to create a truly immersive experience.[50]

Concret PH—A Retelling was performed at the University of Maryland, College Park, USA in April 2022 (see Media 38.1). The performance was captured via a high-quality 3D binaural microphone, so stereo headphones are recommended.[51]

Media 38.1 Video performance of *Concret PH—A Retelling* using audience smartphones, at the University of Maryland, College Park, USA, April 2022.
https://hdl.handle.net/20.500.12434/3c3e3f35

Éolienne PH (2022)

Éolienne PH (or *Be the Wind*) was composed in the context of the 2022 Meta-Xenakis transcontinental celebration. It was performed at the International Symposium on Electronic Art (ISEA 2022) in Barcelona, in June 2022. It was partially inspired by the ISEA 2022 conference themes, "exploring our relationship with nature," and "transforming/inhabiting our world."

Éolienne PH is based on Xenakis's *Concret PH* (see previous section). It demonstrates the importance of separating the two parts in Xenakis's compositional process:

1. The *algorithmic process* used to generate numerical data.
2. The *sonification choices* mapping these data to sounds.

It should be emphasized that *Éolienne PH* utilizes the *same probability density function* as its sister piece, *Concret PH – A Retelling*—in fact, they share the exact same code. However, the sonification design of *Éolienne PH* employs natural, soothing sounds, such as flowing water, and birdsong. The piece was composed during COVID-19, and

49 See pelodelperro, "Iannis Xenakis - Concret PH" (4 January 2011), *YouTube*, https://youtu.be/XsOyxFybxPY
50 Forgette et al., 2022.
51 Recording courtesy of Ian McDermott, Immersive Media Design, University of Maryland.

given the ISEA 2022 conference theme, the sonification choices were meant to create a restorative, meditative, and potentially healing experience. Similarly to its sister piece, these sounds are partitioned into small fragments, and then pitch-shifted and overlaid, to create a granular, ever-unfolding sound texture.

Éolienne PH utilizes audience smartphones to deliver its sounds. Participants are asked to move around, creating independent, aleatoric sound trajectories. This is also inspired by Xenakis's *Polytope de Mycènes* (1978).[52] This free movement creates infinite possibilities for sound texture and placement, as each person traverses a unique and unpredictable sound path.

Finally, the composition allows participants to generate high-quality, binaural sounds of wind-chimes—tuned in C *aeolian* scale—by tapping on their screens. This makes them active contributors to the unfolding soundscape, and invites (but does not require) deep listening and potentially collaboration.

A video of the ISEA 2022 performance, in Barcelona, Spain (June 2022) is available below (Media 38.2). While identical to *Concret PH* in terms of algorithmic design, the new sonification design produces a completely different (diametrically opposing?) aesthetic experience, and emotional outcome. This demonstrates the intrinsic value, and independence from sonic outcome, of Xenakis's algorithmic and stochastic contributions.[53]

Media 38.2 Video performance of *Éolienne PH*, at the International Symposium on Electronic Art (ISEA 2022), in Barcelona, Spain, June 2022. It includes photographs from the performance site of Xenakis's *Polytope de Mycènes* (1978) taken by author (2022).
https://hdl.handle.net/20.500.12434/6400503c

Nereides/Νηρηΐδες (2023)

As mentioned above, Xenakis was deeply interested in statistical properties of natural phenomena:

> [O]ther paths also led to the same stochastic crossroads—first of all, natural events such as the collision of hail or rain with hard surfaces, or the song of cicadas in a summer field. These sonic events are made out of thousands of isolated sounds; this multitude of sounds, seen here as a totality, is a new sonic event. This mass event is articulated and forms a plastic mold of time, which itself follows aleatory and stochastic laws.[54]

52 Kotzamani, 2014.
53 This also suggests that those who possibly dislike Xenakis's music, may only dislike his sonification choices, but not his algorithmic ones.
54 Xenakis, 1971, p. 8–9.

Interestingly, originating in a different (emotional, intuitive, non-mathematical) space, Debussy makes a similar observation, in 1911:

> Who will discover the secret of musical composition? The sound of the sea, the curve of the horizon, the wind in the leaves, the cry of a bird, register complex impressions within us. Then suddenly, without any deliberate consent on our part, one of these memories issues forth to express itself in the language of music. It bears its own harmony within it. By no effort of ours can we achieve anything more truthful or accurate. [...] No doubt, this simple musical grammar will jar some people. [...] I foresee that and I rejoice in it. I shall do nothing to create adversaries, but neither shall I do anything to turn enmities into friendships.[55]

It is intriguing to see how similar Xenakis and Debussy are, both being inspired by statistical properties of natural phenomena, and both being unapologetic about it. Still, they use different compositional tools and techniques: Xenakis, algorithmic and mathematical means; while Debussy, traditional (classical/impressionist) compositional processes.[56] We have reached a point, where both Xenakis's and Debussy's processes (and those of other composers) can be modeled through algorithmic means and computer programming.[57]

Xenakis uses mathematical formulas to model natural phenomena. Being mathematical, these formulas are abstractions or generalizations, approximating trends in the actual data. They do not actually account for slight "imperfections" or noise. It should be noted that nature is never exactly ideal.[58]

This leads to the following compositional idea or "syllogism": What if, in an attempt to be more precise, we bypassed the intermediate models of mathematical formulas (such as Gaussian or Poisson distributions), used by Xenakis (and others) to describe statistical tendencies of natural phenomena? Instead, what if we captured data directly from the natural phenomenon, since—technologically—we can do that now relatively easily? Thus, we can use the exact distributions or fluctuations of densities in natural phenomena, for instance, through processing of *high-quality* audio recordings, or *high-resolution* images.[59]

Nereides/*Νηρηΐδες* is an experimental piano miniature piece, which demonstrates this approach. It was composed for the seventieth anniversary celebration of The Friends of Music Society of Greece. It explores the ever-unfolding interplay between sky and sea–the *evaporation-condensation-precipitation* cycle. It is named after the female spirits of sea waters of Ancient Greece, the Nereides, that personify the cycle of water. I

55 Debussy, cited in Vallas, 1933, p. 226.
56 Cope, 1997.
57 For example, see Manaris and Brown, 2014.
58 For example, the Earth is not spherical, and its orbit is not a perfect ellipsis—there are perturbations not captured by traditional geometrical or mathematical models, which tend to be ideal.
59 This was not an option during Xenakis's time, since computing and related technologies were at their infancy. Now, this is easy, given advances in computer science (e.g., see Manaris and Brown, 2014, p. 191–240).

used our UPIC approach to capture trajectories or curves of white light (or luminosity), in the cloudy sky image shown in Figure 38.3. I extracted the distributions of light straight from the source material (an image, in this case), making deliberate choices where trajectories begin and end, and how they spread onto the piece's timeline—some are lengthier, others shorter, some slower, others faster, some inverted, and so on. This is similar to Xenakis's choices using UPIC, i.e., where to draw shapes, how long to draw them, etc. *Nereides/Νηρηΐδες* is then literally, and figuratively, a stochastic study of light in a cloudy sky. Through this process, intuitively, I selected six trajectories, or curves. These were given the following Nereid names: Autonoe/Αὐτονόη, Ianassa/Ἰάνασσα, Eione/Ἠιόνη, Galene/Γαλήνη, Melita/Μελίτη, and Evarne/Εὐάρνη.[60]

Fig. 38.3 Source of thematic material for *Nereides/Νηρηΐδες*. Six trajectories, or curves, were selected intuitively (i.e., by ear) to capture the variety of white light distributions and densities (not shown). Photo by author (2022).

Nereides/Νηρηΐδες resembles Xenakis's *Evryali* (1973) for solo piano, as it also consists of arborescences, or branching patterns of melodic material (see Figure 38.4). Similar to *Evryali*, these interweave to create harmonic patterns of varying and unfolding complexity.[61] Unlike *Evryali*, the sonification design resembles Arvo Pärt's (b. 1935) Tintinnabuli style, used, for example, in *Für Alina* (1976).

Nereides/Νηρηΐδες has a fractal, or self-similar structure. This is a direct result of the source material (i.e., cloud formations) being fractal.[62] Also, the piece may sound deceptively simple. However, under the apparent musical simplicity, hides an intricate interweaving of pitches and rhythmic material that fit harmoniously together.[63] It

60 Fifty Nereid names have survived from antiquity. These six were selected intuitively, to match the musical characteristics of each trajectory, based on what we know about each of the Nereides.

61 Harley, 2004, p. 74.

62 Spehar, et al., 2003; Schroeder, 1991.

63 This is perhaps reminiscent of the deceptive simplicity of Bach's *Trias Harmonica* (BWV 1072)—where a single theme is inverted, doubled, and time-shifted in various ways, to create eight independent trajectories (voices), that fit perfectly/harmoniously together (Manaris and Brown, 2014, p. 108–9). It is also perhaps reminiscent of tessellations in M.C. Escher works (Hofstadter, 1989; Manaris et al., 2015).

should again be emphasized that the source material originates from a cloudy sky. The trajectories were selected intuitively (i.e., non-algorithmically, by ear) to consist of reflective patterns. These patterns originated in the natural processes that produced these clouds. This image in Figure 38.3 contains unusual, yet very appealing—or aesthetically pleasing—groupings of cloud patterns. The sonification design attempts to preserve this essence, or aesthetic quality, and reflect it (or map it) in the harmonic interweaving of melodic lines. The source material depicts a natural phenomenon—cloudy sky—that is somewhat unpredictable, contrasting, yet relatively stable, non-chaotic. Thus, the extracted probability distributions reflect a natural phenomenon that has reached a plateau of low entropy, or relative balance.[64] Some might say it is beautiful.

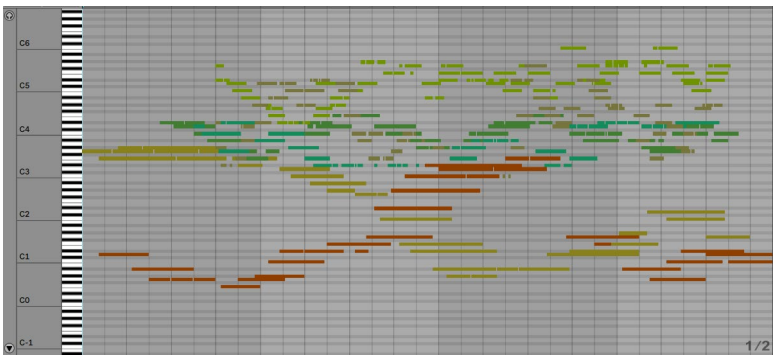

Fig. 38.4 The arborescences/branching patterns of *Nereides*/*Νηρηΐδες*, generated from intuitively combining the six trajectories, in piano roll notation. It is interesting to note the emergent large fractal X, consisting of many, smaller X's (reminiscent perhaps of Xenakis's initial on some CDs of his music). Figure created by author (2023).

Nereides/*Νηρηΐδες* supports the performance approach suggested by Xenakis in his stochastic pieces, such as *Evryali* (1973) and *Synaphaï* (1969), which invite the performer to engage their dexterity and decide which notes they may play, and which to omit. Being fractal (due to its source material), *Nereides*/*Νηρηΐδες* has the same stochastic quality, i.e., not every note is necessary. In other words, the piece sounds approximately the same, even when some notes are left out. Here is a relevant part of Xenakis's earlier quote, to emphasize this point:

> [T]here are works, such as *Synaphai*, where it's up to the soloist whether he plays all the notes or leaves some out. Of course, I prefer it if he plays them all. [...] Why shouldn't I give him the joy of triumph—triumph that he can surpass his own capabilities?[65]

Being inspired by both Xenakis's and Debussy's perspectives above, here is the composer's artistic intent, for this piece:

64 Manaris et al., 2005.
65 Kanach, 2010, p. xii.

> "Only from the heart can you touch the sky" (Rumi). I gazed upon this breathtaking sky [...] and then began to translate it to sound. Wrote some code to help. I kept interweaving parts, until I managed to "liberate" the sound I was seeing...

Given its fractal nature, the piece can be played at different levels of abstraction. In its original form, it requires six hands, one for each melodic contour or trajectory. It has also been reduced to be playable by two hands. This version was performed at the Megaron Athens Concert Hall in November 2023, as part of the celebration for the seventieth anniversary of The Friends of Music Society of Greece (see Media 38.3).

Media 38.3 Performance of *Nereides*/*Νηρηΐδες* at the Megaron Athens Concert Hall in November 2023, as part of the celebration for the seventieth anniversary of The Friends of Music Society of Greece.
https://hdl.handle.net/20.500.12434/ed314ac8

on the Fractal Nature of Being... (2022)

As a final example, the piece *on the Fractal Nature of Being...* was also composed in the context the 2022 Meta-Xenakis transcontinental celebration. It was performed at the Music Library of Greece in May 2022. It brings together everything discussed so far, exploring how stochastic and aleatoric techniques introduced by Xenakis may be combined with traditional music theory and modern mathematics/fractal geometry. Also, audience members are invited to participate via their smartphones, contributing to the performance via their speakers and accelerometers.

The piece is modeled after a fractal plant-like structure, or arborescence, known as the golden tree, which incorporates the golden ratio, or φ (0.61803398...). Figure 38.5 shows the code used to generate a golden tree. Figure 38.6 shows one possible output. Following this format, the piece is built from a one-minute-long harmonic theme, shown in Figure 38.7, which serves as the "trunk" of the tree. This theme is expanded and embellished upon, at different levels of granularity, as the piece unfolds.

```
# goldenTree.py
#
# Draws a golden tree using recursion.
#

from gui import *
from math import *

# create display
d = Display("Golden Tree", 250, 250)
d.setColor(Color.WHITE)

# calculate phi to the highest accuracy Python allows
phi = (sqrt(5) - 1) / 2     # approx. 0.618033988749895

# recursive drawing parameters
depth = 10                  # amount of detail (or branching)
rotation = radians(60)      # branch angle is 60 degrees (need radians)
scale = phi                 # scaling factor of branches

# initial parameters
angle = radians(90)         # starting orientation is North
length = d.getHeight() / 3  # length of initial branch (trunk)
startX = d.getWidth() / 2   # start at bottom center
startY = d.getHeight() - 33

# recursive function for drawing tree
def drawTree(x, y, length, angle, depth):
    """
    Recursively draws a tree of depth 'depth' starting at 'x', 'y'.
    """
    global d, scale, rotation

    # draw this line
    newX = x + length * cos( angle )    # calculate run
    newY = y - length * sin( angle )    # calculate rise
    d.drawLine(int(x), int(y), int(newX), int(newY))

    # check if we need more detail
    if depth > 1:

        # draw left branch - use line with length scaled by phi,
        # rotated counter-clockwise
        drawTree(newX, newY, length*phi, angle - rotation, depth-1)

        # draw right branch - use line with length scaled by phi,
        # rotated clockwise
        drawTree(newX, newY, length*phi, angle + rotation, depth-1)

# draw complete tree (recursively)
drawTree(startX, startY, length, angle, depth)

```

Fig. 38.5 Code for generating a fractal arborescence, known as golden tree, in Python. This algorithm models the *on the Fractal Nature of Being*... piece structure. As seen above, the structure incorporates the golden ratio and fractal geometry (i.e., self-similarity through subdivision). Figure created by author (2014).

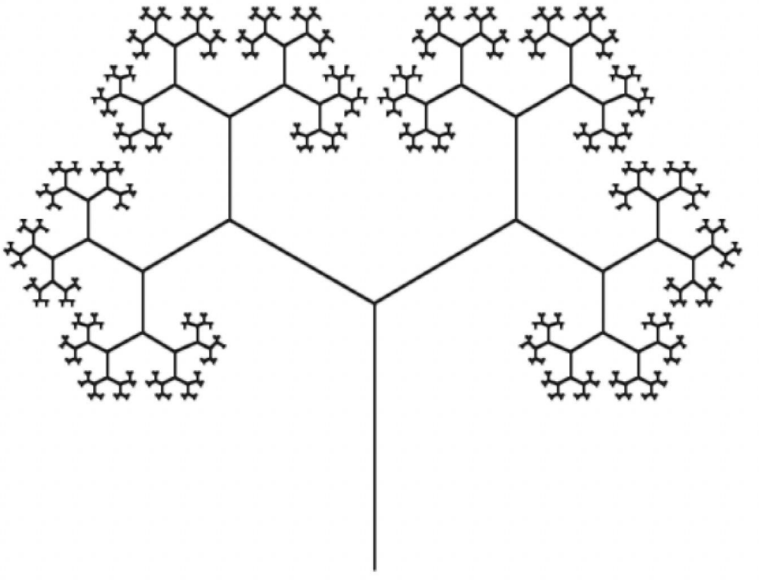

Fig. 38.6 Output of code in Figure 38.5—a golden tree—is a fractal plant-like shape, which incorporates the golden ratio, or φ (0.61803398...). The musical structure of *on the Fractal Nature of Being*... is based on this shape. Figure created by author (2014).

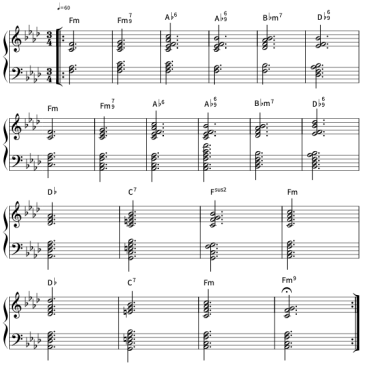

Fig. 38.7 The musical theme—or fractal trunk—of *on the Fractal Nature of Being*... The piece unfolds fractally from this theme, following a golden tree structure (see Figure 38.6). Figure created by author (2022).

The fractal structure of the piece begins with the harmonic theme being introduced on the piano. As the piece progresses, this theme is repeated at different levels of granularity, by different instruments, including smartphones, cello, bassoon, and guitar—using tempo (faster), register (higher octaves), and randomness (improvised, aleatoric notes), in order to create musical space for the fractal to unfold, and other instruments to enter.

A UPIC-based probability density function controls the interplay between *consonance* and *dissonance*, which is a meta-Xenakian idea (as Xenakis mainly focused on the statistical interplay between sounds and silence). The piece moves through seven phases, each introducing a new instrument, while earlier instruments cyclically move to higher levels of detail (via register and tempo). The fifth phase introduces dissonance utilizing *stochastic probabilities* from the first minute and a half of Xenakis's *Metastasis* (1953–4).[66] This phase also uses increased loudness of notes on smartphones, to highlight them. Then, at the piece's golden ratio, the dissonance ends, and a new phase begins with the bassoon restoring consonance. In the seventh and last phase, instruments go out one by one, ending the piece on an ambiguous interval (a major 2nd). Smartphone sounds are controlled via algorithm, while physical instruments improvise on the theme (in F minor), at different levels of granularity, based on their fractal level in the piece structure at the time. On the visual side, the performance includes fractal images displayed on a screen (see Media 38.4), a new image per phase, whose fractal properties (or entropy) are controlled by the accelerometers of participating audience smartphones. When the audience smartphones are still, the image's fractal structure is precisely the golden tree.[67] As the piece progresses, phase transitions are marked by new fractal images, selected to match the tone or aesthetic of the phase.

Finally, the algorithmic part of the piece—which includes transitioning from one phase of the piece to the next, updating images to be displayed on the venue's main screen, sending control messages to smartphones with instructions on what sounds to play and when, and adjusting volumes of smartphone speakers in real-time, as needed—is done partially through a specially-designed user interface, running on a dedicated smartphone or tablet. This allows one of the performers to serve in part as a human conductor,[68] walking through the venue (among participants and performers), listening to the piece unfold, adjusting volumes in real time, keeping track of time, and deciding when to transition the piece to a new phase, including when to end the piece. For simplicity, human performers are synchronized through transitions of images on the venue's main screen, and a small visual score.

Media 38.4 Performance of *on the Fractal Nature of Being…* at the Music Library of Greece, in Athens, Greece (May 2022). The piece utilizes audience smartphones for distributing sounds and controlling aspects of the performance.[69]
https://hdl.handle.net/20.500.12434/1a7eb5c9

66 See jarkkkoo, "Iannis Xenakis – Metastasis" (9 Oct 2006), *YouTube*, https://youtu.be/SZazYFchLRI
67 This can be seen later in the video of the piece's performance.
68 The other part is done automatically, through a digital musical score of the piece, which sends control messages to participating smartphones on what sounds to play and when.
69 Incidentally, this performance coincided with the last day of COVID-19 restrictions.

The Algorithmic Arts: Discussion and Closing

The infusion of algorithms in the arts has increased dramatically since the greater availability of computers starting in the 1960s. All areas of art and entertainment, such as graphics, design, animation, sculpture, dance, theater, music, and film, to name a few, have been impacted greatly. At the same time, the inverse infusion of artistic creativity, design, and innovation into computing, engineering, and other STEM fields produces a creative tension, which leads to new ideas, and continues to produce new discoveries:[70]

> Art and science are in a tension that is most fruitful when these disciplines observe and penetrate each other and experience how much of the other they themselves still contain.[71]

As Xenakis himself said in 1979:

> From here nothing prevents us from foreseeing a new relationship between the arts and the sciences, especially between the arts and mathematics: where the arts would consciously "set" problems which mathematics would then be obliged to solve through the invention of new theories.[72]

In the intersection of music, computing, and engineering, we find significant advances relating to the aesthetic, as well as the algorithmic, mathematical, and technological. In this context, Iannis Xenakis is a prime example of a polymath: an individual who combined mathematics, computing, and technology; with music, architecture, visual arts and performance; and multimedia to produce artifacts existing in this intersection. These contributions should also be seen from an algorithmic arts perspective to be fully and adequately appreciated.

In the United States, where this chapter is written, we have the emergence of a pedagogic movement to promote the combination of the creative-arts and design with science, technology, engineering and math (STEM + Art = STEAM). This movement has also spread to Europe and other parts of the world. For instance, Zeyenp Özer and Rasim Erol Demirbatır present a study of STEAM-inspired computer applications used in music education, including UPISketch (mentioned above), MIT Scratch, earSketch, and iMuSciCA. For more information on these programs, including how to access them, please refer to their article.[73] Xenakis might have appreciated this development.

Being funded by both the US National Science Foundation (NSF) and the US National Endowment for the Arts (NEA), an algorithmic arts (AlgoArts) meeting was held in January 2022 to examine the potential for standardizing and bringing greater

70 STEM is a common acronym in education that stands for science, technology, engineering and mathematics. See National Endowment for the Arts, 2019.
71 Rillig et al., 2001, p. 1.
72 Xenakis, 1979, p. 3.
73 Özer and Demirbatır, 2023.

amalgamation—or synthesis—between the aesthetic sophistication, creativity, and design of the arts; and the technological mastery, mathematical rigor, and theory of computer science, and engineering.

This two-day meeting, entitled "The Arts and the Algorithm – An Amalgamation" was the first of its kind in the United States. It brought together 422 researchers, educators, and practitioners who synthesize, or integrate computing, engineering, and the arts.[74]

In closing, this chapter argues that we have finally reached a point where the algorithm has become a creative medium, for artists and musicians. As we move forward into the twenty-first century, researchers, composers, artists, and educators are engaging algorithmically, and are interweaving algorithmic thinking and development of technological solutions, into their art theory and creative practice.

Young composers and musicians, who are learning common practice notation, should also learn this new, powerful musical notation, and thus enter the magical world of Xenakis.[75] In fact, some may argue that this should be a requirement in a well-rounded musical curriculum, not unlike algebra (which was probably a revolutionary concept in the Renaissance), given the de-facto importance and prevalence of computers in music creation. There is a fundamental difference between a creator of music via an existing program, such as Logic Pro or Ableton Live, and a creator of new musical tools and compositional approaches (notice the shift to the meta-level), like Xenakis with his ST program and UPIC, among others.

This is captured very eloquently, but perhaps a bit polemically by Douglas Rushkoff:

> When human beings acquired language, we learned not just how to listen but how to speak. When we gained literacy, we learned not just how to read but how to write. And as we move into an increasingly digital reality, we must learn not just how to use programs but how to make them. In the emerging highly programmed landscape ahead [...] it's really that simple: Program, or be programmed.[76]

In analyzing Rushkoff's point, we see that, as students become creators of new digital material (e.g., images, sounds, videos, etc.) through available options in professional software, such as Photoshop and Ableton Live, their creative thinking is limited by what is easily achievable–and ultimately possible–in the specific "sandbox" they use. And, while this is a wonderful way to be introduced to the world of art and music creation, and a powerful motivator to learn more, the future demands "out-of-the-box" thinkers–people who will create new things that have not been done before.

This is precisely what Xenakis did in a pioneering way, given how early he engaged with algorithms and computer programming, for musical and artistic purposes. In essence, Xenakis paved the way. Now, we must follow it…

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74 AlgoArts, http://algoarts.org

75 Who learned to read and write the now arcane syntax of Fortran on his own, and created so much with it.

76 Rushkoff, 2010, p. 7.

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39. The Process of Creating a Computational System: A Collective Audiovisual Composition

Hugo Solís, Mizky Bernal, Diego Jiménez, Guillermo Leonardini, and Eunice Pérez

Introduction

In the year 2021, the Music Technology Group of SUICREA (University Seminar for Research in Artistic Creation at the National Autonomous University of Mexico) was created as a pedagogical platform focused on the exchange of computational ideas and collaborative work. Directed by Dr. Hugo Solís, this space aims to imagine and seek creative solutions in the field of music technology and computation from a practical perspective, where the sonic imagination guides the developmental processes and computational implementations.

In 2021, the team developed a web application that emulates, in a simplified form, the original UPIC system of Iannis Xenakis. Subsequently, in 2022, instead of expanding and detailing the system, the group decided to create an audiovisual web application that combined the compositional concerns and interests of each of the course members into a single project. The unifying element of the proposals was the integration of autonomous agents that resulted in the use of the "flocking behavior" proposed by Craig Reynolds.[1] This flocking behavior is directly related to the approaches and concepts of agency, intelligences, and emergent phenomena. Another original element of the system is the correlation mechanics between the 3D geometric space and the sound parameters, since the latter are derived from free projections of the rotation of this geometric space.

Finally, a model of synchronization and collective organization of the rhythmic pulse was implemented based on experiments and research related to synchronization

1 Reynolds, 1987.

 https://doi.org/10.11647/OBP.0390.41

in groups of agents including Yoshiki Kuramoto's (b. 1940) model, among others.[2] The behaviors and visual actions give rise to a reading of parameters that controls a bank of frequency modulation (FM) oscillators that, as a whole, generate the sound complexity and the evolution of the work.

Background

SUICREA's Music Technology Group was created within Music Creation Laboratory (LaCreMus) under the direction of Julio Estrada (b. 1943), who suggested the creation of a space for computational research. Since this initiative arose during the times of the pandemic, this work team integrated a Latin American community, and allowed its members to be located in Mexico and Bolivia. This made it possible for the group to work online throughout the process.

In 2021, the group proposed their first group project: to create a simplified version of Xenakis's UPIC (within the Replit platform for writing code on the web).[3] We implemented this through a programming platform with audiovisual capabilities that we called UpicMX.[4] The purpose of this first project was to introduce the teaching of the programming language for audiovisual purposes; the aim was to create a graphical sound system to learn the basics of computing.

Xenakis devised a computerized music creation tool: UPIC (Unité Polyagogique et Informatique du CEMAMu), developed at the Center for Studies in Mathematics and Musical Automatics (CEMAMu) based in Paris, France, the first prototype of which was completed in 1977. The UPIC was a system consisting of a processor with a digital vector display, in the form of a drawing table, on which music was "drawn." With the help of an electronic pen, a curve or series of curves were drawn, which the machine would convert into sound; the X plane corresponded to time, and the Y plane to pitch. By means of controls on the board, some other variables such as register and intensity could be defined; a television screen reproduced the drawings, while the resulting music was listened to by means of amplifiers after having been processed in a synthesizer.[5]

The UPIC opened enormous possibilities for musical creation and revolutionized the field of electronic music, implying a paradigm shift in drawing music: it created possibilities for creative impulse and continuous movement, overcoming the previous restrictions of a fragmented musical thought that was largely based on a limited writing. The new system was an innovation because it also broadened the perspective of music in close relation to other disciplines such as geometry and its spatiality,

2 Kuramoto, 1975. Explained in "Synchronization," *Ichi*, https://ichi.pro/es/sincronizacion-la-danza-sama-de-la-naturaleza-20453629169086

3 *Replit*, https://replit.com/

4 *Soundflock*, https://soundflock.site/

5 For a fuller description of UPIC see Marino et al., 1993.

mathematics, drawing, and electronics.

The UpicMX project was successful in achieving two different programming solutions to convert traces into sound. The first solution was "plastic sonification," which consists of a graphical approximation of the reading of the traces; the function obtains, according to a process of conversion, the time and frequency of the pixels of the drawing in order to assign each pixel an oscillator in real time. Each of the oscillators is superimposed on the next one for a fraction of a second, constantly generating an additive synthesis in frequencies so close that beats are produced that enrich the resulting timbre (see Code 39.1).

```
function sonoficarPlastica() {
  loadPixels(); // Loads all pixels in an array. Function of
p5
  var filasConNegro = []
  var frequencias = []
  //tiempoApixel converts the pixels into a time
relationship
  var timeActualPix = int(min(tiempoApixel() + 3, width));
  // The following code goes through all pixels column by
column
  // in each column it scrolls through all the rows and if a
  // pixel in black adds it to a list where the
  // coordinates with black pixels.
  for (var cont = 0; cont < height; cont++) {
    var pixCanalRojo = pixels[(cont * width + timeActualPix)
* 4 + 0];
    if (pixCanalRojo == 0) {
      filasConNegro.push(height - cont);
    }
  }
  //The frequency corresponding to each coordinate is
obtained.
  //that has black in frequency format.
  frequencias = filasConNegro.map(pixNegro => {
    let midi = map(pixNegro, 0, height, notaGrave,
notaAguda);
    //midi2freq converts the midi note to its corresponding
frequency
```

```
    return midi2freq(midi);
  });
  // For each frequency a 20 millisecond oscillator is
generated.
  for (var i = 0; i < frequencias.length; i++) {
    var osc = new p5.Oscillator(frequencias[i], 'sine');
    // amp, start and stop are functions of the webaudioapi.
    osc.amp(0);
    osc.start();
    osc.amp(0.1, 0.05);
    osc.amp(0, 0.1, 0.05);
    osc.stop(0.2);
  }
}
```

Code 39.1

The second type of "sonification," called "parametric," reads and stores the trace information in time and frequency parameters, then assigns it to a single oscillator per line that modulates its values over time using envelopes in its frequency and amplitude parameters. When the "touch" button is pressed, the oscillators are activated and change their frequency according to the movement of the base generator trace (see Code 39.2).

```
function sonificarParametrica() {
  destruyeOsc(); // Release all active generators with stop
  //del webaudioapi.
  osciladores = [];
  // compositionTF is an array of arrays in which
  //each internal array contains the stroke points.
  for (var i = 0; i < composicionTF.length; i++) {
    var gestoTMP = composicionTF[i];
    var osc = new p5.Oscillator(composicionTF[i][1][0],
'sine');
    osc.start(composicionTF[i][0][0]);
    // A single oscillator is generated whose frequency
changes
    // discretely but at a speed that gives us
```

```
    //a perceptual glissando.
    osc.amp(0.0, 0, composicionTF[i][0][0]);
    osc.amp(0.1, 0.1, composicionTF[i][0][0]);
    // nesting for that goes through each point of each
stroke and assigns
    //frequency at the corresponding moment (time).
    for (var j = 1; j < gestoTMP[0].length; j++) {
      var tTmp = composicionTF[i][0][j];
      var fTmp = composicionTF[i][1][j];
      var tTmpAnterior = composicionTF[i][0][j - 1];
      osc.freq(fTmp, tTmp - tTmpAnterior, tTmpAnterior);
    }
    // On the last point of each stroke the volume is turned
down and off.
    var indxtUltimo = gestoTMP[0].length - 1;
    osc.amp(0, 0.1, gestoTMP[0][indxtUltimo] - 0.1);
    osc.stop(gestoTMP[0][indxtUltimo]);
    // All oscillators are added to one array
    //to be able to turn them off in another external
function.
    osciladores.push(osc);
  }
}
```

Code 39.2

Another feature of the project is the incorporation of a grid in both the X and Y axes that can be activated or deactivated, depending on the accuracy with which you want to manage the times and heights (pitches) in the traces.

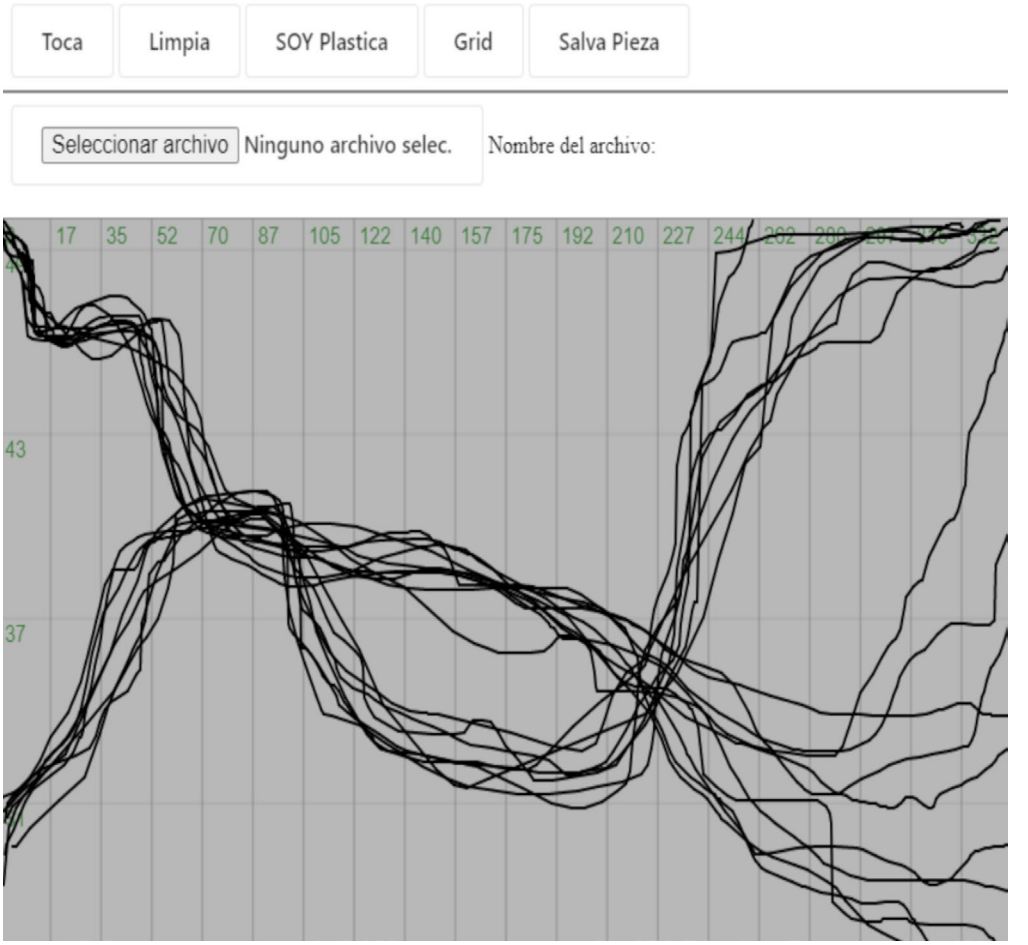

Fig. 39.1 Graphical representation where X is time and Y is frequency. Figure created by authors (2022).

Derived from this first exploration, a second project was generated throughout 2022, which we named Sound Flock. We will now jointly present these projects below.

The Collective Imaginary as a Triggering Process

In January 2022, a meeting was held within the course to propose the characteristics of the project that would be developed throughout that year. This project was the conjunction of the individual imaginations and ideas that interested the members of the course, which were unified to produce a single project integrating the points in common while preserving the particularities of the students' proposals. Each member of the team proposed specific needs, both in the field of sound and in the field of usability, user interface, possibilities, and control ranges. Throughout this

stage, the common needs were amalgamated, and the individual particularities were incorporated into the resulting product, leaving out some non-compatible elements. Among the common ideas, the following stand out:

1. The design of a system where the user could interact and modify parameters of the environment—in this way, the user is both interpreter and spectator of the work.[6]
2. The design of a 3D space where there were moving objects (agents).
3. The idea that the behavior of these objects/agents would concretely imitate the movement of fireflies, which resulted in two important characteristics (items 4 and 5 below).
4. These agents had to follow certain patterns/interactions when moving, which have to do with flocking behavior where, broadly speaking, the individuals of the group have reciprocal influences among themselves without any hierarchies.
5. The agents would have an individual light pulse where the flash of each one would seem independent of the others at first, but after a certain amount of time, a synchronization of all of the light pulses would be provoked.

Within the 3D space, the principle that the absolute interpretation of the positions of the agents is accompanied by a reading from any viewing angle, so that the user may rotate and move within the 3D environment at will. It is important to note that the user may also activate planes from any point in space, moving towards the background.

Consequent on (4) above, different simultaneous readings can be made of the behavior of the agents. These planes advance on their relative Z axis, which corresponds to time—the transit speed of which can be defined by the user—and where the X and Y axes, also relative to each plane, correspond to different parameters of the rhythm/sound, also defined by the user. Since the parameters respond to the position of the space, by changing the reading point, it is possible to generate multiple, ever-changing versions of the sound creation.

These five characteristics gave birth and shape to the entire project and guided the decision making and computer code development over the following months, resulting in the Sound Flock project, which is described below (see Figure 39.2).[7]

6 For the sake of clarity, we use the term "user" despite its possible reductionist connotation. However, we think that, given the nature of the platform, the person using the tool will be at different levels a creator, performer, player, explorer, researcher and interpreter.

7 The functional version can be found at https://soundflock.site/. The source code can be found at "hugosoli/soundFlock," *GitHub*, https://github.com/hugosoli/soundflock

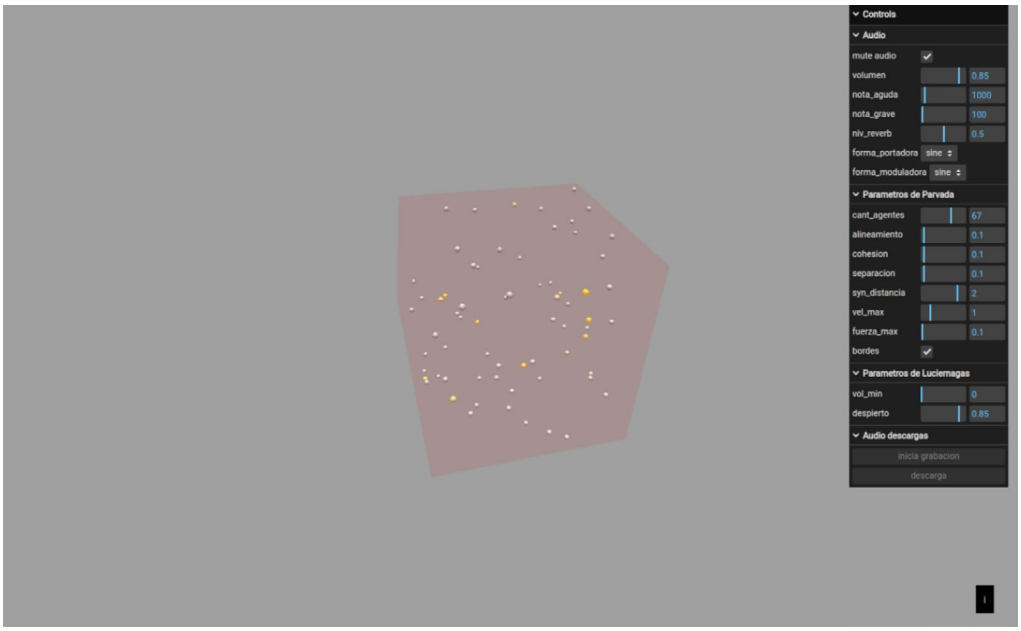

Fig. 39.2 Screenshot of the system, the sand-colored and orange dots correspond to the agents. Figure created by authors (2022).

Development of the Work

The development of the work was guided by the vision raised in the investigation with the aforementioned factors: agentiality, flock behavior, and interference of planes on the space. The general purpose was to have an audiovisual experience in which the events, and their ranges and parameters, were manipulated by means of a control panel. In this way, a resultant was planned that could produce "compositions" to be downloaded, with the objective of preserving them in fixed format for their future and possible diffusion.

In order to develop and achieve the proposed objectives, it was essential to work step by step with the following elements:

1. Define the 3D space.

The first decision was to establish a 3D space, which we called "external space," which corresponds to the Cartesian absolute coordinates of the digital graphic system. Within this virtual space, a cube was placed whose function is to be the container for the graphical representation of the agents.

2. Characteristics of the agents.

During this stage, work was done on the graphic representation of the agents and the following was determined:

a. That they should be confined inside the cube, in a spherical representation where the agents have the capacity to flash with cyclic pulses as real fireflies do.

b. That they should demonstrate a capacity of movement in three dimensions with different degrees of randomness.

3. Agent behavior.

The main objective at this stage was to get the agents to have a flocking behavior. Several examples of this movement were studied in order to adapt them to the goals of our proposal. To organize the computational code, several classes were designed, among which the Boid class and the Flock class stand out.[8] The first class contains all the behaviors of each agent, and the second one groups the collection of agents. Within these two classes it is possible to completely define the behavior that the agents would have, clarifying that their movement is given through acceleration, position, velocity, attraction, and distance between all of them.

Sound Behavior

At this stage, it was decided that each of the agents would emit a sound generated through Frequency Modulation synthesis. The sound process was linked to the behavior of the agents in such a way that generated an association between the parameters of the virtual physical space and the sound parameters. The modulation index was associated with the position on the Z axis, the intensity with the position on the Y axis, the intensity with the position on the X axis. It is important to mention that the intensity not only depends on the position but is also modulated by the cyclic pulsations of the flashes.[9]

1. Sound process recording.

During the development of the project, the importance of making recordings of the sound actions for their possible preservation and/or editing became clear. Therefore, the necessary code was implemented to generate files in WAV format; to achieve this, codes found on the web that took advantage of the Web Audio API for recording digital files were adapted.

2. Sound capture by intersecting planes.

At this stage, a mechanism of reading by means of blueprints was developed in relation to the position of the agents. This reading is generated when the plane crosses the cube, reading the relative position of each of the agents, adding a new sound.

8 We refer to the concept of Class, within object-oriented programming (in English OOP).
9 Estrada, 2001.

This procedure was performed by identifying the relative coordinates of each agent in space.

3. Control panel.

Within the original conception, one of the goals was to allow the user to interact with the system and thus achieve a more interactive experience. With this objective in mind, a control panel was implemented that allows the manipulation of a large number of parameters and ranges that help to control the sound results.

Emerging Behaviors

Flocking Behavior

Flocking behavior is present in groups of small individuals: it is most commonly found in flocks of birds, schools of fish, groups of insects, etc. Emergent behavior is considered to be the phenomenon that arises from the decisions made by each individual following simple rules, where the most important are the relationships of each individual with its environment. There are many works that have simulated this type of behavior. The one that has been followed as a model for the project is the work of Craig Reynolds, implemented in the P5.js library by Daniel Shiffman.[10] During the course, this code was adapted to the Three.js library for modeling in three dimensions.[11]

In this model, an agent-object is created, named "Boid," which has the following properties: a velocity and acceleration, a maximum velocity and force, a pulsation velocity together with its phase, and a "step" which consists of the amount that its phase is advanced.[12]

As stated, flocking behavior is defined by the "individual decisions" of each agent where such decisions are defined with three functions: separation, alignment, and cohesion, as established by Reynolds.

The separation function consists of how agents avoid colliding with each other, avoiding and pushing each other according to a given range. The function has two important local variables: "desiredseparation," which consists of the level of separation of the agent from the rest (in other words, this impulse indicates what the range of action of the function is), and "steer," which indicates a vector with the future direction and position of the agent. To know which of the agents are in the range of action of the function, the distance between each agent and the rest must be calculated. If the

10 "processing/p5.js," *Github*, https://github.com/processing/p5.js; "The Nature of Code" (2024), *Github*, https://github.com/nature-of-code/book-website-2nd-edition

11 "mrdoob/three.js," *Github*, https://github.com/mrdoob/three.js/

12 In the following paragraphs sections of the source code are explained, so it is suggested to accompany the reading with a review of the source code.

distance is greater than the "desiredseparation" then three operations are applied: the vector of the agent must be subtracted from the vector of the nearby agent, the subtraction normalized, and then divided scalarly with the value of the distance. Finally, this value is added to the variable "steer." This process is repeated with each of the agents, as long as their distance from the agent is less than the "desiredseparation."

The second part of the function consists of dividing the overall "steer" by the number of times that the previous operation was performed; i.e., normalize the value of "steer," and finally adapt this value to the general properties of the agents (in other words, adapt to the maximum speed, the current speed, and the maximum force). Thus, we finally have the "steer" to be applied to the agent in question.

The alignment function instructs each agent to change its direction of movement according to the position of the rest of the agents, causing groups of agents to move in the same direction. Like the separation function, the alignment function has two important variables: "neighbordist" and "sum." "Neighbordist," is the distance at which the function will come into effect, and "sum" is a vector that will indicate the direction and final position of the agent. For each agent within the range of "neighbordist," the current velocity of each of them will be added to "sum."

The second part of the function consists of taking the value of "sum" (the sum of all velocities) and dividing it by how many agents are within the range of action of the function; i.e., normalize such division and adapt it to the general properties of the agent and, finally, return the value of "sum." In case there is no agent within the range of action, a vector with values of 0 in each axis must be returned. In this way, the behavior of the agent will not be affected in any way.

The cohesion function acts on the agents to calculate the average position of nearby agents and instructs them to move to the average position. Like the separation and alignment functions, the cohesion function has two parts: in the first part, a variable (again defined as "sum") is obtained that sums all the positions within the action range (as in alignment, the action range is defined by the variable "neighbordist"). In the second part, this sum is divided into the number of agents within the "neighbordist." Before returning the value of "sum," the secondary function "seek" must be applied, which adapts the value to obtain the final result.

Finally, these three functions are added together with the "applyForce" function, to indicate to each agent its next position in each interaction of the animation. In this way, one has a new position that summarizes how separated and aligned the agent will be with respect to the others and if its direction has cohesion with the rest.

According to different configurations of these functions, movements will be obtained that are either more synchronous or more chaotic. It should be noted that some functions can override the effect of others; for example, in the case of alignment with separation, a high level of separation and cohesion will generate a hesitant movement of the agents.

Synchronization

Two different strategies were used to achieve synchronization: pulse synchronization and phase synchronization. For this purpose, two different functions were used: "bpmsync(),"which is in charge of synchronizing the pulses, and "syncronization(),"which is in charge of synchronizing the phases (see code 39.3).

In the "pmsync()" function, there is a local variable named "sigma," which is the sum of the differences between the sine of the variable "step" of each of the agents. Then we proceed to normalize "step" where the value is multiplied with a predetermined value that controls the speed of synchronization. Kuramoto proposes that each agent listens to the rest of the nearby agents when they press and, therefore, each time any agent presses, the rest of the nearby agents will slightly advance the speed of their pulse, being affected by the collectivity.[13]

On the other hand, in the function "syncronization(),"a counter was assigned to each agent with the variable "step," which generates cycles between 0 and 1. If the "step" state is less than 1, then the firefly has an OFF state; on the contrary, when "step" is equal to 1, the firefly's state is AWAKE, generating a light and timbre pulse. In turn, if "step" is equal to 1, then each phase of each agent will be advanced by a small amount the variable "step;" that is, every time any agent presses, the other nearby agents will begin to synchronize, equalizing their phases with each other.[14]

This procedure helps to ensure that the groups that are close in space gradually grow closer in their phases; that is to say, are constantly synchronizing with each other. It is possible to control the number of agents, and also how far away they can sense other agents in their "flashes." With these variants, it is possible to accelerate the synchronization process or, on the contrary, to generate asynchronous pulses independent of each other (see Code 39.3).[15]

```
bpmsync(boids) { //Kuramoto
  let sigma = 0;
  for (let i = 0; i < boids.length; i++) {
    sigma += Math.sin(boids[i].paso - this.paso);
  }
  let term2 = 1 / boids.length * sigma;
  this.paso += term2 * 0.001; // Value that reduces the
speed at which synchronization is done.
 }
```

13 See Nicky Case, *Fireflies*, https://ncase.me/fireflies/
14 Ibid.
15 Ibid.

```
  syncronization(boids) {
    if (this.estado == "DESPIERTO") {
      for (let i = 0; i < boids.length; i++) {
        let d = this.position.distanceTo(boids[i].position);
        // If the distance is greater than 0 and less than
an arbitrary amount (0 when you are yourself).
        if ((d > 0) && (d < SYNC_DISTANCIA)) {
          if (boids[i].estado == "DESPIERTO") {
            this.fase += this.paso;
          }
        }
      }
    }
  }
```

Code 39.3

Individual Comments

Mizky Bernal, Bolivia

I recently started to explore computer music creation. This exploration allowed me to learn technical aspects of programming languages, the study of the possible tools provided by the implementation of programs, and the scope of working in the various specialized virtual platforms—all within the framework of the possibilities and limitations that I still find because of my limited training in this area.

This approach made me consider everything that the subject produces in my person from a creative perspective. From this reflection I understood that my creative approach could be modified at certain points, since the tools provided by technology are quite broad. That is how I began to speculate about the possibilities of sound control, the incursion into multidisciplinarity, the work on exploratory listening, possible audiovisual inquiries, the manipulation on semiological-musical management, and many other interesting elements. Undoubtedly, the development of this course boosted my curiosity towards the exploration of the virtual world.

Diego Jiménez, Mexico

Throughout the course I was able to realize the creative and technical possibilities of sound creation by computer, as well as the benefits of programming in general, both

to organize my thoughts and to enrich my creative process. This type of creation helps to structure thinking, by the very nature of programming languages and by the need to give the computer clear and precise indications about what it has to execute. This puts the programmer in an uncomfortable situation, because it forces him to specify absolutely everything that the machine—which does not have the capacity to make decisions—needs to do; no matter how basic or logical the idea is, it must be described. Therefore, it is necessary that all instructions be given in a conscious way in order to be declared. On the other hand, computer creation requires a high degree of imagination and organization, since there cannot be an answer without a question and, therefore, it is not possible to have a direction without a problem to solve. You must first imagine, in order to understand the problems and implications of what you want to do, and then design possible solutions to achieve that goal.

As for my artistic work, the creation of sound by computer has implied a significant enrichment since it has forced me to consider paradigm changes. For example, I now treat the computer as just another instrument or as an extension of traditional instruments. This allows me to materialize in a more reliable way what I need. On the other hand, programming and its field of action invites me to consider areas of knowledge that are not necessarily limited only to sound, so it can be a useful tool to create multidisciplinary works in which the artist's perceptive capacities are completed, without restricting them to a single sense.

Guillermo Leonardini, Bolivia

During the time that I have studied the subject of musical computing I have learned several things. The first one is that technology functions as a tool at the service of one's fantasies, instead of as a mere technical exercise, where the achievement of connecting some devices would be enough to justify the existence of the proposal. I find more interesting the position that technology, as a tool, allows a faster understanding of the phenomena studied and, therefore, drives creativity more effectively. On the other hand, I have learned that every imagination has a second process: that of translating the execution of the imagined into the real plane, to order that which is in the mind, to decipher the tools for its execution, to glimpse the steps to concretize it, and to achieve the construction—in the luthier's sense—of the material and the device to finally fulfil one's imagination. If something cannot be done, it can be codified, and it can be built.

The concept of work/tool within a digital platform is appealing to me. I had never worked on such a project before. One continually thinks about how the audience—or perhaps, in this case, the solitary virtual surfer—perceives the work; but one also thinks about how the composer operates the tool to get something to their liking. Experimenting with "the form of the work equals the utility of the tool" or "the final version of the work equals the audience's experimentation with the tool" were attractive approaches during the process. One never knows how far the audience will

take the proposal. Will it achieve what was imagined? Can one say that there can be a misuse of the tool? Delegating decisions to someone else is always a bit of a mystery.

Eunice Perez, Mexico

Programming languages are generally complex. They require a great capacity for abstraction, a gradual process of learning and constant practice, but, as rich as their complexity is, so is their scope. It is fascinating that the ideas and fantasies of a creator can take concrete form in the programs or works created through them. Programming works from the root, at the origin of sound objects, offers the ability to decide their acoustic essence and their behavior in space; it is a more radical process than working with pre-established objects such as musical instruments.

My artistic praxis is enriched by these tools and, at the same time, I find new paths to follow, not only in the field of audiovisual creation, but also in the area of artistic research, as a means of auditory or visual exploration. Electronic media offer possibilities for handling information and sound and visual objects that are alien to the analogical world. It is possible to transform or move them at will, which facilitates the study of the researcher-artist's personal interests. The collective creation of a program such as the one we have worked on in the two projects within the Music Technology Group is a way of sharing processes, concerns, and interests with colleagues.

Hugo Solís, Mexico

Guiding a process of technological creation under the premise that the most important thing is to give materiality to a development of the collective imagination is a challenge and, in itself, a process of creativity. Questions such as where to put the emphasis, whether in the technological development or in the sound result, in the learning process or in the pristine result, are solved in the moment, during each session. The trade-offs and decisions were made on a meeting-by-meeting basis and, as a whole, were influenced by the profile of the group. As a supporter of "learning by doing," the methodology of teaching programming along with the creation of a specific project has its particularities and challenges. However, this is how we humans acquire language, and it was in this sense that I tried to guide each of the sessions. We learned through listening, repetition and, above all, under the impulse and the need to communicate. It is under this premise that, over two semesters, the process of designing first a web version of the UPIC, and later a unique approach to collective audiovisual creation was carried out. The first semester functioned as a stage to learn the basic principles of computer programming where concepts such as variables, arrays, cycles, functions, and logical operators were gradually used, as they were required within the code designed in a multi-user platform that allowed everyone, to view and manipulate a shared code from their computers. During the second semester, assuming that the basic principles

had been assimilated, we had the opportunity to delve deeper into various concepts, at creating new code and, being able to review the open-source code that, in this case, offered us parts of the solution to implementation. However, the nature of such codes required specific adaptation or translation from another computer language to JavaScript. On certain occasions, it was necessary to make sketches or code fragments in other computer languages including PureData's graphical language. At a certain point, when it was decided to implement a recording system within the application, it was necessary to dedicate several sessions to the theory of signal processing and the theory of digital sound synthesis, in addition to mentioning topics such as Frequency Modulation synthesis. I must confess that some of the processes were smoother than others; one that took a significant amount of time was writing the code that allowed us to perform the 2D projections of the 3D plane from a specific camera position view.

In relation to the distance learning dynamics, it is important to mention that half of the group is not in Mexico, so the course could not have been given in any other way. However, from a deeper point of view, I consider that teaching with the shared code platforms and the electronic whiteboards facilitated the teaching-learning process, given the predisposition of the group to maintain an active and attentive attitude during the sessions.

In this way, the result described in these pages was achieved: a digital system for audiovisual sound composition, created collectively. Undoubtedly, this result can grow and be refined in its details, but, at the same time, I celebrate that a functional system was achieved, derived from an intention of collective creation that served as a learning process. With this, I can say that we obtained a real, tangible audiovisual system, as well as a sound reality.

Sound Examples Available

The generated audio materials are available on SoundCloud,[16] where each of the materials presents different ranges of parameters translated into particular sonorities and evolutions. However, the reader-listener-receiver-user, above all, is invited to use the tool and to exploit it according to his/her own needs and under the impulse of his/her particular listening.

Conclusions

This chapter presents different perspectives on a collaborative process, a technological result, an audiovisual creation proposal, and a learning process mediated by remote distance learning. Undoubtedly, like any evolving digital object, the system is perfectible and improvable. However, perhaps it is born as a mutable, changing

16 Guillermo Leonardini, "console.log(ban.da[da])" (2022), *SoundCloud*, https://soundcloud.com/user-511292729/consolelogbandada

proposal in a constant state of transformation, and it is alive. That is to say, the system was not born to be finished, or to acquire such a static state; but rather remain a system in evolution and adaptation, a laboratory of changing sound experimentation where the subject changes. On the other hand, this version—with its very specific restrictions, possibilities, and particularities—is the reflection of a kind of serendipity, an aggregation of individual searches and needs put together, through sessions of discussion, reflection, and decision making, including elimination and negotiation of tasks within the limits of knowledge, time, resources, and computational creation skills. We must say, it is attractive that this proposal is the result of collective thinking and collective imagination. After the first semester was over, the possibility was raised for each member of the group to develop his or her own audiovisual solution; however, it would have would have been complicated to guide different ideas in parallel. It was in this way that the joint proposal started from each of the individual proposals—not from the sum of isolated ideas, but rather under the reflection on how to achieve their unification, their fusion, and the dialogue between them. Some elements of the individual visions were discarded, and others were incorporated once the proposal acquired unity and clarity.

In the territory of sound, we manage to control and listen to processes that are at a particular boundary, as they are neither deterministic, on the one hand, nor chaotic, on the other. The tool is at a point where control of the resulting sonorities is maintained, although several of the processes are not directly controlled by the user. At this stage the user can suggest ranges, dynamics, and interaction situations, but the particles have the same control over the resulting sonorities and a certain "creative independence."

What is presented here is the materialization of one possibility among many others. It is the sum of thoughts, needs, and curiosities of the teacher and the students who, in a collective search for a digital composition tool, arrived at a specific synthesis which allows a particular—and hopefully original—exploration for the creation of sound structures with the particularities described in this chapter. Therefore, this chapter is a description of a methodological work guided by the fantasies and curiosities of all the members of the group in an analogous way to the agents of the system.

Future Work

As part of the development and improvement of this project, several points are planned to achieve a greater sonic and perceptual richness and, thus, to grow and improve the users' experiences. Among the points to be implemented in the future, the following stand out:

1. Change the reading of the agent values on the axes X,Y, Z from the center to the ends to achieve a better sound balance.
2. Incorporate the binaural and/or multichannel audibility of the system, and consequently enable the download of a recording with such characteristics.

3. Clean and refine the reading of the plans on the 3D space.
4. To be able to change the waveform of the agents, as well as to incorporate the option of uploading an audio file to be used as a sample for sound generation.
5. Consider the possibility of incorporating not only a cube as a delimiter of the agents' space, but also other geometric figures.
6. To have the possibility of having delimiters within other delimiters, such as, for example, cubes inside cubes.

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40. The Xenakis Networked Performance Marathon 2022: An Experiment in Networked Performance Collaboration Inspired by Iannis Xenakis

Iannis Zannos, Martin Carlé, Vasilis Agiomyrgianakis, Takumi Ikeda, and Hanako Atake[1]

Introduction

This chapter documents the results of an international collaborative performance project organized in honor of Iannis Xenakis at the hundredth anniversary of his birth. Xenakis's work exerts lasting influence in the world of music as well as in the broader context of the avant-garde. His engagement with mathematics and technology from a broad philosophical scope within the program of modernism is a source of inspiration for artists working at the threshold between art and technology. Furthermore, his philosophical approach of music and the role of technology and mathematics in music forms a long-lasting foundation for creative engagement in the field.

In this context the "Xenakis Networked Performance Marathon 2022" (XNPM22) project was conceived as a challenge to engage with the legacy of Xenakis from the perspective of contemporary movements in music and performance arts, while also exploring the potential of online musical collaboration through the use of digital technologies falling within the extended scope of Xenakis's technological and

1 The authors would like to thank project HAL (Hub of Art Laboratories) at the Department of Audiovisual Arts Ionian University for the financial support which was indispensable for realizing the project. Thanks are equally due to Professor Haruka Hirayama of Hokkaido Information University for support and collaboration in the years leading up to the project, for her invaluable efforts to provide the organizational and technical framework for the trials leading up to the project, and for participating in the project both remotely and locally. Finally, the authors are indebted to Professor Satoru Takaku of Nihon Daigaku for providing valuable support and rehearsal infrastructure for this research.

 https://doi.org/10.11647/OBP.0390.42

mathematical vision: program code as an implementation of mathematical thought, and sensors as interfaces in experimental techniques extending the expressive modes of performance.

The project was realized through the collaboration of several institutions. The result was a marathon performance in the main Dance Studio classroom of Athens Conservatoire, presenting sixteen pieces from artists in ten different countries in the span of eight hours.[2] The marathon included four ensemble dance pieces using wireless wearable sensors tracking movement by means of inertia to control sound synthesis, as well as numerous pieces demonstrating networked performance with diverse software and approaches. The technical and organizational problems encountered are too many to report here in all detail.

Some of the solutions to these problems led to unexpected insights and to prototypes of software and hardware systems that merit further examination and development. Here we mainly center on the original work done for the development of alternative wireless wearable sensor hardware during the extensive rehearsals of the dance ensemble pieces. These can be seen as examples of frugal innovation, in the sense of assembling or modifying (hacking) low-cost hardware to meet the requirements of the project. We also outline the software framework used in most of the live coding performances and discuss the impact of self-contained minimal setups in other experimental performance practice forms such as a street performance that formed part of a complementary collaborative project in parallel to the marathon. In Chapter 41 in this volume, we cite the descriptions of all pieces as provided by the artists, in order to give an overview of the scope of the project, and provide links to the videos of the pieces.

IMU and Frugal Innovation in Dance-driven Music Performances: Overview

Inertial measurement units (IMU) are amongst the most ubiquitous and readily available sensors. We used IMU sensors to explore their potential as instruments for musical expression in a variety of settings that challenge and expand the conventional notions of (music or dance) performance, testing several different types of wearable IMU-based motion tracking devices, thus enabling dancers/musicians to control sound synthesis through their body movements. Hardware includes self-made devices based on Arduino, Linux OS, custom systems using Zigbee and N24 NRF protocols, off-the-shelf Wi-Fi devices such as iPhones or the ESP based M5Stick, low-cost health-monitoring watches using Bluetooth.

We encountered challenges at all levels: hardware, software and networking configuration, interaction design, and performance practice. A distinguishing

2 One piece needed to be cancelled due to illness of the performer, Thanos Polymeneas-Liontiris.

characteristic of the present work is that it required participation and collaboration between members of a small team, and that hardware, software, networking, sound design or compositional and choreographic work proceeded hand in hand in real time while developing the performances. This provided practical evidence that it is both possible and necessary to deal with these aspects in an integrated manner, and indicated the need for developing a work methodology that supports a close feedback loop between these components, and provides continuous creative motivation and guidance to artists.

IMUs and New Performance Practices

By combining readily available inertial measurement units with equally widely available wireless hardware components, one can build low-cost wearable systems for tracking human body movement. Sensor-based tracking of human movement is thus being established as a trend in live performance with body movement, parallel to camera-based systems. This opens up many possibilities, while at the same time requiring a fundamental rethinking of the methodologies and roles of the artists involved.

The ability of performers to trigger sounds or to modify the flow of sonic events by moving their bodies freely is a powerful and attractive feature. Yet it is not easy to build performances with these elements that keep the attention of the audience and build a captivating or meaningful narrative. Most importantly, the relationship between body movement and generated sound is complex and unexplored. Musicians/programmers and performers face the challenge of developing a language or system which interconnects body movement to sound in such a way that allows one to create performances that are satisfying and meaningful both to the artist and to the audience. This is a large task. The present chapter does not attempt to give answers but limits itself to reporting the experiences made through several projects and to provide information and ideas that may prove useful for future work in the field. We report as practitioners who develop fully fledged performances based on low-cost hardware. We believe that the best way to develop the new languages hinted at above is to collaborate on hardware, software, and performance design methodology, and we therefore deal with all these aspects in this chapter.

Musician/Programmer and Dancer: Form Design, Improvisation, Interaction Design

While the use of motion sensors in music technology is gradually becoming widespread, most of the basic questions regarding their aesthetic function and their nature as a form of performance remain unanswered. Why employ motion sensors instead of other controllers? What is the intention of including movement in music in the first place? Dancers are arguably more aware than musicians about how to

express themselves by moving their bodies. However, they are less accustomed than musicians to having their movements directly converted into sound. Even if a musician or programmer, assigns different functions to each of the three motion axes of a sensor for musical reasons, it is very unlikely that the dancer will move as the musician or programmer intended. For this reason, we adopted an alternative methodology, which requires the musician to consider the characteristics of dancer's movements when programming the sensors. The dancer performs with the sensors while also taking their choreography into account. Then the musician adjusts the program according to the dancer's choreography. The performance is gradually polished over iterations of these processes. In light of the above, describing this piece simply as music or dance is inappropriate. The present project thus ventures into the field of performances that do not belong to an established genre. These represent at the same time a threat to prevailing conventions and a way to escape the system. We view this is a first step towards defining performance conditions and paradigms better suited for performance with motion sensors. Here we focus on two performance categories that venture outside the conventional concert-hall configuration: (a) Telematic performances where the performers play in remotely located venues at the same time and coordinate through motion data and code sent over the internet and (b) mobile performances in open public spaces. These settings present concrete technical and methodological challenges which we discuss below.

Background and Challenges

The initial goal of this project was to investigate how dancers can perform in remote locations simultaneously by sharing their body movement through data over the internet and creating sound from this data in real time. Sound is generated by SuperCollider from data shared via Open Sound Control (OSC).

Since 2018, several performances based on this idea have been realized in different settings, including telematic performances between up to three different locations and local performances. Challenges arising from this task are:

1. Capturing the data with sensors and sending it to the music-making workstations.
2. Transmitting these data over the internet, across firewalls and to computers connected to local subnetworks.
3. Designing interaction algorithms to produce sound (and graphics) from the data.
4. Adapting the algorithms to be used by the dancers. This presupposes a common understanding between dancer and programmer/musician about the principles governing body movement and sound and the relationship between these two.

5. Designing performances together with the dancers, resulting in choreographies coupled with music.

To the above should be added the overall challenge of working with multiple hardware and software, and ideally also different interaction strategies, at the same time. This is an essential requirement to permit collaboration, and therefore a necessary condition to develop a shared performance practice. The following sections describe the work of the project in these fields.

Performance Criteria for Wireless Communication Standards

We explored different wireless protocols: Wi-Fi, Bluetooth, Zigbee, and Nordic Radio Frequency wireless data protocol (NRF24). The criteria which emerged from work in different performance settings are:

1. Range and reliability: How far can the sensor be located from the receiver and still transmit data? Can the sensor transmit data even when there are other physical objects between the sensor and the receiver? These characteristics depend on whether the sensor is in a closed space in which reflections from other surfaces amplify or re-transmit its signal, and on other characteristics such as the permeability of objects interjected between the sensor and transmitter, and the quantity of wave absorbing surfaces in the room. When a sensor loses its connection to the transmitter, how quickly and reliably can it reconnect? Reconnecting depends mainly on the software that manages the connection, and which may require fixing in order to reconnect faster.
2. Power requirements: How much electrical power is required to connect the device to the network? Implementation standards that use much power may produce a stronger signal and achieve better range. However, requiring less power is preferable, because it allows devices to work for a longer time with the same battery capacity.
3. Number of devices that can be connected to the network at the same time. Zigbee supports up to 256 devices in a Network, while Bluetooth supports up to seven and RF24 up to six devices per receiver.
4. Cost and availability of individual sender and receiver modules. These may vary according to time and country. Consequently, the information that we give here is bound to the local conditions in Greece during 2020–2. The cost factor can become irrelevant in certain situations when using devices that are already owned by the performers, such as smartphones.
5. Dependency on transmitter hardware and existing internet infrastructure: using Wi-Fi for sensor data transmission can interfere with the connection

of the main workstation to the internet which is required for telematic performances. This disadvantage, as well as the difficulty of setting up a connection in some situations, speaks against using Wi-Fi for wireless IMU performance.[3]

6. Robustness, size and ease of use of the device. How long does the device function on a single battery charge? How easy is it to recharge and to wear? How resistant is it to shock and fast movements?

Early Attempts

Our first prototype was made by connecting a Bosh BMF055 9 axis IMU to a CHIP Pro minicomputer running Alpine Linux.[4] Support for this system was discontinued at early stages of our work in 2018 due to failure of the manufacturing company. Subsequently, we continued with an Arduino-compatible Feather Huzzah ESP module by Adafruit, and finally to a Raspberry Pi Zero. Because there was no working Arduino library for Bosh BMF055, we substituted it by an Adafruit LSM6DSOX 6 DoF Accelerometer and Gyroscope. With this system, we were able to do several performances. However, connecting to Wi-Fi proved unreliable in many situations, even when using our own stand-alone Wi-Fi router. It furthermore required custom reconfiguration of routers when we wanted to connect to remote locations on the internet, which were not always feasible. On the whole, our experience confirmed the arguments already presented by other researchers that it is strongly preferable to use a dedicated (Wi-Fi-independent) protocol.[5]

Sense/Stage System (Zigbee)

Sense/stage is a system developed by Marije Baalman specifically for use in interactive performance.[6] It uses the Zigbee protocol. The data are received by the computer via a communication module that connects via USB. Its independence from Wi-Fi is a major advantage. The system performs well in open spaces at distances up to fifteen meters at direct line of sight, and in medium-sized closed spaces with few performers. However, when rehearsing in larger spaces with greater numbers of performers, we noticed that data transmission tended to diminish in rate or to stop, especially when the performer's body lies between the sensor and the receiver. For these performances, we sought alternative solutions, as shown next.

3 Baalman et al., 2017.
4 Zannos and Carlé, 2018.
5 Baalman, 2017.
6 Baalman et al., 2009.

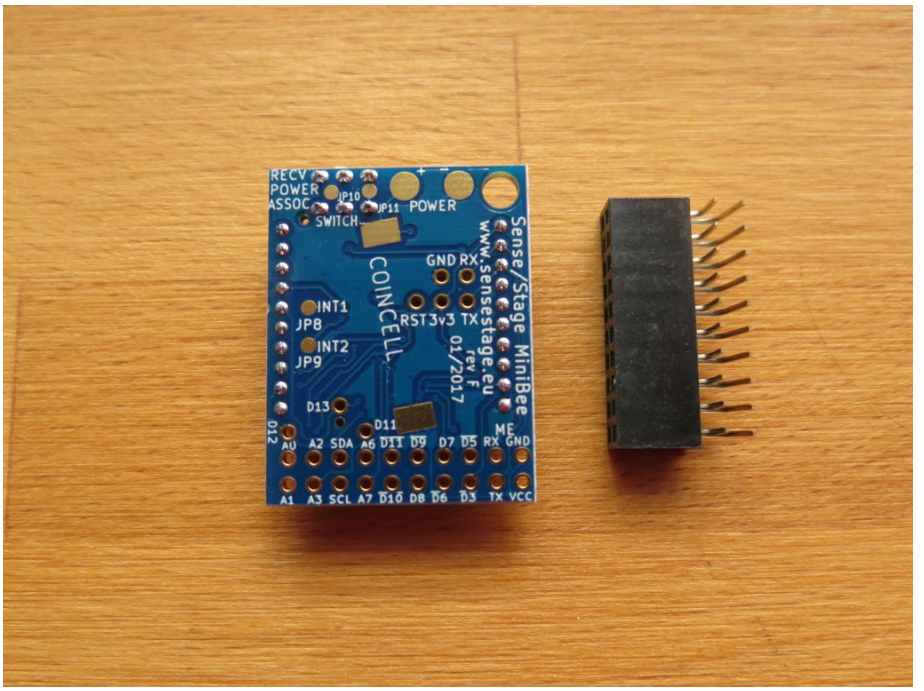

Fig. 40.1 Sense/Stage MiniBee with Header. Photo by Iannis Zannos (2023).

Smart Watches Using Bluetooth

As replacement for the XBee-based sense/stage system we use a wireless sensor system built on low-cost, nRF52-based smart watches providing real-time accelerometer data as OSC messages. Two smart watch models outwardly similar in hardware but otherwise very different were employed: the PineTime smart watch ships with an open-source firmware and OS by PINE64.[7] Variants are available under various names by a no-name Chinese manufacturer and use proprietary technology (P8). Lack of time and financial resources and limited market availability forced us to use both watch models. We canvassed through small low-tech shops in Athens selling out their remaining stock of "Colmi P8," a medium-priced health tracker popular in Southern Europe two years ago, and then hacked the gleaned models to access the data. While for our purposes we focused on accelerometer data, these watches offer many other options for feedback and control which are accessible through a programmable touchscreen, which invite creative uses (see Figure 40.2).

7 "PineTime" (13 January 2024), *Wiki.pine*, https://wiki.pine64.org/index.php/PineTime

Fig. 40.2 PineTime Smartwatch showing X-Y-Z Data. Photo by Martin Carlé (2023).

The smart watches are compact sealed devices designed for athletic workouts. This makes them ideally suited for use in dance performance because they can be easily attached in various places on the body and are shock and moisture resistant. The thin wire aerial inside these watches (see Figure 40.3) connects to the integrated Bluetooth Low-Energy radio of the Nordic nRF52832 chip[8] providing wide signal range and high data throughput.

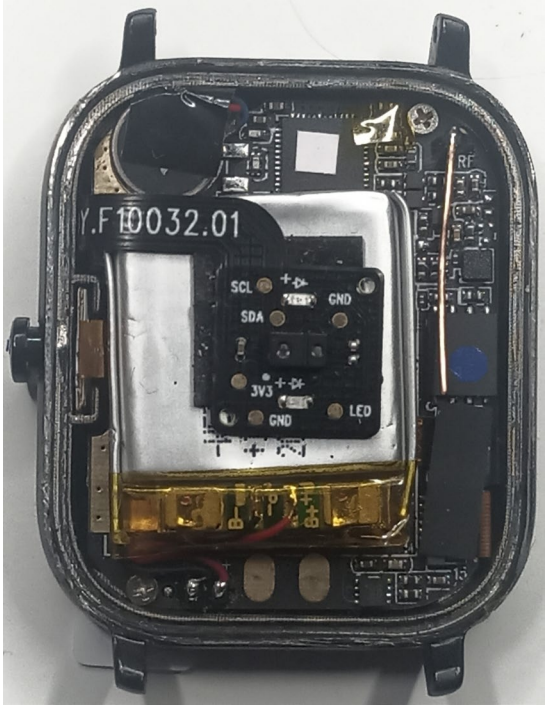

Fig. 40.3 P8 opened showing thin wire aerial. Photo by Martin Carlé (2023).

8 Nordic, 2022.

When paired with a class 2 wireless chipset of a common laptop, PineTime outperformed the XBee S1 [8] radio module of the Sense/Stage MiniBee [9] adapter. However, to achieve the required range of fifteen meters, an omni-directional antenna attached to an external BLE 5.0 class 1 adapter was necessary.

Improving The Fault Tolerance

While the BLE connection had a stable update rate, in would entirely stop transmitting when the signal strength dropped below a critical threshold. In these cases, the open-source software for BLE on Linux took several seconds to re-establish a connection to the smart watches. In order to overcome this disadvantage, we had to find a way to reduce the recovery time to a minimum. This required us to search amongst a variety of environments and software platforms for a solution. We summarize the required work in the following section.

Accessing PineTime Software and Firmware

Since its launch in 2020, PineTime has been widely used as a development platform. Due to its open nature and the widespread use of the Nordic nRF52 series for Internet of Things (IoT) projects there is a variety of real-time operating systems available, such as Zephyr or RIOT, and a number of language specific runtimes, from RTFM (Rust), and Tiny Go, to wasp-os (MicroPython).[9] PineTime ships with InfiniTime an OS written in C++ that builds on FreeRTOS and employs the NimBLE open-source Bluetooth 5.1 stack as a complete replacement for the proprietary SoftDevice on the Nordic chipsets \cite{nimble}.[10] We had to modify these environments in order to modify the software responsible for the recovery of BLE connections. InfiniTime supports Over The Air (OTA) firmware updates and even has a recovery firmware in place. Yet a sealed PineTime cannot be used for development because it may brick the device. We encountered this when attempting an OTA hack of the P8. To bypass this obstacle, we employed the DaFlasher software by Aaron Christophel.[11] This software exploits the stock DaFit firmware to install a custom bootloader which in turn allows a downgrade of the Nordic SoftDevice to an unprotected version, enabling the use of several other flashing tools for hacking the device. At present, this involves a daunting series of nine delicate steps, continuously replacing one bootloader after the other with wasp-os as intermediary, and finally enabling InifiniTime on the P8. If something goes wrong, the device is bricked, i.e. inaccessible, and one needs to perform a wired

9 "PineTime Development" (21 April 2023), *Wiki.pine*, https://wiki.pine64.org/wiki/PineTime_Development

10 InfiniTimeOrg, "InfiniTime" (2022), https://github.com/InfiniTimeOrg/InfiniTime; apache, "mynewt-nimble" (2022), *GitHub*, https://github.com/apache/mynewt-nimble

11 Aaron Christophel, "DaFlasherFiles" (2022) *GitHub*, https://github.com/atc1441/DaFlasherFiles

hardware glitch-hack using Christophel's ESP32 SWD Flasher.[12] Eventually, the seal had to be broken on both the PineTime and the P8. Each firmware update had to be tested on each of these development devices before installing it on the production watches.

Final Steps

Of the various methods for accessing the IMU of PineTime or P8, InfiniTime OS offers a uniform and nearly interruption-free method for accessing motion data in real-time. In addition to companion apps, like Gadgetbridge or AmazFish, which use standard BLE implementations on both mobile and desktop platforms, InfiniTime also supports a custom motion service.[13] This service can be accessed through any BLE API (application programming interface). On Linux one can use the daemon application itd implemented in Golang by Arsen Musaleyan to forward motion data received from BLE to a standard UNIX socket.[14] We used the liblo [19] and GoOSC libraries to forward these to the operating system via UDP as OSC messages.[15]

Finally, two more hacks were necessary: first, we needed to alter ltd so that it could handle multiple watches at the same time, and secondly, we had to modify the source code of the Goroutines in GoOSC to allow for quick recovery from data connection failures, thereby reducing the amount of offline time to an imperceptible minimum. After resolving those problems, the restriction of having a maximum of seven devices per master adapter via Bluetooth was easily overcome by using additional low-cost BLE adapters. In our experiments we used up to twelve IMU smart watches connected via Bluetooth at the same time. If more devices were available, we could have increased this number easily.

Comparing Sense/Stage with Pinetime

When comparing connectivity beyond a distance of six or seven meters, we found the sense/stage modules had a drastically reduced data update frequency, whereas PineTime and the P8 continued to send motion data at the same rate. This was especially conspicuous in stage settings with weak radio reflections (compared to rehearsal spaces), or in choreographies where bodies frequently twist around or line up creating a barrier between the sensors and the receivers. In such situations, the actual transmission distance may reach only about a fifth of the thirty meter range indicated by the Zigbee protocol documentation.[16] Since in our performances the

12 Aaron Christophel, "Swd Flasher Files" (2022), *GitHub*, http://atcnetz.blogspot.com/2021/06/ esp32-swd-flasher-fur-die-nrf52-serie
13 InfiniTimeOrg, "InfiniTime" (2022), https://github.com/InfiniTimeOrg/InfiniTime
14 Elara6331, "itd" (2022), https://gitea.arsenm.dev/Arsen6331/itd
15 Hypebeast, "go-osc" (2022), *GitHub*, https://github.com/hypebeast/go-osc
16 "Zigbee Protocol," *ScienceDirect*, https://www.sciencedirect.com/topics/engineering/zigbee-protocol

sensor data were directly mapped to audio synthesis parameters, it was critical to maintain a constant update rate. Under these conditions the PineTime and P8 smart watches clearly outperformed the sense/stage system. As a result, for the conditions set by our performances (continued long range under low-reflectivity conditions and large number of performers) the BLE based PineTime watches were preferable compared to sense/stage.

NRF24-Based Prototype

In parallel with the development of the PineTime based devices, we also started work on an alternative system using NRF24 transmitters coupled with Arduino nano. NRF24 is a radio frequency wireless protocol with excellent long-range performance. Its transmitter and receiver modules are available at very low prices, as shown in the list at the end of the present section. This solution relies on transmission technology with low-power radio, using an Arduino-programmable microprocessor (Arduino Nano) with a wireless transceiver module (nRF24L01) and a 6-DOF motion sensor (MPU6050). Despite the reservations due to limited number of nodes per adapter, expressed by Baalman, we thought it worthwhile to evaluate this technology because it promises longer range and stabler connectivity.[17]

The radio transceiver module nRF24L01 is a low power and low-cost wireless module by Nordic using a 2.4G license-free ISM band. According to the specs, this module can reach a range of one hundred meters with its built-in antenna and up to one kilometer using an external antenna. One receiver can receive data from multiple transmitters. Both transmitters and receiver use the same wireless Module (nRF24L01). Figure 40.4 shows the prototypes in development.

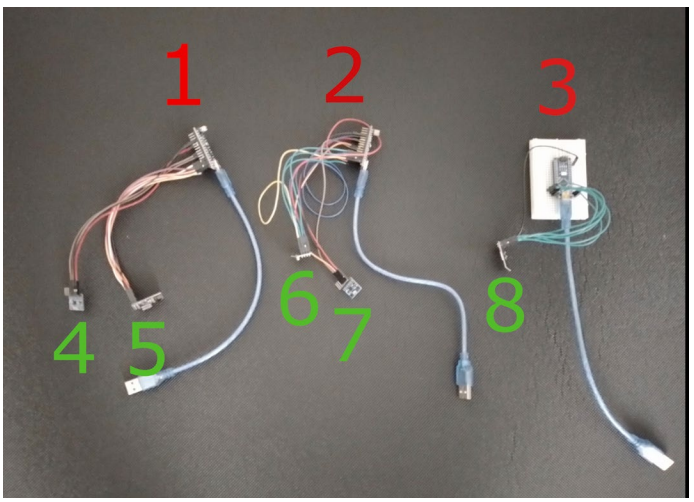

Fig. 40.4 nRF23L01 prototype: (1, 2) transmitter, (3) receiver, (4, 7) sensor, (5, 6, 8) transceiver. Photo by Vasilis Agiomyrgianakis (2023).

17 Baalman et al., 2017.

The transmitters are connected with a battery via USB. We added a DC-DC step up converter booster power supply module for connecting 3.7V 1000mAh Lithium Polymer rechargeable batteries.

We employed a six-axis accelerometer-gyroscope sensor (MPU6050) and used the x, y, and z axes of the accelerometer to measure movement data. We tested this system in rehearsals with actors and dancers at Athens Conservatoire and in Hokkaido, Japan in preparation for the Xenakis Networked Performance Marathon.

Programming in Arduino IDE is the first step in using this system. We programed the Arduino microcontroller with the nRF24L01 (transmitters and receiver) to communicate at the maximum distance that the particular chip offers (one hundred meters with its built-in antenna) as well as behind surfaces like walls, dancers' bodies, and other obstacles. The data was then sent serially to the computer via USB, using Python 3 to relay the data to SuperCollider in the form of OSC messages. To adjust sound characteristics like pitch, loudness, grain density, and duration in the granular sound synthesis technique among others, we use individual parameters from the accelerometer axes (x, y, and z). Additionally, we designed the circuit layout in preparation for a stand-alone, wearable system. Figure 40.5 shows the Arduino system connected to the IMU sensor and the N24L radio transmitter.

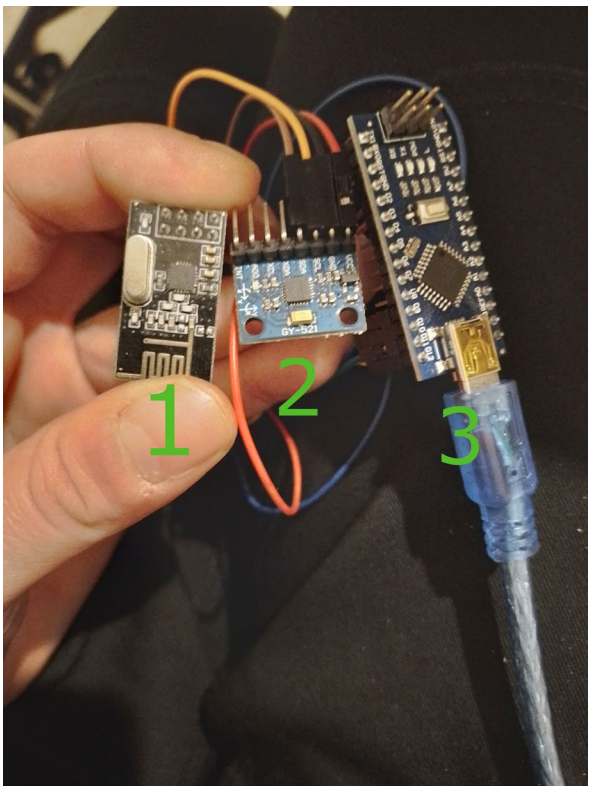

Fig. 40.5 The transmitter with (1) the nRF24L01 transceiver module, (2) the MPU6050 IMU sensor and (3) the Arduino nano. Photo by Vasilis Agiomyrgianakis (2023).

This system is still under development. The prototypes performed with constant update rates even when the sending module was behind a wall or a number of human bodies.

Software

Sensor-based dance performances involving concurrent remote locations encounter the problem of exponentially growing complexity of control parameters and coordination commands. The present project addressed this issue by sharing all data and all code between the performing locations in real time. In that way, the performers at each venue are participating in one virtual performance, consisting of the shared data and control code. This virtual performance is physically translated into replicas at each location. Thus, by definition, the performers and the audience share a common experience independently of the actual physical space in which they are located. The data sharing is implemented through the use of the open-source software OscGroups by Ross Bencina.

Increasingly complex challenges arise when one tries to use this system in settings that are not limited to a single user, type of sensor hardware, or rendering software system. Thus, the software architecture must be designed in order to be capable of operating under the following three conditions:

1. Multiple live coders performing at the same time.
2. Multiple different types of sensors with different signal specifications and OSC message protocols are in use in the same system.
3. Multiple different types of software for sound and/or graphics are operating at the same time in one performance setting.

We outline here the design principles that resulted from this research, and which are implemented in the SuperCollider library found on GitHub.[18]

1. Using Multiple Environment Dictionaries

This principle follows one of the fundamental design patterns of JITLib, an early and widely used environment for live coding in SuperCollider.[19] This is the idea of a ProxySpace, that is an environment where objects are stored as dictionary entries, and accessible to the user as environment variables when the ProxySpace is made current by the command "push." The present library defines a subclass of EnvironmentRedirect, called Mediator which is responsible for storing sound processes and the objects

18 See Iannis Zannos, "sc-hacks-redux," *GitHub*, https://github.com/iani/sc-hacks-redux. An early version is discussed in Zannos, 2018.

19 Rohrhuber et al., 2005.

associated with them such as control busses, but which behaves in a different way than ProxySpace in JITLib, as explained below.

2. Stop Processes When Replacing Them

One of the first obstacles faced by live coders in SuperCollider is keeping track of sound processes stored in variables. When such a process is replaced by a new one, the reference to the old one can be lost, resulting in a hanging sound which cannot be stopped. To help with this, Mediator automatically stops a sound process when something else is stored in its place.

3. Operators for Creating and Modifying Sound Processes

The library operators such as +> and ++> are used as shortcuts for commands that convert a function or a dictionary of type Event into a sound signal synthesis process or a stream generating many sound events, and for modifying the state of sound syntheses or event streams.

4. Operators for Accessing Control Busses and Buffers

Sensor-based systems for music performance commonly create a mapping between the values of the parameters input from the sensors into parameter changes of the sound synthesis processes. This rapidly becomes complicated when many sensors with many parameters of possibly different value ranges are involved, because each of these must be mapped into parameter changes in possibly many different parameters of different sound synthesis processes. Additionally, mapping strategies are not just limited to linear or exponential scaling between value ranges, but may also involve logical decisions denoting state changes such as on or off, or translation into trigger events that initiate event state changes (start or stop a sound event). It is therefore necessary to separate processes that operate on signals to produce control signals or triggers from processes that produce sound in response to control signals. For this reason, the sc-hacks-redux library of this project defines operators and shortcuts for accessing control busses, mainly denoted by use of the @ mark (for example @>), and for defining signal processing processes that operate on these. As a result of this distinction, it is possible to separate the design of control signal processing from the design of sound signal synthesis, and to combine these by using as keys the names of busses pointing to control signals. One future potential of this approach to be explored is the possibility to design information processing networks in a manner resembling artificial neural networks.

5. Use of Observer Pattern

The Observer pattern is a widely used language pattern in object-oriented programming. It is based on the principle of a notifier object issuing a notification that it has changed, which is then received by any other objects that may need to respond to the changes in the notifier. The library of this project defines a new class Notification that implements this pattern along with an API that enables one to easily define custom responses of any object to the message changed when received from another object. This pattern is almost ubiquitously used in the library and serves as basis for designing both graphical user interfaces (GUIs) and for customizing the behavior of the system in response to OSC messages. The Notification class combines two mechanisms implemented in the built-in SuperCollider library with the methods update and changed and with the class NotificationCenter, in such a way as to provide a uniform solution for all Observer pattern use contexts. In this way it provides a basis for programming asynchronous communication in both GUI and server-language object updates.

6. Dynamic Definition of Responses to OSC Messages

Based on the Observer pattern protocol of the Notification class, the library defines operators and methods which enable the user to modify the response of the language to incoming OSC messages on the fly. Selected examples of functionalities enabled by this feature set of the sc-hacks-redux library are:

- Automatically send code strings locally evaluated by the user to other users in the network, using OscGroups.
- Evaluate locally code strings received from other users via OscGroups
- Write numeric values received via OSC messages into control busses

This results in a tool that enables coders to customize the behavior of the system and is therefore the current focus of the present research, along with information processing networks.

7. Code Management

Making use of the basic tools mentioned above, the library provides a basic GUI framework for navigating a folder system holding SuperCollider code files, and for executing any of those files either as a whole, or in part based on the separator `//:`. Furthermore, it is possible to play any such file as a score where each part or code snippet has a predefined duration given in the comment header in the form of `//:[duration]`. This makes it possible to write scores as program files and to play these at any moment from the GUI.

8. Saving and Replaying of OSC Data

Since OSC is the de facto basis of communication both between sensor hardware and between live coders in a performance, the library provides a way to store all data in any performance session into a series of files as SuperCollider code and to replay these later for experimentation purposes.

Performance Practice

1. Networked Performance

Our telematic performance settings are similar in principle to those encountered by online game players sharing an experience in a virtual world, where the actions of each player are always transmitted to and reflected in the local systems of all other players, thereby creating a virtual space or game-universe shared by all players independently of their locations or gaming platform hardware. The performance is controlled by live coding in SuperCollider where the coders are responsible for configuring, mapping, and routing the sensor input from the dancers to the various rendering modules. In practice, it is possible for a single user to run a performance remotely with multiple dancers performing on multiple remote locations. The major difference, however, is that the players are controlling the sound by performing on stage with their entire bodies. This creates an entirely new situation, whose analysis lies beyond the scope of the present chapter.

2. Outdoor Performance

In some cultures, plazas are not inherently accepted as public spaces for performance, so alternative spaces are used, such as public roads. However, such locations serve only as temporary performance spaces, and attending audiences eventually disband. In societies that do not support plaza culture style, arts are usually allowed to exist only in closed spaces such as theaters, concert halls, and galleries whose function is predefined. However, it can be argued that the major factor inhibiting street performances is the influence of cultural stereotypes, rather than institutions themselves. A prevailing stereotype underlying the performance paradigm in closed spaces is the presupposition of a sequestration of the senses to allow the audience to focus their undisturbed attention on the performance. By contrast, performances in open spaces receive interference from various aural and visual sources, such as passersby and unintended sounds perceived as “noise.” Therefore, the performance must creatively embrace the constraints arising from the circumstances in which it is embedded. The performer is obliged to function within these constraints. We experimented with performances that expose both the dancer and the live coder jointly

to these conditions and set them the task to face together, on the spot, the challenge of creating new performance constraints outside the box of predefined computer-music performance settings (see Figure 40.6).

Fig. 40.6 Street performance with M5Stick and portable Wi-Fi system. Photo by authors.

Such a performance setting served as testing ground for working with one more IMU system. We used M5Stick, a thumb-sized off-the shelf sensor by M5Stack, equipped with gyroscope and accelerometer sensors. This uses ESP-based Wi-Fi. To make our system mobile, we employed a compact USB-powered Wi-Fi router by TP-Link (TL-WR802N Wi-Fi Nano) (see Figure 40.7). Sound was generated by SuperCollider on a laptop and rendered via battery-powered speakers. This gave us full self-sufficiency and mobility. The internet connection was hard coded in Arduino on the M5Stick, rendering connection immediate and automatic. This system served well in various outdoor urban locations. We recorded gyroscope and accelerometer data for comparison with that of other systems.

Fig. 40.7 Mobile system with M5Stick and mini-Wi-Fi router. Photo by authors.

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META-XENAKIS: SUSTAINABLE RESOURCES

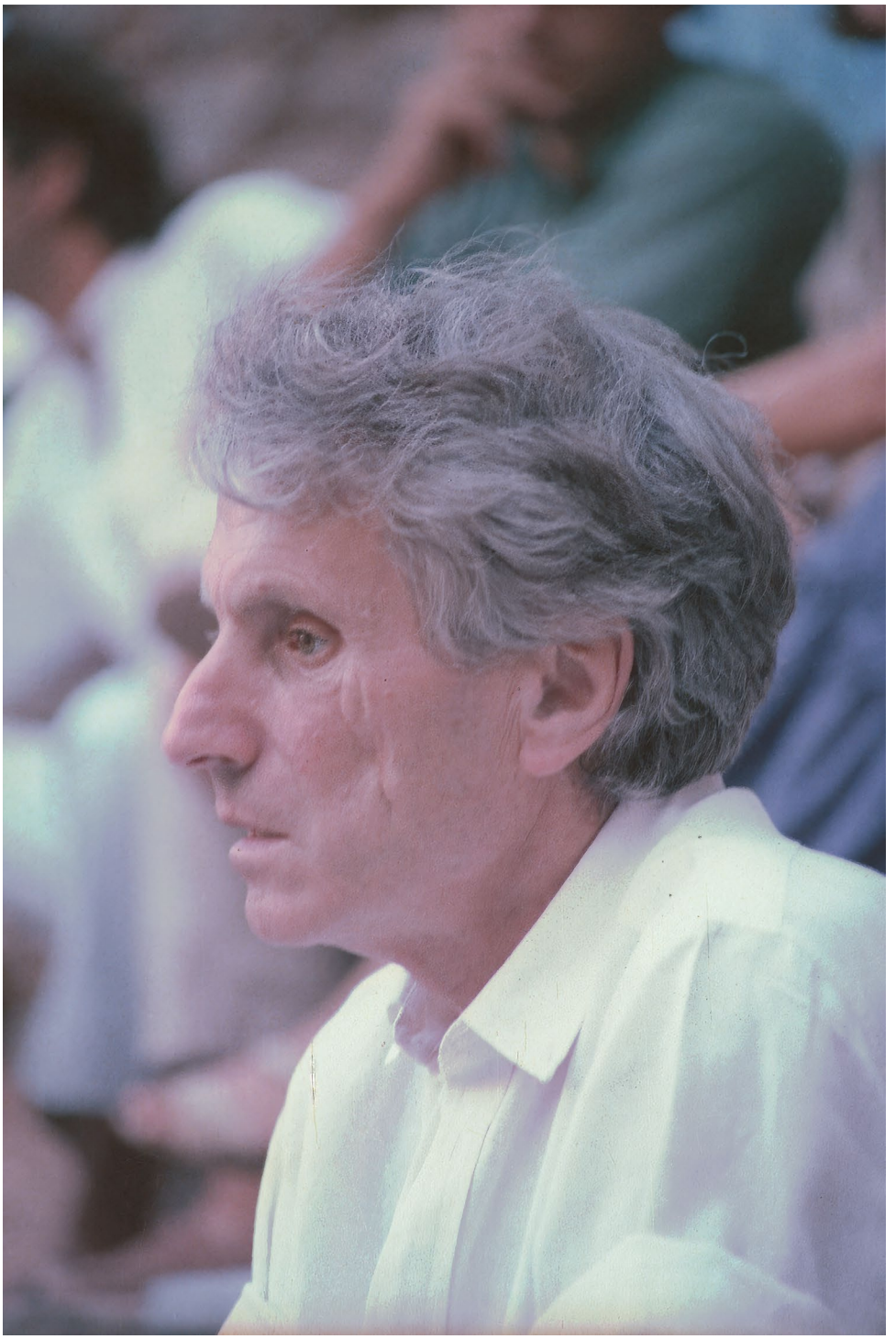

Plate 11 Iannis Xenakis attending an open-air concert of his music at the Ancient Theater in Delphi, Greece, Summer 1985, as part of the Centre Acanthes monographic focus. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

41. The Xenakis Networked Performance Marathon 2022 (Sustainable Resources)

Iannis Zannos, Martin Carlé, Vasilis Agiomyrgianakis, Takumi Ikeda, and Hanako Atake

This chapter functions as an appendix to Chapter 40.

Press Release of the XNPM22 Concert[1]

The year 2022 marks the one hundredth anniversary of the birth of the Greek-born pioneer composer and thinker Iannis Xenakis, and is accompanied worldwide by events dedicated to his memory and work. To honor this Greek-born musician, a marathon concert will take place at Athens Conservatoire, on Saturday, 17 December 2022, presenting works inspired by his musical work and his reflections on science and technology, and the role of music in society and the arts. This event, will take place at the Athens Conservatoire from 7:00 PM until 3:30 AM the following day, featuring musicians and artists from ten different countries (Greece, Italy, Germany, Turkey, Japan, Mexico, England, Ireland, Germany, Turkey, United States). The artists will perform the works remotely from their countries with simultaneous participation of other artists on site and elsewhere, connected via internet. This concert is a tribute to the visionary research of Iannis Xenakis and his efforts to push the boundaries of technology and artistic creation. It highlights the potential of technology to support international collaboration in artistic creation, to create works that are performed live in multiple venues simultaneously regardless of distance, using new experimental media that allow for direct communication and exchange of musical data. In addition, with some of the central works presented, the concert is a tribute to Xenakis's vision of international collaboration among young people to overcome the "biological struggle between generations unfurling all over the planet," as he wrote about his monumental composition *Kraanerg* (1968–9), choreographed by Roland Petit (1924–2011).[2]

1 The following text was the official public announcement of the marathon.
2 Xenakis quoted in Harley, 2008.

 https://doi.org/10.11647/OBP.0390.43

Piece Descriptions

The following paragraphs are the descriptions of the pieces performed at the marathon, as submitted by the artists.

FeedbackLoopExpansion (20′)

For Pure Data (Pd), synthesizer with feedback and Open Sound Countrol (OSC).

Concept and implementation: Stelios Giannoulakis, Jiannis Papadakis.

"XNPM22 part 01 Stelios Giannoulakis and Jiannis Papadakis Greece FeedbackLoopExpansion 20' HD 720p" (29 Mar 2023), *YouTube*, https://www.youtube.com/watch?v=blTKAdcGrts&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=2

The project as an experiment is part of research into a generalized feedback-based model for structuring variably stable soundscapes and pieces of performative sonic art. The Synthi100 in the studio of the Contemporary Music Research Center (CMRC; ΚΣΥΜΕ) at the Athens Conservatoire will be patched for a generative behavior, the network including a microphone feeding back with the studio speakers. A Pd patch in the studio will manage the synth output and generate real-time analysis data. In the performance space, there will be a laptop with a local feedback network made in Pd, incorporating analysis of the sound of the speakers over a microphone. Audio and data will be transmitted over the internet between the two stations, using OSC and maybe Sonobus or some other audio peer-to-peer solution. The whole feedback system will be tuned to respond to microphone input. This will consider the microphone's position in space, both in physical areas and as part of a performative action: settling down with no input, then getting denser and more complex as it is being exited. The idea is to create, between the studio, the Synthi100, and the performance venue, an intuitively tunable and reactive organic soundscape piece with grains and drones, noise, and harmonic relationships, that can be played.

Kraanerg Variations 1: Polymorphic Universes (15′)

Dance with sensor-controlled sound

Mariannina Simatou

Dance: senior students and members of Corporis Miracula Ensemble: Athina Kolovou, Andrea Michailidi, Vilelmini Kalambratsidou, Giannis Varsos, Dimitra Filippaki, Evgenia Oikonomou, Elektra Smyri, Ioanna Ragia, Katerina Gerali

Choreography: Marianinna Simatou (Athens Conservatoire Professional Dance School Alumna, member of Corporis Miracula Ensemble)

Sound design: Vasilis Agiomyrgianakis

Sensor design and development: Martin Carlé

'XNPM22 Part 02 Mariannina Simatou Greece Kraanerg Variations 1 Polymorphic Universes 1 HD 720p' (29 Mar 2023), *YouTube*, https://www.youtube.com/watch?v=Wzalo_zHhhA&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=3

The music of the sound masses by Iannis Xenakis is embodied in three dimensions, with the movement of the bodies of the universe, the galaxies. Universes are malleable and distinguished by simple, sonic, and architectural structures and patterns, which are approached, intertwined, coexisting, and juxtaposed, creating intense contrasts and dynamic spaces. They compose a visual universe that brings Wassily Kandinsky's (1866–1944) seemingly still and silent work to life and alters spatial sense through alternations of basic colors and shapes and through the sound sculptures born from the bodies, the moving masses. They pass through different atmospheres, sometimes thinner and sometimes denser, affecting the frequency of movement and sounds and creating a surge in the changing patterns, a chaotic delay in the reaction of the points of mass.

Gendy Cloud (8′)

Csound controlled over the web via OSC

Concept and implementation: Serkan Sevilgen

'XNPM22 Part 03 Serkan Sevilgen Turkey HD 720p' (29 Mar 2023), *YouTube*, https://www.youtube.com/watch?v=9etZeH5JHAQ&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=4

This work is heavily inspired by an event that occurred during the Xenakis Centenary Symposium. In front of the building where Xenakis was wounded, participants played a stream of sounds generated by GENDYN with their phones.[3] The idea is to generate a cloud of GENDYN sounds around the audience with multi-spatial setup. I use Csound's "gendy" opcode to build eight instruments whose parameters are determined randomly at different intervals. The performers are assigned for each instrument, and they control the duration of the state with a very simple web-based user interface. If they choose 5 seconds for instrument 1, then the parameters of the "gendy" opcode in instrument 1 will be recalculated every 5 seconds. The durations can be changed freely between 1 and 100 seconds during the performance. The performers can be anywhere, thanks to the web interface. The communication between the web interface

3 @serkansevilgen (24 May 2022), *InstaGram*, https://www.instagram.com/p/Cd9M4beoade/

and Csound will be handled via Remote OSC (a Node.js library written by Serkan Sevilgen to enable hassle-free data and code sharing between computer musicians).

Kraanerg Variations II: Route through Time (30′)

Dance with sensor-controlled sound

Choreography: Marianinna Simatou (Athens Conservatoire Professional Dance School Alumna, member of Corporis Miracula Ensemble)

Sound design: Vasilis Agiomyrgianakis

Sensor design and development: Martin Carlé

Dance: senior students and members of Corporis Miracula: Artemis Strongylaki, Vasia Koutsilianou, Garyfalia Kontrafouri, Irini Dimojianni, Katerina Psaroudaki, Konstantina Kondyli, Maria Bosda, Nefeli Anthidi.

"XNPM22 Part 04 Mariannina Simatou Greece Kraanerg Variations II Route through Time HD 720p" (29 Mar 2023), *YouTube*, https://www.youtube.com/watch?v=KnGXvx3bRTs&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=5

A creature exists in time to serve a specific purpose, to regulate the flow of time, in a laboratory beneath the Earth. It is a moving sound mass that produces sounds, originating from the environment, which it feeds on and absorbs. These sounds are then emitted from the body through the voice and through special extensions—members of its limbs. It moves perpetually in a plane of parabolic hyperbolicity, where each step forward is a subsequent moment in time, during which the frequency of movement and sounds changes. Each stop on the line of time freezes the linear continuity of it and brings to life memories of the molecules that make up the sound creature, in the dilated time of the stop.

Study for a Cosmic City (8′)

Pure Data (control), Max/MSP (Sound) and IanniX (Graphics)

Concept and implementation: Julian Scordato

Performers: Arazzi Laptop Ensemble: Giorgio Klauer (Conservatory of Trieste), Nicola Privato (Iceland University of the Arts, Reykjavík), Julian Scordato (Conservatory of Padova), Giovanni Sparano (Conservatory of Reggio Calabria), Paolo Zavagna (Conservatory of Venezia)

"XNPM22 Part 05 Julian Scordato Italy: Iceland Study for a Cosmic City HD 720p" (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=wkV9Uv-VsVQ&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=6

Study for a Cosmic City is an audiovisual work inspired by a utopian urban planning proposal exposed by Iannis Xenakis in his essay entitled "The Cosmic City" (1965).[4] As an attempt to relate computer graphics to the formalization of sound, the structures that characterize the utopian city are designed using superquadratic curves capable of describing reasonable variations of sound parameters, such as amplitude and pitch. Parameter values extracted from buildings and pathways are sent remotely to an ensemble of electroacoustic performers via OSC messages. Performers are free to map the score data to the variables of their favorite devices and algorithms. The aim is to preserve an autonomous design of digital musical instruments within a common environment based on data sharing. Performative gestures are left to the sensitivity of each musician. In the graphic representation of the score, each building transmits continuous messages relating to the position of a running cursor. Moreover, paths on the ground activate messages at road intersections and define the macro-formal articulation of the score. The graphic project and management of control parameters have been implemented exploiting advanced features of IanniX, (a poly-temporal and multi-formal graphic sequencer based on Xenakis's UPIC) such as recursion, cursor acceleration patterns, and complex curves described by mathematical equations.[5]

Time Warp (12′)

For dancer with wearable motion sensors

Choreography: Marianinna Simatou (Athens Conservatoire Professional Dance School Alumna, member of Corporis Miracula Ensemble)

Sound design: Vasilis Agiomyrgianakis

Dance: Sabina Mouratidou (Athens Conservatoire Professional Dance School Alumna, member of Corporis Miracula Ensemble)

"XNPM22 Part 06 Marianinna Simatou Greece Time Warp HD 720p" (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=aKtMy_E9UZ4&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=7

A creature awakens in a temporal space where the boundaries between memories, dreams, and experiences of the present and the past are confused, in a malleable

4 Xenakis, 2008, p. 136–41.
5 *Iannix*, https://www.iannix.org/en/

space where we find it difficult to perceive whether it is real or imaginary, and which generates an inner struggle. The creature moves in a musical tableau, which disturbs its balance, creating new spaces and places, sometimes immerses itself in it and sometimes seeks to converse, through its own music, with this jumble of living moments, sounds, images, sensations, and tries to bring back with all its senses the memory of experiences and sometimes wishes to share them with us.

Politics I (15′)

For Python, SuperCollider, Ableton Live, Twilio CLI Interface, ngrok CLI Interface, Postgresql, Redis, Processing

Concept and implementation: Eric Lemmon

'XNPM22 Part 07 Eric Lemmon U S A Politics I HD 720p' (29 Mar 2023), *YouTube*, https://www.youtube.com/watch?v=iGrtxuyOB8A&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=8

In Western concert art music, the audience's participation in the presentation of a musical work is traditionally restricted to a staid listening experience within a proscenium setting. *Politics I* aims to overhaul this rigid notion of music-making by breaking down the barriers between composers, performers, and the audience and rendering audible the politics of aesthetic preference that exists within participatory music settings. In this new computer music system, audience members submit a text, the text is processed by the system, and then depending on the movement, this textual "action" impacts the music generated by the system in specific ways. Drawing on insights from musical semiology and political theory, I argue that this setting allows audience members to recognize the possible sonic effects of their own inputs and make choices that impact the aesthetic experience in real time. In effect, composer and audience determine the shape of *Politics I* together. Because this participatory setting provides the audience with agency to impact the musical work, the audience's interactions give rise to an internal discourse contained within the domain of the participating individuals and their submitted texts. This discourse, in turn, generates a concert-going, consensus-based public. Within the internal discourse of this public, audience members articulate a politics of aesthetic preference, wherein the sonic results that are preferred by more audience members can take precedence within the musical texture of the work.

The resulting politics of aesthetic preference is most easily recognizable through the interplay between groups vying to determine the shape and experience of the musical work, with the groups being generated through either spontaneous mimesis or pre-planned and coordinated action. To systematically analyze these discursive processes within the audience, and their potential to effect change within the music, the computer music system behind *Politics I* parses text messages submitted by the

audience through an array of natural language processing (NLP) techniques in Python. In SuperCollider, it then sonifies the analyzed content of the input messages while simultaneously displaying them visually. The system is customized to generate music such that distinct code-bases act as individual movements of a complete piece. *Politics I* has three distinct movements: "Digital Discourse," "Cybernetic Republic," and "Technoautocracy." Each of these movements serves as an analogy to a particular political system, with the purpose of musically representing how systemic structures influence political decision-making but can also be subverted through coordinated action.

Telluric Oscillation (5′)

For SuperCollider with live coding

Concept and implementation: Eduardo García

'XNPM22 Part 08 Eduardo García Mexico Telluric Oscillation HD 720p HD 720p' (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=jNhntqRzwM4&list=
PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=9

Piece created by sonification of data from earthquakes registered in Mexico from 1970 to 2020 by the Servicio Sismologico Nacional (National Seismological Service) of UNAM (Universidad Nacional Autónoma de México). The piece suggests that the measured forms of these natural disasters resemble those of stochastic models, and communicates this hypothesis through sound.

Sarcophagus (35′)

Dance with wearable motion sensors

Choreography: Danae Papadopoulou (Graduate of the Professional Dance School of Athens Conservatoire and member of Corporis Miracula Ensemble)

Assistant choreographer: Garifalia Kontrafouri (Senior at the Professional Dance School of Athens Conservatoire and member of Corporis Miracula Ensemble)

Sound design: Vasilis Agiomyrgianakis

Sensor design and development: Martin Carlé

Dance: Seniors at the Professional Dance School of Athens Conservatoire and members of Corporis Miracula Ensemble: Vasia Koutsilianou, Dimitra Filippaki, Marianinna Simatou, Viki Rondogianni, Evdokia Tzari, Sabina Mouratidou

'XNPM22 Part 09 Danae Papadopoulou Greece Sarcophagus HD 720p' (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=IyuETRA0uWU&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=10

The work *Sarcophagus*, choreographed by Danae Papadopoulou, aims to express through movement a fundamental situation in today's society, in which everyday life and friction within society devours human flesh. This work investigates the relationship between "man and society." Man appears as a part of the whole, a small but necessary part of a fractal. We are talking about an interactive relationship in which criticism, reward, punishment, acceptance and rejection are integral features and the causes of its erosion. The word "flesh," which is the first part of the compound word "sarcophagus," is used metaphorically in an attempt to approximate the process of decomposition of the human body (and soul?). Not in a superficial, temporary way, in which case we would probably use the word "skin," but referring to an in-depth, irreversible decomposition. The group that appears in the work seems to create a new language in its need to communicate the things that result from this slow-moving collapse. Through communication they create relationships and form a cohesive group, which forms a society. Each molecule of this group can express its inner world to others and free itself. Originating from primordial instincts, the language created by the creatures in the play arises from sounds that are inarticulate to us, but understandable to the group. The way these sounds are created is through the creatures' impulse in direct relation to "what their movement sounds like," but also through some form of randomness. Iannis Xenakis's revolutionary "contemplative music" and "music of sound masses" through mass *glissandi*, creates a sense of perpetual movement of huge masses. As he says in his book, he was inspired by mass phenomena such as the demonstrations he experienced as a resistance fighter:

> Everyone has observed the sound phenomenon of a crowd of hundreds or thousands of people at a political demonstration. The human river shouts a slogan in a uniform rhythm. Then another slogan starts at the head of the demonstration and spreads to the tail, replacing the first. [6]

In exactly the same way, these unarticulated sounds (language) are created by the group. The interplay of this music, varied through the sensors in response to the dancers' movements, combined with the peculiar language created by these archaic beings in the work *Sarcophagus*, could possibly lead to a very powerful audiovisual performance.

6 Xenakis, 1992, p. 9.

Sieve Algebra Study for Groups of Unknown Size (15′)

Networked live coding on SuperCollider

Concept and Implementation: Juliane Blum, Sebastian Fecke-Diaz, Dennis Scheiba, Julian Rohrhuber (Algebra Ensemble, Robert Schumann Music University Dusseldorf).

'XNPM22 Part 10 J. Blum, S. Fecke-Diaz, D. Scheiba, J. Rohrhuber (Germany) Sieve Algebra' (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=YfgUC4eJTIs&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=11

At the crossroads of time and frequency, this piece departs from the sensitivity of composite formulas and follows the compass of Xenakis's sieve algebras into a combinatory logic of sound.

Heartland (5′)

For dancer and SuperCollider controlled by wearable EKG sensor

Concept, sensor interface, dance: Vilelmini Kalabratsidou (Athens Conservatoire Professional Dance School, graduation year, Athena Research Center)

Choreography consultant: Iris Fousteri

Dramaturgy Consultant: Garyfalia Kontrafouri

Programming and data sonification: Iannis Zannos

Research consultant: Katerina Elraheb (Athena Research Center)

"XNPM22 Part 11 Vilelmini Kalabratsidou Greece Transparent Heart HD 720p" (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=o5nkPPv_8Y0&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=12

Heartland is a land where the rhythm of music is not determined by a fixed metronome but by a vital organ that changes and adapts to the needs of the body movement. Here, the heartbeat augments in the world of dance and, along with live percussion instruments, it creates music. The question is, does the rhythm of the music determine the movement or does the movement affect the heart and therefore the music?

Brain Dead Ensemble: BDE (30′)

Live performance with networked audio feedback

Performers, members of the Brain Dead Ensemble: Alice Eldridge (feedback cello), Chris Kiefer (feedback cello), Thor Magnusson (Threnoscope)

"XNPM22 Part 12 Brain Dead Ensemble BDE UK, Iceland HD 720p" (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=K7wkz8yOtjI&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=13

The Brain Dead Ensemble are an acoustically networked feedback quartet/assemblage in which the structural, acoustic feedback pathways within and between "open" instruments create a fundamentally distributed musical agency. The current ensemble consists of two feedback cellos, a feedback bass, and a Threnoscope, acoustically coupled to form a multi-instrument, multi-channel system—an expanded music interface. The feedback cellos and bass are electro-acoustic-digital resonator instruments. Each instrument has pickups under each of its strings, and one or more transducers built into the acoustic instrument body, inducing electromagnetically-controlled feedback which can be subject to digital processing. The classical model of a bowed instrument is inverted: the player no longer controls and excites the strings to produce sound, but negotiates with an ongoing, lively, self-resonating instrument. The Threnoscope is a software system created by ixi audio for drones, live coding and microtonal, spatialized composition. All the instruments are networked acoustically: the seven channels of the Threnoscope are diffused to a quadraphonic PA plus the integral speakers of the string instruments. The acoustic result of these feedback processes is characterized by a variety of sonic colors including airy microtonal micro-melodies, serene yet colorful drones, complex spectral gestures, and vast explosions surfacing gradually or unpredictably into screams. Performances are improvised; an emergent, negotiated form of performance which involves the steering and shaping of evolving, distributed, sonic energies rather than the instigation and exchange of discrete musical ideas. No one is in control, although everyone is playing.

Acts for Hacks (20′)

For conductive paint, custom-made sensors, Raspberry Pi, SuperCollider

Composition and performance: Vasilis Agiomyrgianakis (Ionian University), Haruka Hirayama (Hokkaido Information University)

Acting: Konomi Kaneko (Drama theater DOMO)

Technical Support: Yuto Fukuda (Hokkaido Information University)

"XNPM22 Part 13 Vasilis Agiomyrgianakis Greece, Haruka Hirayama Japan Acts for hacks HD 720p" (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=9JGm1oQOcVo&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=14

Acts for Hacks is an interactive-telematic performance which combines traditional art such as painting and acting with computer music (real-time sound synthesis and manipulation) and electronics (microcomputers and sensing technology) suggesting new relations between senses, subjects and technologies.

Duel Revisited (15′)

Python, SuperCollider

Concept and Implementation: Stefano Kalonaris

Coding for Networked Implementation: Iannis Zannos

Live Coding: Iannis Zannos, Georgios Diapoulis

XNPM22 Part 14 Stefano Kalonaris (Japan) Duel Revisited HD 720p" (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=dWEIZWcJ_Oc&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=16

Duel (1959) is based on a finite zero-sum game and it is the earliest of three pieces that Iannis Xenakis composed inspired by game theory, the other two being *Stratégie* (1962) and *Linaia-Agon* (1972). *Duel* stylizes a conflict between two conductors who direct their respective orchestras in the execution of musical scores (events). Conductors choose which event to play conditioned upon the choice of the other conductor and on the payoff value that the resulting strategy tuple yields according to a game matrix designed by Xenakis.

In this revisited version of Xenakis's piece, the conductors are modeled computationally by means of probabilistic automata that can choose according to different rational strategies viable from a game-theoretical viewpoint. However, they also possess some subversive states that simulate aesthetic preference and attitude, allowing for less obvious solutions (albeit numerically sub-optimal). Performed by orchestras in the original piece, the musical scores/events are instead, in this implementation of the piece, rendered via means of a popular audio synthesis programming language, by interpreting the instructions regarding the events' musical content given by Xenakis in *Formalized Music*.[7]

7 Xenakis, 1992, p. 113–30.

hipercuboLab LiveSet (5′)

For SuperCollider and TouchDesigner

Sound design and live coding: Michel Soto

Graphics: Aidé Aspicit

"XNPM22 Part 15 Michel Soto and Aidé Aspicit Mexico hipercuboLab LiveSet HD 720p" (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=FjqB6sRHaEc&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=16

hipercuboLab LiveSet is an algorithmic system inspired by mathematical techniques described by Iannis Xenakis in his book *Formalized Music*.[8] A 3D environment is controlled in real time by the live-coded changes made in the generative musical system. Markov chains, weighted random systems, machine learning processes, 3D geometry and real time animation are controlled using SuperCollider and TouchDesigner.

Sound Ping-Pong (5′)

Smartphones and SuperCollider

Concept: Hidehiro Fujiwara

Implementation support: Iannis Zannos

Sound design and live coding: Hidehiro Fujiwara and Iannis Zannos

"XNPM22 Part 16 Hidehiro Fujiwara Japan Sound Ping Pong" (29 Mar 2023), *YouTube*,
https://www.youtube.com/watch?v=er2cNDlU0Sw&list=PL1yHvCYr9BvbSJyrNX3cdY2xwt3CHM9Bb&index=17

Sound Ping-Pong is a telematic, participatory sound installation work using a computer and smartphones, where information from the smartphones' sensors is sent to the computer via OSC communication, and sounds are generated by the music programming software SuperCollider.

- Player 1's sound is output from the L speaker.
- Player 2's sound is output from the R speaker.
- A smartphone (iPhone or Android) is used as a table tennis racket and music is created by answering each other's ball-sound to continue the rally.

8 Xenakis, 1992.

- The players can be anywhere in the world. Their movements are transmitted over the internet regardless of the distance.
- Instead of competing to win or lose, the players work together to weave together a piece of music, which they can then enjoy together after playing.

References

HARLEY, James (2008), *Xenakis Edition 8-Kraanerg*, Liner notes, CD (mode 196), New York, Mode Records.

XENAKIS, Iannis (1992), *Formalized Music: Thought and Mathematics in Music*, additional material compiled and edited by Sharon Kanach (rev. ed.), Stuyvesant, New York, Pendragon.

XENAKIS, Iannis (2008), *Music and Architecture: Architectural Projects, Texts, and Realizations*, compilation, translation, and commentary by Sharon Kanach, Hillsdale, New York, Pendragon.

42. Japanese Society for Electronic Music (JSEM) Concert—A Tribute Celebrating Iannis Xenakis's Centennial

Mikako Mizuno

On 9 December 2022, a monumental year for the Japanese Society of Electronic Music (JSEM), marking our thirtieth anniversary, a concert at the Shibuya Densyo Hall in Japan featured an opening lecture by Takehito Shimazu, the diffusion of the eight prize-winning pieces of the First UPISketch Competition,[1] and the world premieres of five new pieces composed by JSEM composers and dedicated to Iannis Xenakis. The five new pieces composed by JSEM composers, dedicated to Xenakis, are embedded below.

Media 42.1 Kyohei Hayashi, *Galactic Blood* (fixed audio-visual), 2022. Reproduced with permission from the composer.
https://hdl.handle.net/20.500.12434/f5230631

Media 42.2 Masafumi Oda, *Vertigo* (fixed audio-visual), 2022. Reproduced with permission from the composer.
https://hdl.handle.net/20.500.12434/8677c154

1 "Open Calls," *Meta-Xenakis*, https://meta-xenakis.org/open-calls/#upisketch

https://doi.org/10.11647/OBP.0390.44

Media 42.3 Osamu Kadowaki, *measure space X* (fixed audio), 2022. Reproduced with permission from the composer.
https://hdl.handle.net/20.500.12434/705ec08f

Media 42.4 Satoshi Fukushima: *uncountable structures I* (fixed audio), 2022. Reproduced with permission from the composer.
https://hdl.handle.net/20.500.12434/918568c1

Media 42.5 Mikako Mizuno, *Rosehip Surface* (fixed audio), 2022. Reproduced with permission from the composer.
https://hdl.handle.net/20.500.12434/eeeb65aa

Fig. 42.1 Program of 9 December 2022. JSEM concert dedicated to Xenakis.[2]

2 "About JSEM" (2011), *Japanese Society for Electronic Music*, https://jsem.sakura.ne.jp

43. Meta-Xenakis Concert at Suntory Hall, Tokyo

Kuniko Kato

As a part of the Meta-Xenakis Consortium's centennial celebration of the life and works of Iannis Xenakis, Kuniko Kato and ARTSWORKS presented the following concert at Suntory Hall, Tokyo, Japan on Friday 11 November 2022.

Music by Iannis Xenakis

Rebonds A & B (1987–89)
Kuniko Kato, Solo Percussion

Hibiki Hana Ma (1969)
Yuji Sagae, Sound Design

Sound Installation – Improvisation
Kuniko Kato, Percussion

Psappha (1975)
Kuniko Kato, Solo Percussion

Intermission

Post Performance Talk
Tadashi Yamanouchi・Mikako Mizuno・Kuniko Kato

The concert was co-sponsored by the Meta Xenakis Consortium, Centre Iannis Xenakis, Japan Society for Contemporary Music, The Embassy of Greece in Japan.

The concert footage was filmed by TV MAN UNION.

https://doi.org/10.11647/OBP.0390.45

Media 43.1 Recording of a concert given by Kuniko Kato (percussion) at Suntory Hall, Tokyo, Japan on Friday 11 November 2022 (1 hour 39 minutes).
https://hdl.handle.net/20.500.12434/fd27c5e9

44. The Establishment of the CMRC—KSYME in Athens: A Virtual Exhibit

Nickos Harizanos, Katerina Tsioukra, and Dana Papachristou[1]

The Contemporary Music Research Center (CMRC)—Κέντρο Σύγχρονης Μουσικής Έρευνας (KSYME) was founded in 1979 by Iannis Xenakis, John G. Papaioannou (1915–2000),[2] and Stephanos Vassileiadis (1933–2004)[3] in Athens. The fundamental goals behind the creation of the Center were the research and the development of electroacoustic music in Greece, with pioneering musical equipment such as Xenakis's UPIC (Unité Polyagogique et Informatique de CEMAMu (Centre d'Études de Mathématique et Automatique Musicales)). Obtaining sufficient financial resources to finance these goals took seven years and the Center was officially inaugurated in 1985, the same year as the founding of Les Ateliers UPIC by Xenakis in France.[4] KSYME has been and remains active in the musical, cultural, and scientific life of Greece.

Virtual Exhibition

The following virtual exhibition shows the genesis of the founding of KSYME and showcases many photographs, images, and other important documents from our archives in Athens: https://ksyme.omeka.net/exhibits/show/the-establishment-of-the-cmrc-

1 Thanks also to Costas Mantzoros for his invaluable input.

2 John G. Papaioannou, amateur musicologist, professional architect, and city planner.

3 Stephanos Vassileiadis, composer of orchestral and electronic music, pedagogue, choral conductor, and admirer of the many textures and timbres of Greek folk music and Greek Orthodox chant.

4 Weibel et al., 2020, in general, and in particular, Alain Després's chapter (p. 142–57).

 https://doi.org/10.11647/OBP.0390.46

References

WEIBEL, Peter, BRÜMMER, Ludger, and KANACH, Sharon (eds.) (2020), *From Xenakis's UPIC to Graphic Notation Today*, Berlin, Hatje Kantz, https://zkm.de/en/from-xenakiss-upic-to-graphic-notation-today

45. In Memoriam, Joel Chadabe

Sharon Kanach

The inimitable Joel Chadabe (1938–2021): friend, colleague, proverbial big brother for so many.[1] The one and only person I have ever known who never pronounced the words "no" or "impossible."

In this tribute, we hear from some of the people most touched by you: Bill Blakeney, Mike Kupietz, Lori Freedman, Peter Beyls, Roger Reynolds—in either words or music—or both.[2]

What better occasion to render homage than in the Meta-Xenakis celebration, as Xenakis too would have been right there, had he been able, in recognizing and giving thanks for everything you did to champion his music: from releasing the first CD of his electronic works on your EMF label, to all the concerts and events you organized over the years featuring his work in North America.[3]

When, in 2017, at the Xenakis Project of the Americas, we toyed with the idea of creating an oral history around Xenakis in America, you enthusiastically volunteered to be our "guinea pig" and do a pilot interview, with Olga Touloumi, Laura Cocks, and Anne Lanzilotti.[4] Several significant excerpts from that hour-long interview are rendered public here for the first time, supporting the Chadabe motto: "Our mission is to create a gift of knowledge for future generations."

1 *Joel Chadabe*, https://joelchadabe.net/

2 "William Blakeney," *Discogs*, https://www.discogs.com/artist/918718-William-Blakeney; "Michael Kupietz," *Bandcamp*, https://michaelkupietz.bandcamp.com/; *Lori Freedman*, http://lorifreedman.com/en/accueil; *Peter Beyls*, https://www.peterbeyls.net/; *Roger Reynolds*, https://www.rogerreynolds.com/

3 Xenakis, *Electronic Music*, New York, EMF CD 003, 1997, https://www.discogs.com/release/154491-Xenakis-Electronic-Music

4 "Xenakis Project of the Americas," *Brook Center*, https://brookcenter.gc.cuny.edu/projects/xenakis-project-of-the-americas/; "Olga Touloumi," *Bard*, https://www.bard.edu/faculty/details/?id=3650; *Laura Cocks*, http://www.lauracocks.biz/about; *Leilehua Lanzilotti*, http://leilehualanzilotti.com/

https://doi.org/10.11647/OBP.0390.47

Media 45.1 *In Memoriam Joel Chadabe*. Video by Sharon Kanach and Daniel Teige. © 2022 Xenakis Project of the Americas (XPA) (46 minutes).
https://hdl.handle.net/20.500.12434/5d01db28

46. A New Documentary: *Iannis Xenakis: Music of the Universe*

Apostolos Loufopoulos, Renata Dalianoudi, Iakovos Panagopoulos, and Hari Marini

About Iannis Xenakis

Xenakis's identity as an architect made him approach musical composition in an architectural way: he could see both the big picture and the details at the same time, something contrary to the terms of composing according to the classical musical education, which starts with the simple and reaches, step by step, the most elaborate. The details, however, like melody, had a secondary and rather undefined role within the "sound masses" he created, which moved from absolute order to absolute disorder through mathematical stochastic laws in a continuous or explosive manner. Manos Hadjidakis (1925–1994), an Oscar-winning Greek composer, said about Xenakis in 1966:

> Xenakis had the courage to ignore the music traditions of five hundred years (meaning to ignore music history from the Renaissance onwards) and to reposition himself, with all the power of a genuine Greek spirit, bequeathing us a kind of music, certainly not the one we inherited and got used to. [...] His repositioning of music's essence creates a primitive aural/sound effect, beyond the wise academia of the rules of traditional music. Xenakis is very important because he is the first composer in the history of Greek music who dares to re-exist as a Greek. Some more time is needed to realize his importance so that we, too, get to know, through him, our deepest modern Greek temperament.[1]

About the Documentary

The Department of Audio and Visual Arts of the Ionian University, as a partner of the Meta-Xenakis Consortium, wishes to offer quite an "alternative" documentary on

1 Hadjidakis, 1966.

 https://doi.org/10.11647/OBP.0390.48

Xenakis's work from a new perspective, presenting both the key-happenings in his life (based on archival and ethnographic research), as well as the *meta*-Xenakis impact on contemporary performance and contemporary electroacoustic music inspired both by his life and work.

The documentary *Iannis Xenakis: Music of the Universe*, directed by Dr. Iakovos Panagopoulos, offers a fresh approach to Xenakis's life and work, and contributes to a better understanding of his creative, unconventional, pioneering thinking and composing. Focusing on crucial political and social happenings in Xenakis's life, this documentary—as a condensed study—yields new insight into the composer's attitude and work. Through the ethnographic method of the interview, the interviewees' statements reveal the extent to which social and political events formed Xenakis's personal choices and aesthetics.

Both the performance, devised and directed by Dr. Hari Marini, and the sound design and music, written by Dr. Apostolos Loufopoulos, are works within the work, completely integrated. The modular performance represents in a more creative and impulsive way the three different parts/acts of Xenakis's life as well as the emotional connotations that emerge, with the help of the dense existence of music, while the soundtrack's structure reflects Xenakis's approach of massive sound-clouds and detailed sound entities.

Dr. Renata Dalianoudi
Communication and Promotion Executive
Musicologist, Associate Professor, Ionian University

Director's Statement

Directing a documentary about the life and work of Iannis Xenakis was a great challenge; to be able to capture some important information about his life and approach it from a different angle than the films that have already been made. From the start of the pre-production process, we decided to focus more on his life and less on his work since most of the existent documentaries deal with his music, his architectural background, and the connection between these two. Moreover, I always found his life journey and his connection with politics and history fascinating.

The documentary is divided into three parts/acts that each represent a period of Xenakis's life. The first act deals with his earlier life in Greece, his connection with politics, the *Dekemvriana* (December Days) in 1944, and his injury until his self-exile in France. The second act focuses on his life in Paris, his relationship with other composers, and the atmosphere of the era. The last part deals with his return to Greece after the end of the Colonels' Dictatorship and the performance of his *Polytope de Mycènes* in 1978. All three parts are narrated through interviews by scholars, musicians, researchers, and people close to Xenakis. These interviews are enriched

with archival footage from the Greek National Television and archival photos from KSYME (Contemporary Music Research Center) in Athens.

We decided also to create three "bridges" as transitions between the acts. We created four performance videos; the last three represent each period of Xenakis's life discussed above as a "performance bridge," while the first one is just an introduction to our film and the aesthetic or form of the documentary. These interludes really help us to transition our audience from one period to the next, and also to provide the opportunity to visually underline our own perspective of Xenakis's journey through the years.

Dr. Iakovos Panagopoulos
Director
Assistant Professor, Ionian University

Music and Sound Design

The composition of the music for *Iannis Xenakis: Music of the Universe* constituted another challenge, as it has been an effort to express the historical facts aurally, including emotional content that emerges through this documentation of Iannis Xenakis's life over the three different periods. Music and sound design accompany the narration and tell their own story with sounds and instrumental/electronic arrangements.

The sounding content can be described as a soundtrack for film, utilizing electronic music with a cinematographic character, including special tracks combined with the performance video "bridges," as well as individual sound design elements: micro-forms, deconstructed musical textures, and events used to emphasize visual changes and images of the film, emotions, etc., which arise throughout the narration. The inspiration for the music came from listening to the filmed interviews and decoding their narrations, and thus a number of separate musical tracks were created and mixed in the background. But the main musical body lies within the performance introduction and bridges, where a dense musical atmosphere is heard, serving as a basis for the psychological and kinetic expression of the performer.

The greatest technical challenge was to create "music for the music:" Iannis Xenakis's music is unique and well-known for its characteristics and innovations, but cannot be imitated. The soundtrack structure is inspired by the creative philosophy behind his technique, especially the idea of contradiction between massive sound-clouds and detailed sound entities/individualities. The use of *glissandi* often expresses a "continuous change" and the combination of instrumental sounds (piano, percussion, classical orchestra electronically transformed) with synthesized sonic content are some of the fundamental characteristics of the soundtrack, influenced by the structuring scope which Xenakis gave to the music world as a compositional legacy. Finally, soundscape composition was utilized to play the role of real-world

sound effects, which are mixed within the sounding content as part of the musical structure, providing it with a more realistic narrative character where needed.

Dr. Apostolos Loufopoulos
Composer/Sound Designer
Associate Professor, Ionian University

Performance-making in *Iannis Xenakis: Music of the Universe*

Devising and directing the performance acts that function as transitional segments between the interviews and archival material in the documentary *Iannis Xenakis: Music of the Universe* was an intriguing undertaking that allowed for the possibility of experimenting both in terms of content and form. Iannis Xenakis's groundbreaking work in music composition, alongside his commitment to architecture, science, and philosophy, as well as his engagement with politics—especially during devastating periods in history—provoked a broad spectrum of responses and thoughts that were explored artistically. The aim of the performance was not to reconstruct a specific historical period, but to provide an insight into Xenakis's life; to creatively interpret the atmosphere and connotations emerging from significant turning points in his life and career.

The process of making the performance involved research as well as a series of improvisations, writing, and intense physical work with the performer, Vasiliki Makou. The improvisations focused on the imaginative use of objects, the kinaesthetic response in relation to space and music, the development of physical actions and gestures; also, pieces of writing were created and used as prompts for further exploration and personal engagement. During the rehearsals, objects—such as a suitcase, a ladder, a steel drum, a ball of wool, a seashell, marbles, a piece of gauze—and creative writing were introduced and were explored through movement, repetitive actions, durational postures, accidental encounters, in order to encourage experimentation, imaginative associations, and unexpected uses. The performance-making process triggered personal responses and memories that heightened the atmosphere in each act.

The final composition of the performance was shaped by selecting, combining, and developing movement sequences and gestures that echoed aspects of Xenakis's life and were effectively integrated into the music composed for the documentary by Dr. Apostolos Loufopoulos. Given that the performance was devised to be filmed, it was important to consider the use of spatial elements, the movement, the lighting, the focus of performance segments, the shot angles, the rhythm of actions, and the overall aesthetic in collaboration with the director of the documentary, Dr. Iakovos Panagopoulos, and the Black Dogs Production team. As mentioned, each section of the performance functions as a transition between the interviews and archival audiovisual material; it shifts viewers' attention from facts to an imaginative journey created by

the performance and calls for a different engagement. The performance aims to add another layer to the documentary, expanding the viewer's experience by inviting them to immerse in Xenakis's fascinating journey in music and life.

Dr. Hari Marini
Performance Director
Associate Professor, Ionian University

Ιωάννης Ξενάκης: Η Μουσική του Σύμπαντος | *Iannis Xenakis: Music of the Universe*

Please note that the documentary is for educational purposes only and cannot be screened without the permission of the creators

Avarts Webteam, "Ιωάννης Ξενάκης: Η Μουσική του Σύμπαντος | Iannis Xenakis: Music of the Universe" (8 Feb 2024), *YouTube*, https://www.youtube.com/watch?v=4g8SBGFf5aI

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HADJIDAKIS, Manos (1966), "Interview with Renos Apostolidis," *Ta Nea Ellinika*, 1 January 1966, https://diskoryxeion.blogspot.com/2012/01/blog-post_11.html

47. Reportage of a UPISketch Workshop in Japan

Yoshihisa Suzuki

The Meta-Xenakis Japan Team held two UPISketch workshops in 2022. These contributed to the dissemination of Xenakis's concept of the UPIC (Unité Polyagogique et Informatique de CEMAMu) system to young Japanese musicians, as well as to people who are not accustomed to contemporary music. Beforehand, in 2021, in collaboration with Rodolphe Bourotte, the creator of the UPISketch App, one composition class was held at Nagoya City University (NCU). In this class, each student created a short piece using the application. After the class, some students presented their pieces to the other students. Three of the students' pieces were broadcast via YouTube in the online concert Nagoya Electronic Concerts 2021 (NEMC2021).[1]

In the first workshop in 2022, twelve participants presented their pieces based on UPISketch. All the participants were university students studying media art and design. After a presentation of their pieces, they discussed how to manage a workshop for a more general public having no experience in digital music. They created UPISketch user-manual texts in Japanese, based on the UPISketch URL.

The reportage presented here covers our second UPISketch workshop which was held on 29 May 2022, celebrating Xenakis's one hundredth birthday. It was open to high school students and others interested in music as one type of contemporary media art. The workshop comprised an initiation to the application, free time for the participants' creation, and evaluation of the pieces by some of the young composers. Participants were neither professional musicians nor sound designers, but all enjoyed drawing sound; their first experiences composing music!

1 See (in Japanese), from 1:51:44: Yoshihisa SUZUKI, "名古屋電子音響音楽コンサート2021 | NEMC2021" (12 December 2021), *YouTube*, https://www.youtube.com/watch?v=6VAZJp4S8I0

https://doi.org/10.11647/OBP.0390.49

Media 47.1 UPISketch Workshop, 29 May 2022, Nagoya City University. Workshop facilitators: Yoshihisa Suzuki (NUAS), Mikako Mizuno (NCU). Sound Engineers: Kensuke Okano (The Ears), Itsuki Nishimura (The Ears). Workshop Staff: Takuma Osawa (NCU), Ryota Hayashi (NUAS), Mayuko Shimizu (NUAS), Erina Mizoguchi (NUAS), Kodai Ijichi (NUAS), Kento Takahashi (NCU).
https://hdl.handle.net/20.500.12434/dc186204

48. *Polytope XXI*: A Tribute to Iannis Xenakis

Fabrice Marandola, Myriam Boucher, and Dominic Thibault

The Montreal-based Sixtrum percussion sextet presented this *Polytope XXI* concert-tribute on 25 May 2022, at the Salle Claude-Champagne at the Université de Montréal with works by Myriam Boucher, Dominic Thibault, and Iannis Xenakis.

Below is an excerpt of the program notes for this event.

Program

Myriam Boucher and Dominic Thibault | *Polytope XXI* (world premiere).

Presentation

Sixtrum Percussion is pleased to present an exceptional concert in tribute to the composer Iannis Xenakis, whose one hundredth birthday is being celebrated. *Polytope XXI* celebrates this architect, engineer, and composer, who wrote some of the most significant works for percussion of the twentieth century. It is also the name that composers Myriam Boucher and Dominic Thibault have given to their project of a monumental *instrument*, a sort of giant audio-luminous harp, augmented by electroacoustics.

This project was inspired by the first polytope by Xenakis, "an electronic sculpture that combines light, music and structure," which was presented inside the French Pavilion during the Expo '67 World's Fair. The installation took the form of a giant spider web made up of a set of cables installed in the void in the central space of the pavilion, with a multitude of luminous points that appeared and disappeared in accordance with the soundtrack. The project stemmed from a scientific perspective,

 https://doi.org/10.11647/OBP.0390.50

accompanied by an architectural and musical vision: a union of science and art.[1] This re-imagined polytope is made up of large self-supporting structures with luminous cables running through them, a bit like a giant harp around which the percussionists will move to strike, rub, and pluck the cable strings. Integrated microphones that pick up vibrations amplify the sound of the instrument and help control the digital audio effects and the audio-reactive light system.

The second part of the concert will be dedicated to Xenakis's monumental *Pléïades* for six percussionists, which was on the program of Sixtrum's very first concert and which will close the fifteenth season of the Montreal-based ensemble.[2]

Performers

João Catalão

Julien Grégoire

Philip Hornsey

Kristie Ibrahim

Fabrice Marandola

Huizi Wang

Sixtrum Percussion

Since 2007, the Sixtrum Percussion Ensemble has been relentlessly exploring the world of contemporary percussion. With dozens of collaborations with composers and hundreds of concerts, the ensemble has forged a signature in Montreal and on the international scene.

Sixtrum has performed at festivals such as Le Printemps des Arts (Monte Carlo), Présences/Radio France (Paris and Montpellier), Jacob's Pillow Dance Festival (Becket, Massachusetts), PASIC'15 for the opening concert of the Percussive Arts Society International Convention (San Antonio, Texas), and created the *Rythmopolis* event (Montreal), for which it received an Opus Award for the Event of the Year (2018–19). Other awards include the Coup de Coeur de l'Académie Charles-Cros (France) for the CD *De la percussion*, and the "Outstanding Contribution to Theatre" award for the music of the play *Angélique* (Montreal English Theatre Awards).

Sixtrum is in residence at the Faculty of Music of the Université de Montréal and is supported by the Arts Councils of Montreal (Quebec) and of Canada.

This concert event was part of the international program of the Meta-Xenakis Consortium, celebrating the centenary of the composer Xenakis.

1 Xenakis, 2008, p. 203–16.

2 The Xenakis work is not included in this film.

Media 48.1 *Polytope XXI: Hommage à Iannis Xenakis* (2022). Composition: Myriam Boucher and Dominic Thibault. Performers: Sixtrum Percussion. Reproduced with permission. https://hdl.handle.net/20.500.12434/30ba3261

Sixtrum wishes to thank its partners:

Université de Montréal–CAC–CALQ–CAM–CIRMMT–META-XENAKIS

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49. *An Architecture of Alchemy*: A Cinematic Painting

David J. Lieberman

Fig. 49.1 Drawing from "*traces at the edge*." Image by the author (2021).[1]

1 "*traces at the edge*" is a series of sculptural drawings that conceptually and compositionally can be

https://doi.org/10.11647/OBP.0390.51

Architecture is listening …

Architecture is dancing …

Not all architecture can be seen …

As architect, artist, poet, and filmmaker, I identify as an alchemist in asserting that architecture constructs mechanisms by which to transform experience in considering the body as an empathic instrument to apprehend and to understand space. Traditional spatial composition has relied on the surfaces of resistance and reflection; space can be understood as the dissolve, and in the blur of the visual and the aural at the limits of perception and in its tactility. The work of Iannis Xenakis has been the subject of ongoing research and has been an influence on practice for over five decades. Rather than contributing a scholarly presentation in the Japan leg of the Meta-Xenakis Symposium, I proposed a cinematic painting as a personal tribute to Xenakis: *An Architecture of Alchemy*, integrating video excerpts from "*the SPACE between the NOTES*" performance in 2022, itself based on a series of my sculptural drawings "*traces at the edge*" from the previous year, with my voice over reciting personal texts.

An Architecture of Alchemy

Fig. 49.2 Still image from performance of "*the SPACE between the NOTES*," Vienna, 13 June 2022.

understood as choreographic notations for dancers' hour-long performance in response to the music of Iannis Xenakis and poetic texts of the author.

Anatomiesaal Schillerplatz, Vienna, 13 June 2022

Dancers: Andreanne Brosseau, Kaja Piszczek

Video and audio: Paul Bohm, Dila Kirmizitoprak, Stepan Nesterenko

Drawings: *traces at the edge* (2021), David J. Lieberman

Cinematic painting, editor: Martin Riese

Sound recordist: Daniel M. C. Lieberman

Creator, producer, and director: David J. Lieberman

Music: Kuniko Kato plays Iannis Xenakis: *Pléïades: Peaux* (1978), Linn Records, with permission

Fig. 49.3 Photo collage, stills from video of *An Architecture of Alchemy*, image by author (2022).

Media 49.1 *An Architecture of Alchemy: A Cinematic Painting*, Studio of David J. Lieberman Architect, Toronto 2022.
https://hdl.handle.net/20.500.12434/cffbda1e

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LIEBERMAN, David J. (2011), "The SPACE between Notes", in Elena Biserna and Precious Brown (eds.), *Cinema, Architecture, Dispositif*, Pasian di Prato, Campanotto Editore, p. 200–11.

50. The Iranian Context of Iannis Xenakis's *Persepolis*

Aram Yardumian

In this chapter, I will be running through some details to help better understand the premier of Iannis Xenakis's work *Persepolis* (1971). This is also the subject of my recent book, and obviously, there is a lot more detail in the book than I have time for here, but what I can do is to offer a sketch of what can be found in the book.[1]

I want to clear up a popular misconception. A surprising number of books and articles imply that *Persepolis* was premiered at the infamous 2500th anniversary celebration of the founding of the Persian Empire. It was not. It was, in fact, premiered at the 1971 Shiraz Arts Festival, which was held in conjunction with the infamous event, but was a month earlier. The Shiraz Arts Festival was an international festival held between 1967 and 1977 at the initiative of the Empress, Farah Pahlavi. And the idea of this festival was twofold: one, to introduce Iranian audiences to Western music, and also to showcase lesser-known performing artists from within Iran. The Empress sent out emissaries around the country and found musicians and puppeteers and theater artists and referred to this gathering of Iranian unknowns as "an embarrassment of riches." All of this was presented in Iran alongside John Cage (1912–92), Karlheinz Stockhausen (1928–2007), Bruno Maderna (1920–73), playwright Robert Wilson (b. 1941)—some pretty avant-garde material being presented in Iran in the 1960s and 1970s.

Xenakis participated three times at the Shiraz Festivals: first in 1968, with *Nuits* (1967) an a cappella vocal work made up of syllables from Mycenæan, Sumerian, and Persian texts; again in 1969 with *Persephassa* (1969) for six percussionists; and a third time in 1971 with *Persepolis*. In the preface to the *Nuits* score, Xenakis makes an overtly political gesture with his dedication to "disappeared" political prisoners. This was a bold move to make at a time when Iranians who opposed the Shah were routinely being maimed and killed by the secret police. These names, when you research them, yield basically nothing. They were real people, but I think Xenakis chose them not for their being celebrity political prisoners, but precisely because they were obscure people.

1 Yardumian, 2023.

 https://doi.org/10.11647/OBP.0390.52

At the time, opposition to Mohammad Reza Shah (1919–80) was increasing and some five thousand SAVAK (the secret police) agents were out on the streets hunting dissidents and torturing them in secret facilities, as well as acting as media censors. SAVAK had tremendous power and were feared, especially in Tehran. At the same time, bribes were part of the Iranian general economy and the Shah's family made hundreds of millions of dollars each year with money flowing upward. The conditions for revolution were ripening, and ultimately, one of the reasons the Revolution was so successful was that ultraconservative clerics and leftists both opposed the Shah and united, so groups on all sides of the political spectrum, who were otherwise ideological enemies, came together to fight a common enemy—the Shah.

In the eyes of the leftists opposed to the Shah, the Shiraz Festivals and the 2500th anniversary party in 1971 represented the widening gap between rich and poor. For the clerics it represented signs of moral degeneracy. The festivals, it has been argued, contributed something to the final downfall of the Shah. Few were saying such things in public—after all, the Shah and SAVAK controlled the press—but people were saying it.

Despite Xenakis's small, anti-authoritarian gesture in the preface to the score of *Nuits*, he received two more invitations to premier work at the Shiraz Festivals. *Persephassa* in 1969 was held at the Persepolis archaeological site, which had been the ceremonial capital of the Achaemenid Empire. *Persephassa* is a percussion work for six players who are positioned in a hexagonal formation surrounding the audience. I think that is important because it tells us that Xenakis had seen the potential of the landscape, architecture, and acoustic dynamics, and was thinking about what perhaps he could do there if he was invited again.

He received an official invitation from the organizers of the Shiraz Festival to participate a third time, in 1971. That year's events would be different than before, as they would be held on the same year as the 2500th anniversary celebration of the founding of the Persian Empire. Accordingly, the organizers asked Xenakis to develop a *son et lumière* (sound and light show) for premiere at the opening of the 1971 Shiraz Festival and this would be held at Persepolis on the night of 26 August. This time he would expand the range of action out from the site itself into the hillsides and the Naqsh-e Rostam, which is the necropolis where the lineages of Darius and Xerxes are buried. This is part of what would get him into trouble.

Persepolis was certainly the most technically complex sound-assembly process Xenakis had undertaken to date. He began by collecting found sounds, some (but not all) of which he identifies in the sketch plan for the work. We do not know what they all are. They include ceramic wind chimes, a Japanese gong, wind, an airplane ("jet"), timpani rolls, clarinets, strings, and the sounds of cardboard being folded. The rest we cannot identify, but maybe it does not matter because they do not have independent lives since they all blend into the whole of the work. The score for this piece was almost as painstakingly assembled as the work itself. On graph paper, Xenakis carefully pasted measured paper strips representing the sequence of the *objets sonores*, which he called "lambda elements."

1	Jet
2	Strings
3	Clarinet
4	□□
5	Urn (ceramic)
6	"Carton" (i.e., cardboard being folded?)
7	Japanese gongs
8	Wind
9	Timpani rolls
10	Japanese cymbal
11	Ceramic wind chimes

Table 50.1 The ten identified "lambda elements" in *Persepolis* (note that Xenakis "missed" number 4).

The character of some of the elements (e.g. "jet") and their positions were noted on the graph paper. While each always lasted the same length of time, he avoided repetitions by varying the attack point or by using different sections of the same material.

Below is another rendering of the "score." One can see the "lambda elements" arranged in sequence to form the layers of the sound mass.

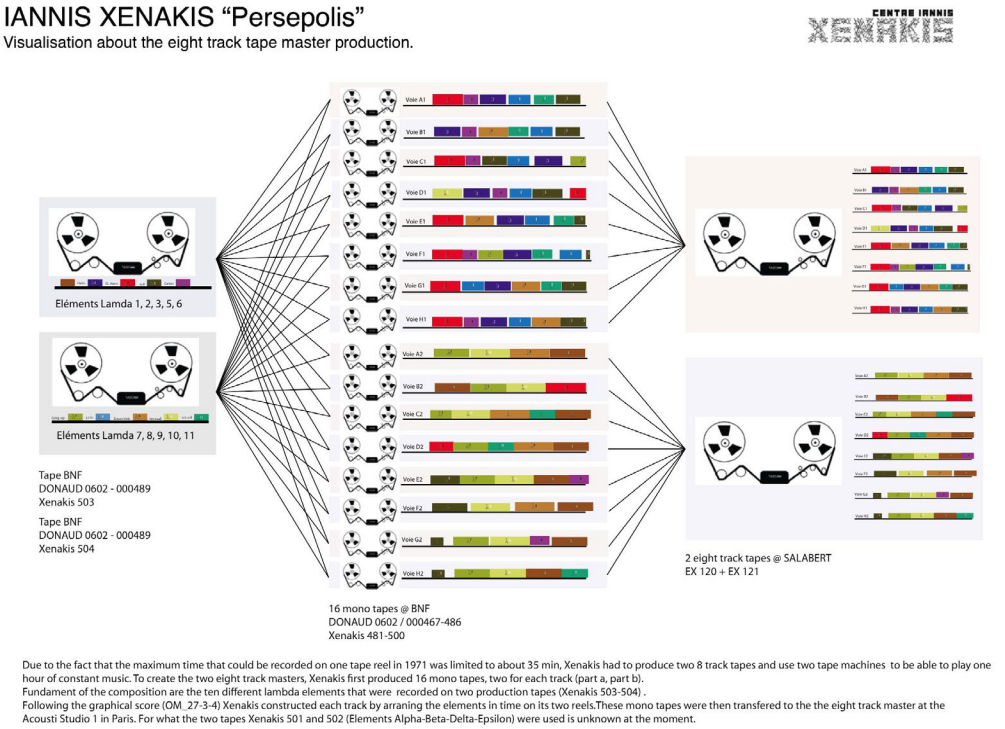

Fig. 50.1 Daniel Teige's rendering of the eight-track tape master of *Persepolis*, composed of the ten "lambda elements." Teige, 2012, reproduced with permission.

In physical rather than conceptual terms:

> This music corresponds to a rock tablet on which hieroglyph or cuneiform messages are engraved in a compact, hermetic way, delivering their secrets only to those who want and know how to read them. The history of Iran, a fragment of the world's history, is thus elliptically and abstractly represented by underground currents of sound.[2]

The event began at 8:00 PM on 26 August. The nearly one-hour *son et lumière* was touched off as Xenakis spooled the first reel of *Persepolis*. There was also a prelude with another of his electroacoustic works, *Diamorphoses* (1957), but the real event touched off with *Persepolis* itself, which was broadcast on fifty-nine multi-channel speakers distributed throughout the six contiguous listening areas in the ruin. In each such "room" either eight or more speakers were distributed. Each set of speakers broadcast one track of the eight-track recording of *Persepolis* to a standing audience. As the music began, the hillsides above the ruin were engulfed in light. Two gigantic gasoline bonfires were ignited at the Naqsh-e Rostam necropolis, with additional light from battery-powered car headlamps, pointed skyward, and from red laser beams sweeping across the ruins. Then several groups of Shiraz schoolboys, about one hundred and thirty in all, gathered with torches at the base of the hillside. In view of the listening audience, they climbed to the summit of the hill, in the direction of the fires, and stood, forming an outline of light between the crest and the sky. A Franco-Swiss documentary film on Xenakis by Pierre Andrégui, released also in 1971, includes footage of parts of the event.[3] Below is a still from that film of the schoolchildren carrying torches up the hill in the dark.

Fig. 50.2 Still from P. Andrégui's film *Xenakis* (1971) of torch-bearing schoolchildren from Shiraz spelling out "We Bear the Light of the Earth" in Persian during the Persepolis Polytope, 26 August 1971.

2 Program booklet for *Persepolis* cited in Xenakis, 2008, p. 221–2.
3 Andrégui, 1971.

Response to the Shiraz Festivals in general and to *Persepolis* in particular is important here. Newspaper articles following the event mostly described it in negative or ambivalent terms. Amir Taheri's 28 August review in *Kayhan* is one example of this, but there were several others.[4] This one was interesting because it mentions the placement of the bonfires at the Naqsh-e Rostam, which is reputed to have been the place where Alexander's troops entered Persepolis to complete their conquest of the Persian Empire. And thus, according to him, here comes another Greek to burn down Persia!

This theme was also taken up at a contentious roundtable discussion with students a few days after the event. Xenakis and his supporters tried to explain that the fire and lights represented the Zoroastrian values of eternal life and the triumph of good over evil, and the children themselves represented the carriers of these values into tomorrow—a cry of hope for the future. But one has to wonder how many of those children went on to participate in the Revolution? Others lambasted the music itself, saying it simply could not even be evaluated as good or bad because "its meaning is the one arbitrarily chosen by its maker." Someone else decried this lack of symbolic meaning, saying, "It could have been presented as an homage to a sausage factory."

It did not help that Xenakis, unlike Stockhausen and the others, had a direct connection to the Empress, and thus with the court of the Shah himself. For this reason, Xenakis received some of the most serious criticisms, not from Iranian journalists, but rather from Iranian expats in Paris who had the ability to speak freely in the press. They openly characterized the Shah as an oppressive dictator and abuser of human rights. Persian-French artist Serge Rezvani (b. 1928) published a letter in *Le Monde* on 24 November 1971 in which he asked how Xenakis (and Peter Brooks) could "actively be taking part in the happening of Persepolis and endorse it" when Asadollah Alam (1919–78), the Iranian minister of the Imperial Court, had supposedly publicly declared that "the peasants must even sell their blankets in order for the festivities to take place."[5] It is ironic that *Persepolis* became, if briefly, a symbol for that which Xenakis spent his life fighting against. It must have been painful not just to be generally misunderstood, but to be misperceived as standing for the *opposite* of his beliefs. In 1976, Xenakis officially cut ties with the Iranian regime, citing the political impossibility of continuing, and thus ending the chance of appearing at the next Shiraz Festival, and designing an arts center with funding from the empress.[6]

Among those taking notice of the festival programming was Khomeini. In 1977, while in exile in Najaf, he preached to a crowd of followers, "You do not know what prostitution has begun in Iran. You are not informed: the prostitution which has begun in Iran and was implemented in Shiraz—and they say it is to be implemented in Tehran, too—cannot be retold. Is this the ultimate—or can they go even further—to

4 Taheri, 1971.
5 Rezvani, 1971.
6 For more information on this unrealized Arts Center, see Xenakis, 2008, p. 171 and 173–5.

perform sexual acts among a crowd and under the eyes of the people?" Khomeini is referring here to *Pig, Child, Fire*, an Artaud-inspired play performed by the Squat Theatre, a Hungarian theater company, that featured, in its Iranian iteration, a forced sexual encounter, but without nudity.

By the time revolutionary activity got fully underway, leading to the permanent ousting of the royal family in January 1979, no one was talking about the Shiraz Festivals or the 2500th anniversary anymore. So much had happened in the meantime. But it could be argued that they were fertile ground for the seeds of anger to be sewn.

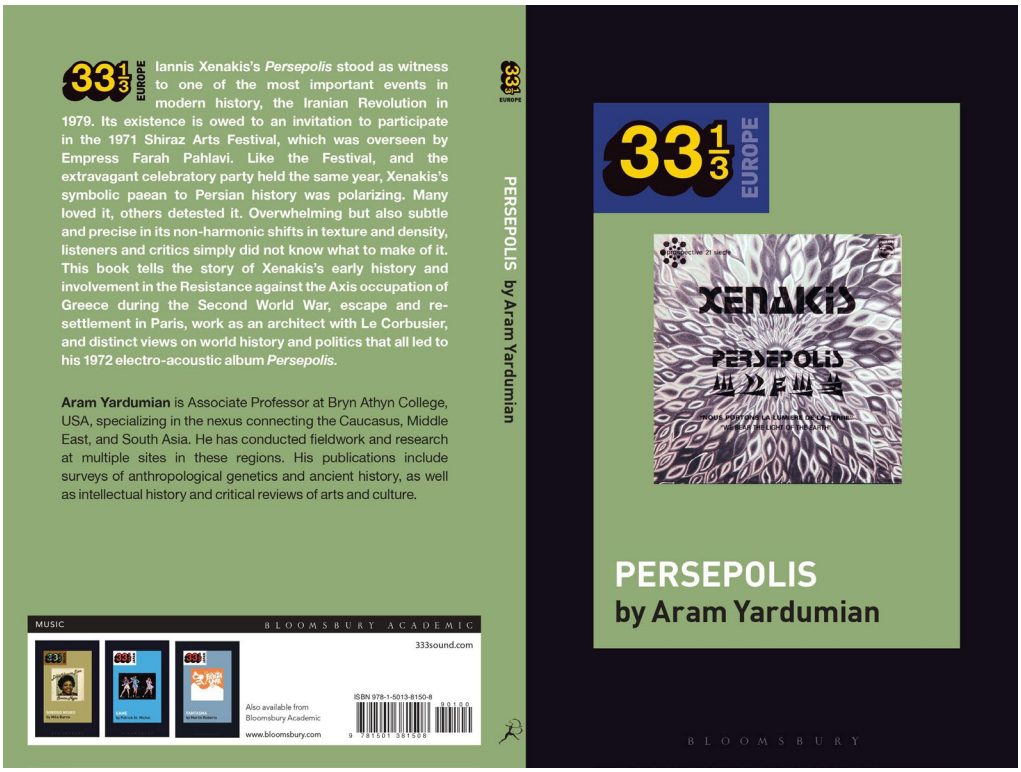

Fig. 50.3 Author's book cover of *Iannis Xenakis's Persepolis* (2023), London, Bloomsbury. CC BY-NC-ND.

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The following is a transcript of the exchange that took place after the presentation of a version of this this paper at the second, Xenakis Project of the Americas (XPA) leg of the Meta-Xenakis Global Symposium Marathon that took place at the William P. Kelly Skylight Room (9th floor), The Graduate Center, the City University of New York (CUNY), 365 Fifth Avenue (at 34th Street), New York City, on 30 September 2022.

Questions

Carey Lovelace: Thank you so much for that. There were so many interesting points you brought up. We did a restaging of this in Los Angeles 2010 and the thing that was so impressive to me that I had never realized about Xenakis's work, even though I had studied with him a little bit and had done these events around his music, was the sheer physicality of the sound.[7] Those 50+ loudspeakers with people wandering through, and it wasn't just a musical or sound experience, it was a primal dip into the history of Greek drama, so I was really surprised when you were talking about the sausage factory. It seemed more assaultive, in a good way, and I was wondering whether there was any commentary about the music itself, which is, more than other things I've heard, gets to this elemental nature.

Aram Yardumian: There were other comments. The way Amir Taheri characterized it in *Kayhan International* was meant to be demeaning but it was also accurate. I don't have the phrasing in my memory now, but he described it as a mass of sound, like jets and wind, and he was correct in that, but he didn't intend for it to be purely descriptive, he intended it to be a takedown. So, there was some description of the sound art itself, yes, but none of it was very positive… which is interesting because Stockhausen had been there. And there were others in the press who came out and said that it was a mistake to have these avant-garde composers at the Festivals because, as they said, we were just beginning to listen to Bach; Stockhausen was impossible.

James Harley: Great to meet you in person! I'm following up on what Carey was talking about. I'm just wondering, with such a huge sound system, and knowing Xenakis is famous for really, really loud playback of his work, and it would have been overwhelming. It's funny that no one was commenting on that. It leads me to wonder whether the reports were written by people who weren't really there?

Aram Yardumian: That's an interesting point. One of the details I was unable to verify for the book is who *was* there. I shouldn't say this if I ever want to visit Iran, but I corresponded briefly with Farah Pahlavi and her secretary and neither she nor he could come up with any names of attendees at the *Persepolis* premier. There's a lot of mixing up of the two events. At the 2500th anniversary party, *everybody* was there. Even Spiro Agnew was there! But nobody really recalls who was present at the *Persepolis* premier. Journalists must have been there. Surely some traveled there. But maybe the reports were also an excuse to be dramatic in print because you couldn't otherwise, in the press, say everything you wanted to say, but you could criticize things in this way and get a certain point across without dragging the Shah and Shahbanu directly into

7 See "Iannis Xenakis' Persepolis L.A.," *Kathryn King Media*, https://www.kathrynkingmedia.com/artist.php?id=2077 and, for some footage of that event, see: Xenakophon, "Xenakis Persepolis Los Angeles" (29 July 2011), YouTube, https://www.youtube.com/watch?v=VeXMMdHAiaQ

it. It was his event, and it was his newspaper.

James Harley: That's the other thing I was going to ask about. It's so tricky in that kind of a context to write anything. In Poland during Soviet times, it was also kind of like that. People developed an ability to write around things and be critical without actually being critical. My sense from what you're reporting is that there was some of that going on in Iran?

Aram Yardumian: I do think there was circuitous criticism of the whole regime. And maybe no one was thinking too carefully about what Xenakis was doing. But you know, there are entire volumes dedicated to just what SAVAK was saying about the Shiraz Festivals. All in Persian. My colleague Houshang Chehabi and I looked carefully, and Stockhausen is mentioned by the secret police but they considered him to be just an idiot, a waste of money, but not threatening in any way. But Xenakis isn't even mentioned! How do you render Xenakis in Persian? That was one problem. We tried every possible way, and we don't think he was ever mentioned in those volumes.

Lauren Roser: Can you tell us more about the recording and mixing process?

Aram Yardumian: I wish I could tell you more about that. Studio Acousti in Paris is out of business. I did reach out to someone who had formerly worked there, but not the owner and not anyone who was there in 1971. Everyone who was there in 1971 is gone. I think we're too late. That studio was quite popular with French folk artists and so on. It was anomalous that Xenakis's *Persepolis* came out of that studio. I think he chose it because of its ability to work with sixteen tracks. Not everybody in 1971 had the ability to do that, maybe not even Pierre Schaeffer. And by then the GRM had probably folded anyway. So, I regret that I can't be more technical about that. At least at the moment.

Carey Lovelace: But didn't Daniel Teige… he remastered the tapes for the version we did. He must have had some contact. What did he say about that?

Aram Yardumian: We know that *Persepolis* had to be recorded on eight tracks on two separate reels. An audio reel lasted about half an hour. So Xenakis had to spool the second reel overlapping the first reel overlapping the first one at the premier. You may have noticed that every version of *Persepolis* runs out at a different timing. One version is a full fourteen minutes different from another! Some of that comes down to versions mastered at the wrong speed, but according to Daniel, who I presume is in the online audience, the version he did allowed for a longer overlap than the recent Karl Records' version, which I think is also pretty good.[8] There is no doubt that more that could be said about how the recording was made but not yet.

8 "IANNIS XENAKIS > 100th Anniversary Box Sets" (22 June 2021), *KarlRecords*, http://www.karlrecords.net/iannis-xenakis-100th-anniversary-box-sets/

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YARDUMIAN, Aram (2023), *Iannis Xenakis's Persepolis*, London, Bloomsbury.

51. *Iannis Xenakis, 1922–2001*

Benny Sluchin

The centennial of Xenakis's birth caught me by surprise. I have many works concerning him, archived for more than forty years already, and it was obvious for me to highlight them through this particular discographic tribute. It contains previously unreleased studio and live recordings accompanied by various texts, many of which are also unreleased to date.

The texts particularly explore the production of Xenakis for Brass: *Eonta* (1964), *Linaia-Agon* (1972), *N'Shima* (1975), *Keren* (1986), and *Zythos* (1997). Personal remarks included in these texts constitute an original contribution. Finally, a kabbalistic analysis of two Hebrew titles of the works included, as well as a text commenting on a work by Sigmund Freud (1856–1939), conclude this tribute. A path that recalls the richness and variety of the composer's theories...

This project is available in two forms:

- CD with a forty-eight-page booklet in French (an English version will soon be available on the publisher's website).[1]
- Book/CD of 116 pages in French.

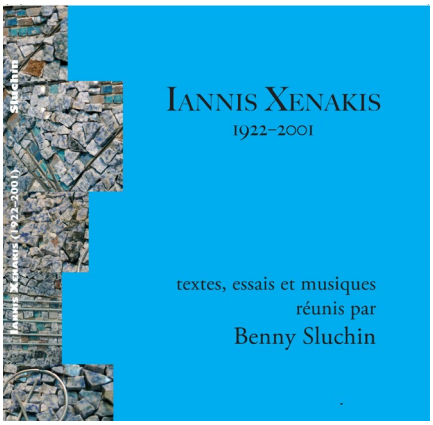

Fig. 51.1a–b *Iannis Xenakis 1922–2000*, book and CD jackets.

1 *Utperformance*, https://www.utperformancecage.com. The book and the CD can be ordered from this website.

https://doi.org/10.11647/OBP.0390.53

Plate 12 Iannis Xenakis en route to the Alliance Française de Glasgow for the celebration of his 65th birthday, Glasgow, 1987. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.

Appendix

The following five sections detail all the Meta-Xenakis events organized by the Consortium.

Events Organized by the Meta-Xenakis Centre Iannis Xenakis (CIX) Team

21 February 2022: Concert: "Tragœdia," Xenakis's *Medea* presented by OCAZEnigma, at Auditorio de Zaragoza (Spain)

15 March 2022: Concert: "Energeia—Hommage à Xenakis" by Ensemble unitedberlin, at the Elbphilahrmonie, Hamburg (Germany)

9 May 2022: Concert: *Oresteïa*, by OCAZEnigma, at Auditorio de Zaragoza (Spain)

9 May–8 June 2022: Exhibition "Xenakis's *Diatope* Seen Through a Visual Artist's Eye, Bruno Rastoin," Maison de l'Université, Université Rouen Normandie (France), https://www.univ-rouen.fr/agenda/le-diatope-de-xenakis-regard-dun-plasticien-bruno-rastoin/ [see also 29 May 2022]

13 May 2022: Lecture: "Presentation of the UPISketch App by its Creator, Rodolphe Bourotte," Maison de l'Université, Université Rouen Normandie (France)

13 May 2022: Guided tour of the exhibition "Xenakis's *Diatope* Seen Through a Visual Artist's Eye, Bruno Rastoin," by Cyrille Delhaye, Maison de l'Université, Université Rouen Normandie (France)

28–30 May 2022: Festival "X3": 28 May: *Kraanerg*; 29 May: chamber music concert of Xenakis; 30 May: *Oresteïa* and post-concert discussion, Berlin (Germany), https://unitedberlin.de/wp-content/uploads/2022/09/2022-05-28-30_programmheft-v3.pdf

29 May 2022: Live online streaming of a documentary of the exhibition organized by the CIX for the global French leg of the Meta-Xenakis "Happy Birthday, Iannis" celebration: "Xenakis's *Diatope* Seen through a Visual Artist's Eye, Bruno Rastoin" [see above: 9–31 May 2022 and Chapter 14 in this volume, including https://www.centre-iannis-xenakis.org/items/show/4982]

18 August 2022: Performance: Xenakis's *Oresteïa*, by Musicatreize, Ensemble unitedberlin, Roland Hayrabedian (conductor), Festival Berlioz, La Côte-Saint-André (France), https://www.musicatreize.org/programmation/oresteia-2/

24 August 2022: Concert: "GAUR! 50th Anniversary ENCUENTROS DE PAMPLONA" Xenakis at the Pamplona Meetings (Spain), https://meta-xenakis.org/events/gaur-50th-anniversary-encuentros-de-pamplona-spain/

9 September 2022: Performance: Xenakis's *Oresteïa*, by Musicatreize, Ensemble unitedberlin, Roland Hayrabedian (conductor), Marseille (France), https://www.musicatreize.org/programmation/oresteia-3/

12 September 2022: Performance: Xenakis's *Oresteïa*, by Musicatreize, Ensemble unitedberlin, Roland Hayrabedian (conductor), Arles (France), https://www.journalventilo.fr/agenda/festivals/110139/la-rentree-des-choeurs

17 September 2022: Concert: "Hommage à Paul Méfano" (former President of the CIX), Le Forum/Maison de l'architecture de Normandie (France)

17 September 2022: Workshop "Dessiner la Musique: Découverte d'UPISketch," Le Forum/Maison de l'architecture de Normandie (France)

29 September 2022: Global Xenakis Centenary Concert: world premieres of the winning entries of the First International UPISketch Competition 2022, Maison de l'Université, Université de Rouen Normandie (France), https://meta-xenakis.org/events/global-xenakis-centenary-concert/

30 September 2022: Launch of the Meta-Xenakis Global Symposium, Maison de l'Université, Université de Rouen Normandie (France), https://webtv.univ-rouen.fr/channels/#meta-xenakis-global-symposium

9 October 2022: Lecture: "Good Things Come in Small Packages When Created by a Giant" by Sharon Kanach, International Pharos Contemporary Music Festival, Nicosia (Cyprus), https://pharosartsfoundation.org/event/sharon-kanach-lecturer/

12 October 2022: Concert: "Celebrating Xenakis" by the Ergon Ensemble, International Pharos Contemporary Music Festival, Nicosia (Cyprus), https://pharosartsfoundation.org/event/ergon-ensemble/

10 November 2022: Concert "Iannis!" by musicians of the Opéra de Rouen (Chapelle Corneille) (France), https://www.operaderouen.fr/programmation/iannis/

18–30 November 2022: Exhibit "Iannis Xenakis et l'UPIC," Conservatoire régional de Rouen (France), http://conservatoirederouen.fr/Agenda-Exposition-Iannis-Xenakis-

et-l-UPIC-1287.htm

19 November 2022: Workshop "Dessiner le son: Découverte d'UPISketch": Conservatoire régional de Rouen (France), http://conservatoirederouen.fr/Agenda-Dessiner-le-son-1306.htm

24 November 2022: Concert "Impact," Conservatoire régional de Rouen (France), http://conservatoirederouen.fr/Agenda-Impact-1290.htm

25 November 2022: Concert/Lecture "Découvrez une œuvre : *Mists* de Xenakis," Christine Marchais (piano) and Pierre Albert Castanet (lecturer), Hôtel de Ville, Rouen (France), http://conservatoirederouen.fr/Agenda-Decouvrez-une-oeuvre-Mists-de-Iannis-Xenakis-1291.htm

2 December 2022: Release of a live recording of Xenakis's *Aroura* by the Orchestre national d'Auvergne, Thomas Zehetmair (conductor) (Référence: 21 Music 082), https://21-music.format.com/orchestrenationaldauvergne

19 April 2023: Inauguration, Installation and Concert "Polytope XIa—An Audiovisual Exploration of Speicher XIa, a New Place for Interdisciplinary Dialogue," Hochschule für Künste, Bremen (Germany), https://polytope-xia.hfk-bremen.de/en.html and https://vimeo.com/813536447

Events Organized by the Meta-Xenakis Xenakis Project of the Americas (XPA) Team

6 May 2022: Concert: "En toute liberté: Tribute to Xenakis and de Pablo," by the NEM, Montreal (Canada), https://lenem.ca/fr/2021-2022/concerts/en-toute-liberte

21 May 2022: Concert "Xenakis Cabaret," by red fish blue fish percussion ensemble, UC-San Diego in the "Transplanted Roots: Percussion Research Symposium" (USA), https://www.transplantedroots.org/2022-schedule

25 May 2022: Concert: "Polytope XXI," by Sixtrum percussion ensemble, Montreal (Canada), https://sixtrum.com/saison-2021-2022/polytope-xxi/] [see Chapter 48 in this volume]

29 May 2022: Video art commissioned by XPA for the global Meta-Xenakis "Happy Birthday, Iannis" celebration: *The Shape of Light* (a visual composition for Xenakis's *Mikka* and *Mikka S*), by Yin Yu (with Conrad Harris, violin) [see Chapter 34 in this volume]

30 September 2022: Second leg of the Meta-Xenakis Global Symposium, Skylight Room, Graduate Center CUNY, New York (USA), https://meta-xenakis.org/symposium/

and https://www.youtube.com/watch?v=w2lTPbfh3e4

21–23 October 2022: Vancouver New Music Festival: "Meta Xenakis," Vancouver, British Columbia (Canada), https://newmusic.org/metaxenakis/

26 October 2022: Concert: "GIRA SIGMA Project in Canada," Cégep Marie-Victorin, Montreal (Canada)

17 March 2023: Workshop and Concert: "Xenakis @ 100," University of Guelph (Canada), https://news.uoguelph.ca/event/xenakis-100/

Events Organized by the Meta-Xenakis Japan Team

18 December 2021: Concert: *Pléïades*: performance by students selected by Kuniko Kato, presented during the YPAM2021 (Yokohama International Performing Arts Meeting) (Japan), https://teket.jp/314/7829

18–20 January 2022: Workshop and concerts "inc. percussion days 2022 in Toyohashi," produced by Kuniko Kato, Toyohashi Arts Theater (Japan), https://www.toyohashi-at.jp/event/performance.php?id=1091

12 March 2022: Concert: « Concert Trio à Cordes de Pointe, » Quartiers Musicaux, Suginami Public Hall (Japan), https://www.suginamikoukaidou.com/event/5794/

12–13 May 2022: Concert "Xenakis and Dance" by Kuniko Kato, Saitama Arts Theater (Japan), https://tokyoartnavi.jp/exhibition/17625/

29 May 2022: Symposium and UPISketch workshop "Draw the Sound, and Architecture Dreams Music" in Mid-Japan Sound Art Festival, Nagoya City University (Japan), https://www.nagoya-cu.ac.jp/sda/media/workshop1.pdf

2 July 2022: Concert: "Izumi Symphonietta the 48th Regular Concert: Splendor of the Intellect; All Xenakis Program", Izumi Hall (Japan), http://iimori-norichika.com/2022-0702-schedule/ and https://ebravo.jp/archives/120542

3 September 2022: Concert: "Ichiro Nodaïra and Arditti Quartet," Concert Hall AOI Shizuoka (Japan), https://www3.aoi.shizuoka-city.or.jp/concert/detail.php?public_uid=2773

26 September 2022: Concert: "Nymphe Art" in Aichi Triennale, Aichi Art Center (Japan), https://aichitriennale.jp/index.html

1 October 2022: Third leg of the Meta-Xenakis Global Symposium, Nagoya City University (Japan), https://www.youtube.com/watch?v=QpVOu5_28Uw

1 October 2022: Concert: "Listening and Transmitting/From Legendary 20th Century

Music to New Works for the Future, vol.17 Xenakis," Kunitachi College of Music (Japan), https://www.kunitachi.ac.jp/event/concert/college/20221001_01.html and https://yakupen.c.blog.ss-blog.jp/_images/blog/_7ff/yakupen/20221001.pdf

11–13 November 2022: Concert: "META XENAKIS" by Kuniko Kato, Suntory Hall Bluerose Auditorium (Japan), https://prtimes.jp/main/html/rd/p/000000003.000100508.html [see also Chapter 8 in this volume]

4 December 2022: Symposium and Concert "Special Concert for the Xenakis Centennial Vol. 2," Tokyo University of Arts (Japan), https://www.pac.geidai.ac.jp/post/xenakis2022

12 December 2022: Concert and Lecture of JSEM (Japanese Society for Electronic Music) Celebration of Xenakis, Shibuya Cultural Center Densyo Hall (Japan), https://jsem.sakura.ne.jp/jsemwp/?p=2046 [see also Chapter 8 in this volume]

Events Organized by the Meta-Xenakis Greek Team

7 April 2022: Lecture: "Iannis Xenakis; Why Was He Important?," by Haris Xanthoudakis (in Greek), Music Library of Greece "Lilian Voudouri" of The Friends of Music Society at the Athens Concert Hall (Greece), https://mmb.org.gr/en/event/meta-xenakis-iannis-xenakis-why-was-he-important and https://www.blod.gr/lectures/giannis-ksenakis-giati-ypirkse-simantikos/

10 April 2022: Concert: Iannis Xenakis: *Pléïades* & *Persephassa*, by Percussions de Strasbourg at the Athens Concert Hall (Greece), https://www.megaron.gr/en/event/les-percussions-de-strasbourg/

29 May 2022: Streamed launch of the teaser of the new Greek documentary film by I. Panagopoulos *Iannis Xenakis: Music of the Universe* for the global Meta-Xenakis "Happy Birthday, Iannis" celebration, https://www.youtube.com/watch?v=6OOe8PxcF9c [see Chapter 46 in this volume]

31 May 2022: Lecture: "Iannis Xenakis and Algorithmic Music," by Bill Manaris (in Greek), Music Library of Greece "Lilian Voudouri" of The Friends of Music Society at the Athens Concert Hall (Greece), https://mmb.org.gr/en/event/meta-xenakis-iannis-xenakis-and-algorithmic-music and https://www.blod.gr/lectures/iannis-ksenakis-kai-algorithmiki-mousiki/ [see Chapter 38 in this volume]

1 June–30 November 2022: Exhibition: "Xenakis3: The Musician, The Mathematician, The Engineer," Music Library of Greece "Lilian Voudouri" of The Friends of Music Society at the Athens Concert Hall (Greece), https://mmb.org.gr/en/event/meta-xenakis-exhibition-xenakis3-musician-mathematician-engineer and https://mmb.org.gr/el/event/ekthesi-xenakis3-o-moysikos-o-mathimatikos-o-mihanikos

28 September 2022: Lecture "The Architecture of Iannis Xenakis" by Panayotis Tournikiotis (in Greek), Music Library of Greece "Lilian Voudouri" of The Friends of Music Society at the Athens Concert Hall (Greece), https://mmb.org.gr/en/event/meta-xenakis-architecture-iannis-xenakis and https://www.blod.gr/lectures/architektoniki-yianni-xenaki/ [see Chapter 23 in this volume]

1 October 2022: Fourth leg of the Meta-Xenakis Global Symposium, KSYME, Ionian University, École française d'Athènes, the Athens Conservatoire (Greece), https://www.youtube.com/watch?v=Tu0BDDwpXJk

14 October 2022: Webinar: "UPISketch Meets Ionian University Students" (exploring its possibilities as a teaching tool in music education) (in English)

16 October 2022: Educational Program: "Iannis Xenakis: Music and Computers" (for ages eight to twelve), in Greek, including a UPISketch Workshop, Music Library of Greece "Lilian Voudouri" of The Friends of Music Society at the Athens Concert Hall (Greece), https://mmb.org.gr/el/event/giota-xi-ix-moysiki-me-ypologisti

6 November 2022: Educational Program/"Iannis Xenakis: Music and Computers" (for ages eight to twelve), in Greek, including a UPISketch Workshop, Music Library of Greece "Lilian Voudouri" of The Friends of Music Society at the Athens Concert Hall (Greece), https://mmb.org.gr/el/event/giota-xi-ix-moysiki-me-ypologisti

17–18 December 2022: Xenakis Networked Performance Marathon (XNPM22), organized by Ionian University, Department of Audio and Visual Arts, online and at the Athens Conservatoire (Greece), https://www.athensconservatoire.gr/μαραθώνιος-δικτυωμένων-μουσικών-εκτ/ [see under Chapter 40 and Chapter 41 in this volume]

Open Call: "Rethinking Xenakis (Re:X) Composition Competition for Ensemble" organized by the Greek Composers' Union (in collaboration with the Friends of Music Society): https://meta-xenakis.org/open-calls/#rethinking

Documentary: *Music of the Universe*, produced by Ionian University, Department of Audio and Visual Arts—Black Dogs Production: Director: Iakovos Panagopoulos, Music: Apostolos Loufopoulos, Performer: Vasiliki Makou, Performance direction: Xari Marini, Additional sound design: Thanasis Epitidios. 103", in Greek and English, subtitled [see Chapter 46 in this volume]

Events Organized by the Meta-Xenakis Mexico Team

16 March 2022: Concert: "Ensamble Cepromusic. X(enakis)100 + 1.0 Aliqua," Xenakis chamber music, Museum Ex-Teresa Arte Actual, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=899:x-

enanos-100-1&Itemid=624&date=2022-03-16-19-00 and https://enfoquenoticias.com.mx/cepromusic-celebra-100-anos-del-compositor-ianis-xenakis-con-una-serie-de-presentaciones/

17 March 2022: Concert: "Ensamble Cepromusic. X(enakis)100 + 1.1 Aliqua," Xenakis chamber music, Los Pinos Cultural Complex, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=900:x-enakis-100-1-1&Itemid=624&date=2022-03-17-14-00 and https://www.mexicoescultura.com/actividad/255198/x-enakis-100-+-11-aliqua.html

1 April 2022: Concert: "Ensamble Cepromusic. X(enakis)100 + 2 Aliqua," Xenakis chamber music, Fine Arts Palace, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=901:x-enakis-100-2&Itemid=624&date=2022-04-01-18-00 and https://musicaenmexico.com.mx/cartelera/ensamble-cepromusic-2/

27 April 2022: Concert: "Ensamble Cepromusic. X(enakis)100 + 3.0 Aliqua," Xenakis chamber music, Museum Laboratorio Arte Alameda, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=902:x-enakis-100-3&Itemid=624&date=2022-04-27-19-30

28 April 2022: Concert: "Ensamble Cepromusic. X(enakis)100 + 3.1 Aliqua," Xenakis chamber music, Los Pinos Cultural Complex, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=903:x-enakis-100-3-1&Itemid=624&date=2022-04-28-14-00

30 April 2022: Concert: "Ensamble Cepromusic. X(enakis)100 PARA NIÑXS," interactive session with UPISketch, app designed by the Centre Iannis Xenakis (France). Session for children guided by Cepromusic musicians, Cepromusic, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=904:x-enakis-100-para-niñxs&Itemid=624&date=2022-04-30-10-30

12–13 and 16 May 2022: Concert: "Ensamble Cepromusic. X(enakis)100 Akádêmos," nine master classes on the work of Iannis Xenakis. José Luis Castillo, director and Cepromusic musicians, Cepromusic, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=905:x-enakis-100-akádêmos&Itemid=624; https://www.youtube.com/watch?v=iN6oeUleZwI&t=15s; https://www.youtube.com/watch?v=SbBvqYf1NOM; https://fb.watch/m9zX3GBoWW/?mibextid=TQoKLE; and https://www.gob.mx/cultura/prensa/canal-22-cierra-el-2022-consolidandose-como-referente-de-la-difusion-de-lo-mejor-del-cine-mexicano

26 May 2022: Concert: "Ensamble Cepromusic. Jose Luis Castillo, conductor. Foco Xenakis 100," Xenakis chamber music (online, streamed) Mexico City (Mexico), https://

cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=907:x-enakis-100-4-1&Itemid=624; https://cultura.unam.mx/evento/29041 and program notes by Magali Palomar: https://musica.unam.mx/uploads/files/Programa_Cepromusic_MAY22_a.pdf

29 May 2022: Concert: "Ensamble Cepromusic. Jose Luis Castillo, conductor. X(enakis)100+4.1 | 100 aniversario," Xenakis chamber music, Biblioteca Vasconcelos, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=907:x-enakis-100-4-1&Itemid=624

29 May 2022: Lecture: "In Memory of Iannis Xenakis" (in Spanish) by Dr. Julio Estrada (online, streamed), celebrating the anniversary of the composer's birth, https://www.facebook.com/SUICREA.UNAM/videos/355215483264868

23 August 2022: Interview: "Entrecruzamientos" radio interview (in Spanish) with José Luis Castillo, director of the Cepromusic Ensamble on the occasion of the centenary of the birth of the Greek composer Iannis Xenakis (online, streamed), Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=908:entrecruzamientos-iannis-xenakis&Itemid=624&date=2022-08-23-17-00 and https://www.youtube.com/watch?v=Twl50TY461A&t=370s

1 October 2022: Final leg of the Meta-Xenakis Global Symposium, Facultad de Música, UNAM, Mexico City (Mexico), https://meta-xenakis.org/symposium/ and https://www.youtube.com/watch?v=lsJNpRzwOYg

5 October 2022: Concert: "X(enakis)100—Electroacústico," by Carlos Iturralde, electronics, resident of Ensamble Cepromusic, Biblioteca Vasconcelos, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=909:x-enakis-100-electroacústico&Itemid=624&date=2022-10-05-18-00

21 October 2022: Lecture: "En torno al vínculo Música-Ciencias Exactas en Iannis Xenakis," by Pablo Araya (in Spanish) (online, streamed), https://www.youtube.com/watch?v=_4eDrseHRYY

27 October 2022: Concert: "X(enakis)100 Orestíada," Ensamble Cepromusic. José Luis Castillo, conductor, 50° Festival Internacional Cervantino, Teatro Juárez, Guanajuato (Mexico).

29 October 2022: Concert: "X(enakis)100 *Orestíada*," Ensamble Cepromusic. José Luis Castillo, conductor, 44° Foro Internacional de Música Nueva Manuel Enríquez, Main Hall, Fine Arts Palace, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=870:orestíada-x-enakis-100&Itemid=624; https://www.cultura.gob.mx/estados/actividades_detalle.php?id=256625; and https://www.gob.mx/cultura/prensa/el-cepromusic-presentara-

la-orestiada-de-iannis-xenakis-en-el-palacio-de-bellas-artes

28 October 2022: Concert: *XAS* for saxophone quartet, by Sigma, Festival Internacional Cervantino, Marfil (Mexico)

27–29 December 2022: Masterclasses: X(enakis)100 Akádêmos, Cepromusic musicians, Cepromusic, Mexico City (Mexico), https://cepromusic.inba.gob.mx/index.php?option=com_icagenda&view=event&id=910:x-enakis-100-akádêmos&Itemid=624

6 June 2023: Special edition of the journal *PILACREMUS*, with the title "Homage to Iannis Xenakis" was released, in which 10 peer-reviewed articles were published in Spanish, including several entries also available in English and revised in this volume, as they were part of the Mexican leg of Meta-Xenakis Global Symposium. It can be consulted at: https://suicrea.sdi.unam.mx/images/revistas/pilacremus_no_6_iannis-xenakis.pdf

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5 Xenakis, 1992, p. 290.

6 The screenshot comes from "Spline Modeling Software Video 4" (10 June 2022), *YouTube*, https://www.youtube.com/watch?v=CMWp3qlqlek

7 Wishart, 1996, p. 187.
8 Julio Estrada, "Théorie De La Composition (I)," in Estrada, 1994.

9 Yin Yu, "Laser Architecture" (19 March 2019), https://w2.mat.ucsb.edu/yinyu/projects/LaserArchitecture.html

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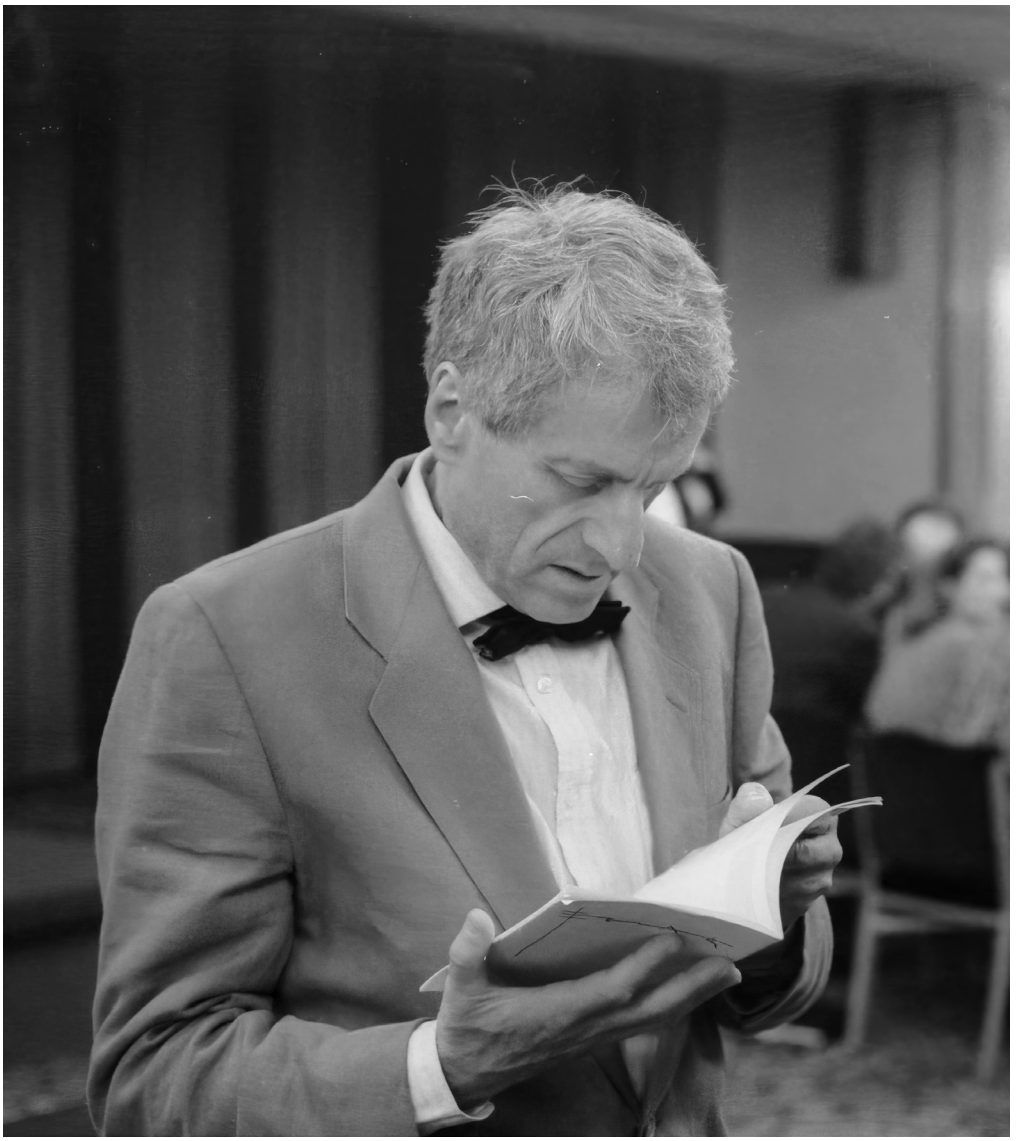

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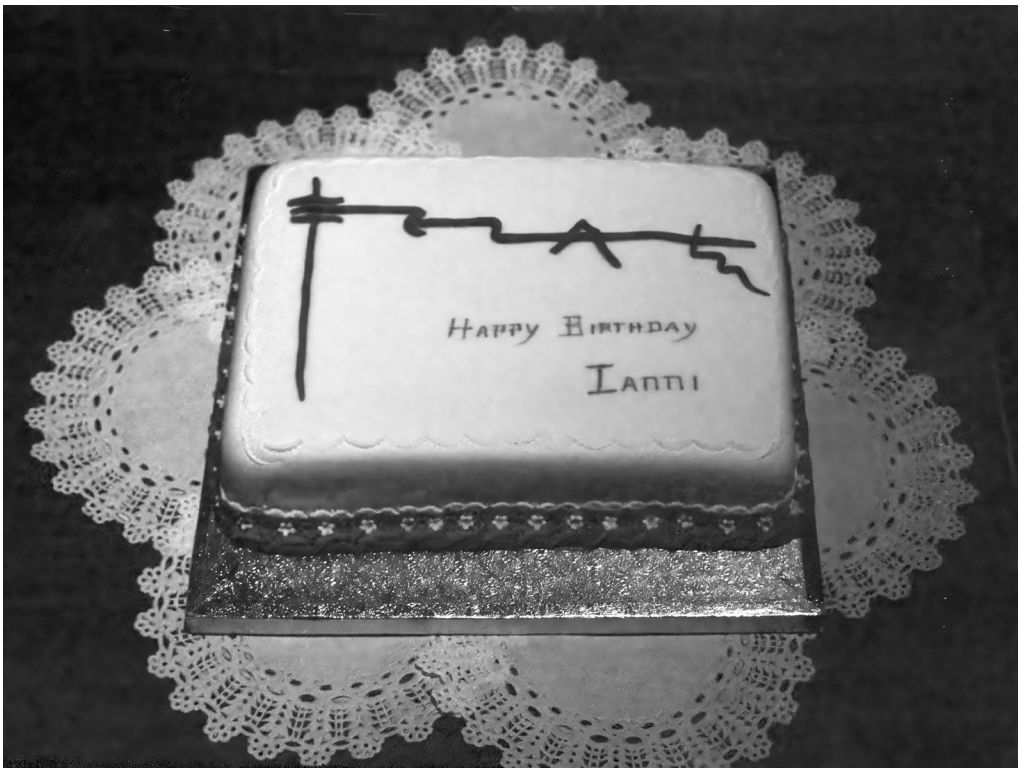

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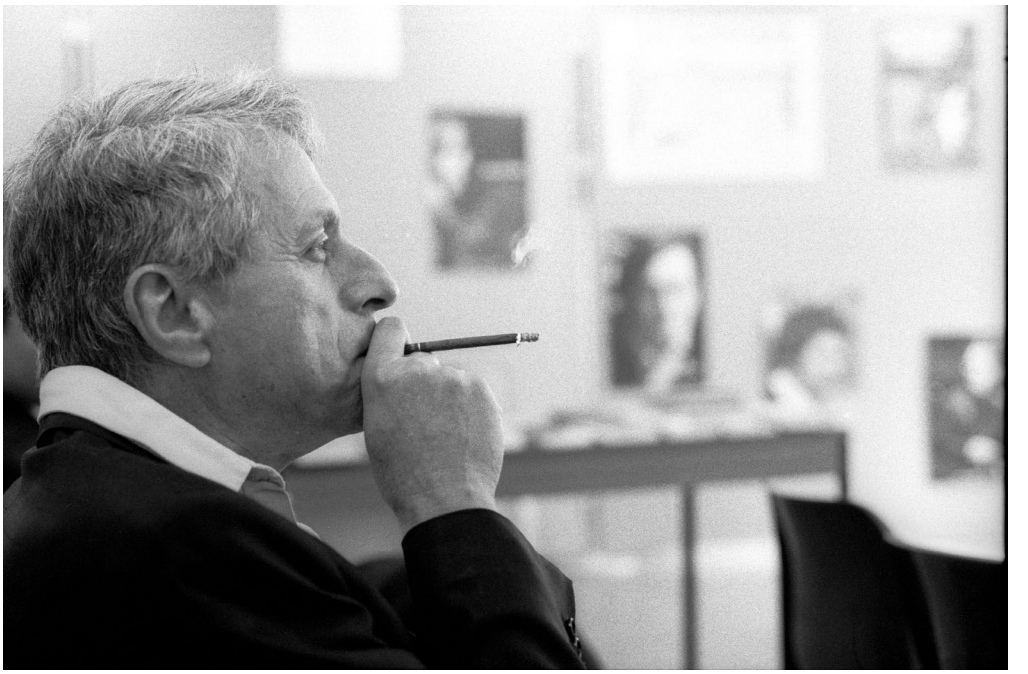
Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection.



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About the Team

Alessandra Tosi was the managing editor for this book.

The text was edited and proofread by by Adèle Kreager, with help from Elisabeth Pitts and Raegan Allen. It was indexed by Adèle Kreager.

Jeevanjot Kaur Nagpal designed the cover. The cover was produced in InDesign using the Fontin font.

Jeremy Bowman typeset the book in InDesign and created the EPUB.

The fonts used in this book are Tex Gyre Pagella (for the main text) and Noto Serif (for special characters).

Cameron produced the paperback, hardback, PDF and HTML editions. The conversion was performed with open-source software and other tools freely available on our GitHub page at https://github.com/OpenBookPublishers.

Raegan Allen was in charge of marketing.

This book was peer-reviewed by Professor Stephen Davismoon and by two anonymous referees. Experts in their field, these readers give their time freely to help ensure the academic rigour of our books. We are grateful for their generous and invaluable contributions.

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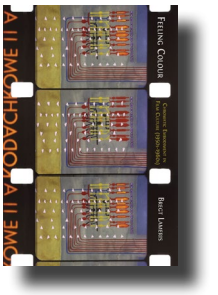

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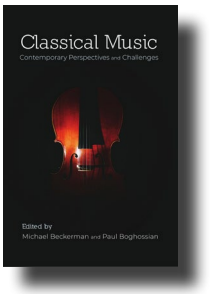

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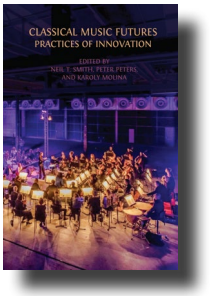
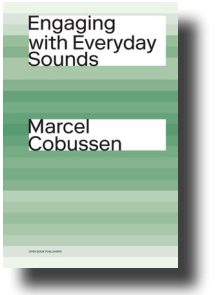


Engaging with Everyday Sounds

Marcel Cobussen

https://doi.org/10.11647/OBP.0288



Meta-Xenakis

New Perspectives on Iannis Xenakis's Life, Work, and Legacies

Edited by Sharon Kanach and Peter Nelson

The breadth and detail of the contributions will, without doubt, make a very important contribution to the knowledge of the life and work of Iannis Xenakis. What I found doubly impressive with the collection was the way in which it is able to deliver incredibly technical accounts and insights, as well as deeply personal, authentic portraits of the man, and a sense of the – at times tumultuous – cultural life that he was immersed within during the immediate post-war period and beyond.

Prof. Stephen Davismoon, Dean of School of Creative and Performing Arts, Liverpool Hope University

This book represents a fascinating panorama of observations, recollections, and recent scholarship around the life, thought, and impact of Iannis Xenakis.

Prof. Robert Rowe, NYU Steinhardt School of Culture, Education, and Human Development

Meta-Xenakis offers readers a comprehensive collection of insights into the history, works, and legacy of Iannis Xenakis, one of the twentieth century's most significant creative figures. It presents a transcontinental engagement with his life and output, focusing as much on the impact of the questions he posed as on the accomplishments of his body of work.

This volume evolved out of the multi-modal, international Meta-Xenakis Consortium's artistic and scholarly events commemorating his centenary. Informative and comprehensive, contributions span subjects including music composition, creative pedagogy, aesthetics, game theory, architecture, and the social and political contexts in which Xenakis operated. The book is organized in eight sections, centered on different facets of Xenakis's work and reception. It includes a digital archive of audio and visual media from the events staged throughout 2022, as well as computer software.

Bringing into conversation the diverse perspectives and insights of researchers, musicians, and artists, this volume serves as a foundational resource for future research on the life and work of Xenakis. It will be of interest to students, scholars, and practitioners across a range of disciplines including music, architecture, cybernetics and computation, and the digital arts.

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Cover image: Iannis Xenakis at the C.R. MacIntosh Museum, Glasgow, Scotland, 1987. Photo by Henning Lohner, courtesy of CIX Archives, Lohner collection. Cover design: Jeevanjot Kaur Nagpal

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