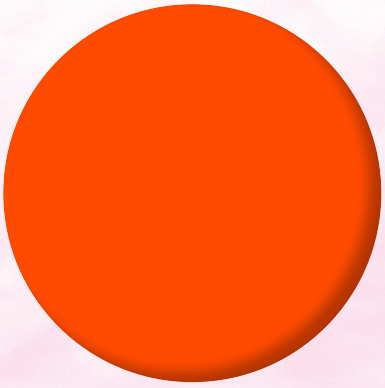
Negotiating
Boundaries
in Exhibition
Research

Stretching Materialities



adocs

Clemens Winkler, Christian Stein
& Object Space Agency (eds.)

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Stretching Materialities

Negotiating Boundaries in Exhibition Research

Introduction

Stretching Materialities is a movement from and in many directions, from many disciplinary perspectives and led by interdisciplinary efforts, culminating in a single point: an exhibition that, in both its content and its formats, makes tangible the elusive activity of matter and materiality in different contexts and opens new realms for dialogue with visitors. The focus, or lens, to view »active matter« originates in the research cluster *Matters of Activity* (MoA),[1] which examines this concept across more than forty disciplines and concretizes it with examples from the most diverse fields. We, the authors of this book, have joined as Object Space Agency (OSA), an interdisciplinary research group.

When we began with *Stretching Materialities*, we asked: is stretching a practice, a manipulation, a discipline, a privilege, a hope, or a tactic? This productive question has no single answer and instead provokes many reactions. In order to cope with the contemporary uncertain, volatile, chaotic, and ambiguous world, we need willpower, understanding, opportunity, and the ability to act and situate ourselves.

With the basic assumption of *Matters of Activity* that matter is fundamentally active and should not be understood as passive, we started rethinking the possibilities of objects and interactions in the exhibition (Fratzl et al. 2021). What does it mean to say that matter is active? Can we claim that matter is alive? To what extent is matter's activity intentional? Can living and non-living actants be considered and described in the same way? Do active and living matter still have different values in this sense?

1 The Cluster of Excellence *Matters of Activity* is part of Germany's Excellence Initiative funded by the German Research Association (DFG).

These questions led to a fundamental shift in our perspective regarding activity in social, mental, ecological, and technological fields. We began to interrogate what it really means to be alive. If we—as scientists, makers, and curators—describe ourselves and even our roles as complex, mere configurations of matter, then it is not only reasonable to understand matter as alive, but, conversely, also to consider life as a form of matter, energy, and information. Throughout the project, the boundary between living and non-living increasingly blurred for us.

Matter became a co-curator of the exhibition through resistances and enablements, entanglements and closures, compatibilities and the material refusal to assume a form or structure without coercion. These are not merely material properties; rather, this is active agency—a co-curation of the non-living in the exhibition space. We ourselves turned into human-material assemblages, shaped by our environment, culture, and experiences, whose activity is not always consciously and intentionally controlled but rather the necessary consequence of our conditioning and desires.

This shift also led to a different view of curation as a practice. The knowledge we wanted to convey in our exhibition influenced us as exhibitors, inscribed itself in us, and changed our own understanding of our roles, our methodology, and our reflection on our significance. Matter and knowledge thus became active co-creators, not only influencing the curatorial process but also shaping how we understood our own work as curators—and increasingly, as care-takers, from the Latin *curare*, meaning »to take care.« This role extended beyond conceptual labor into our daily, embodied maintenance and material attentiveness.

The question of the structural materiality of clothing stands alongside that of the interactive materiality of biofilms; the question of material transformations of cloud formations is placed next to those of weathering surfaces, traditional braiding techniques, and virtual material structures, while the gray matter of the brain stands alongside the material dimension of a book.

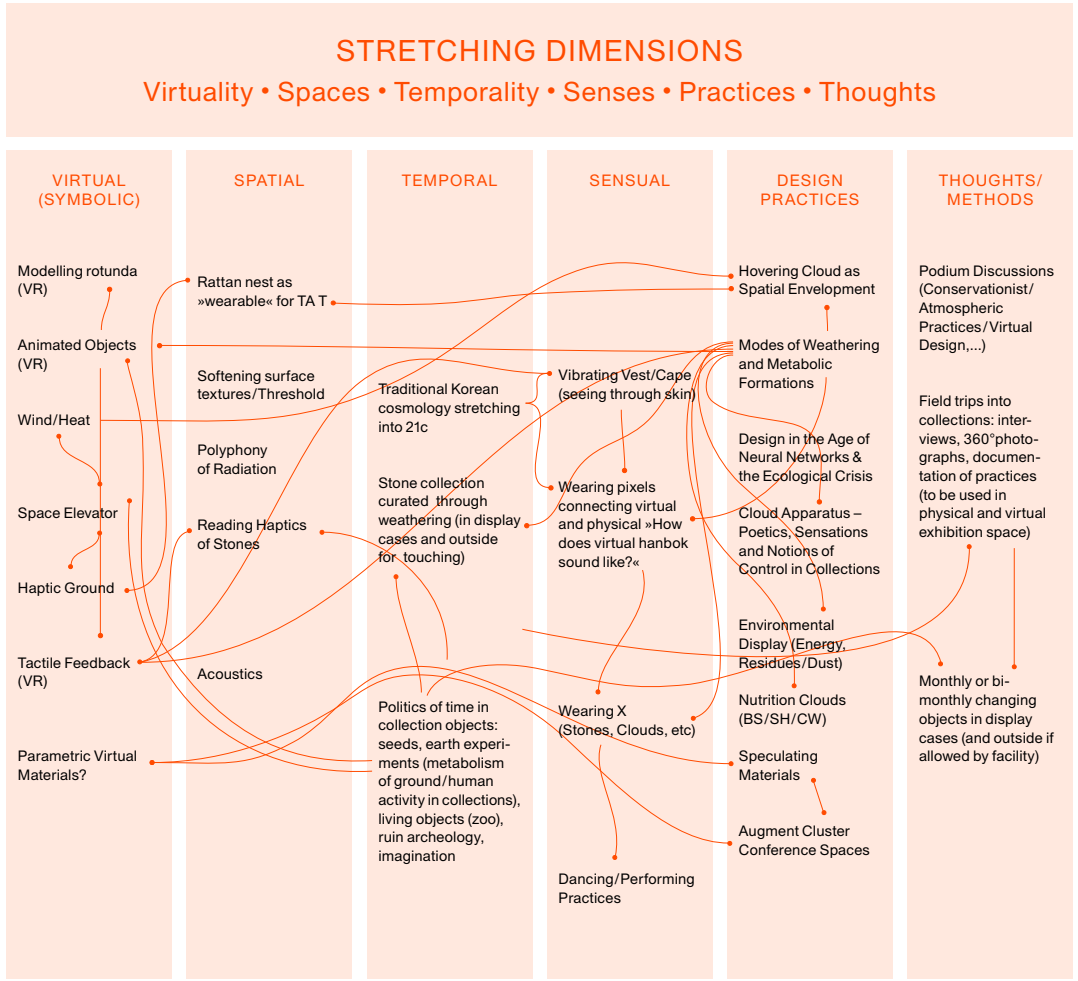
Wherever matter is used, shaped, or designed, it becomes the material *for* something—while continuing to actively contribute to its own material structure, releasing symbolic, energetic, or material

interactions with living beings and other matter. In a project landscape as rich, diverse, and complex as that of MoA, what becomes particularly challenging and at the same time increasingly important is the question of mediation: how can we link the different emerging perspectives and present them to the public? How can we communicate with and about such a vast field of stuff?

With OSA as part of the cluster, we have made this communication our central aim. It's not just a matter of how to present certain content, it is much more about what new suitable exhibition formats we can conceive and test that can provide new points of connection with a constantly shifting body of knowledge, the process of research, and a heterogeneous audience. Amongst the many disciplines interacting across MoA, *Stretching Materialities* itself combines interaction design, architecture, art history, computer science, and anthropology.

The exhibition was process-oriented and kept changing continuously even after the inauguration to an unforeseen end state. During all its alterations and changes, it stayed publicly accessible and offered a rich program of cultural, social, and educational events such as guided tours, workshops, concert series, lectures, and performances. We chose the veterinary anatomical theater (Tieranatomisches Theater, TA T) in Berlin as our venue. In close collaboration with their staff and other MoA members, OSA planned and organized the exhibition. The setup phase of the exhibition took place in the spring of 2021, and after a test research tour, exclusively virtual due to the pandemic in June, the exhibition was finally able to physically open its doors in September 2021.

We expanded the relationships between objects, spaces, and agencies practically and theoretically in the exhibition *Stretching Materialities. Hidden Activities in Objects and Spaces* through four dimensions—virtual, temporal, spatial, and sensory. We presented case studies and prototypes from research conducted within the MoA cluster: aero- and geomorphological knowledge was displayed in multisensory experimental setups; paleontological and neurosurgical research questions were combined to challenge our practical perception of living and virtual materials. The built environment of TA T and its relationship to epistemic virtualities took center stage. A series of



experimental sensory situations and spatial constellations were tested for their significance in the exhibition space: ambiguous cavities, lively membranes, and multi-scalar bridges were imagined, prototyped, and participatorily explored.

As part of a virtual journey through TA T, visitors were invited to discover hidden ecologies and unknown zones of metabolic interactions by traveling through scales of space and time, encountering hidden ecologies and unfamiliar zones of metabolic interactions. By overlaying and allowing the digital and analog to interact, we opened up a way to enhance human receptivity to the more-than-human: exploring the remains, hybridities, and borders of the physical and the digital.

Stretching Materialities built upon earlier collaborative work on exhibition practices, made accessible and tested experimentally by a virtual museum app. The app *TA Tour* provided a virtual, accessible layer of our knowledge productions as a series of 360° views (Le Calvé et al. 2024). Research results, material, and contacts from individual group members fed into the exhibition and conversely enabled intersections and relations.

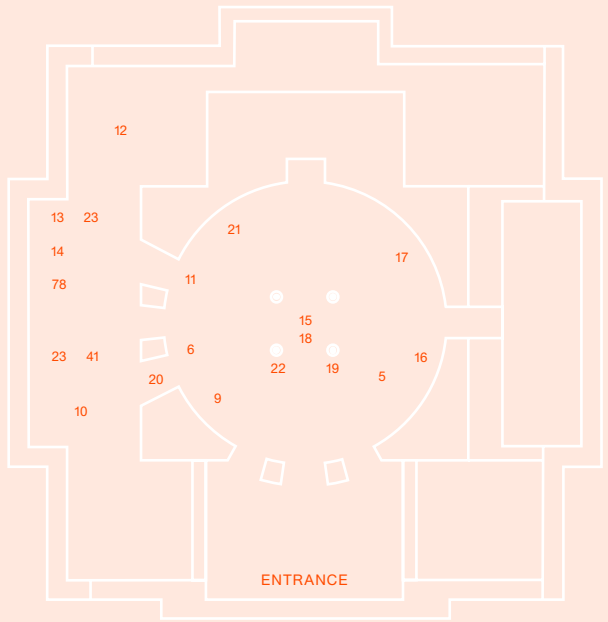
Working as a radically interdisciplinary team, the exhibition was very heterogeneous, both with respect to the methods employed and the knowledges presented. It is impossible to explain active matter in monodisciplinary terms; moreover, it requires various narrative threads, methodological approaches, and discourses. However, simply placing these side by side without interaction would do as little justice to the subject as a unifying, generalized narrative that brings everything together into one simplified view. Knowledges, as we curators were convinced from the beginning, must retain their depth and heterogeneity and yet be able to interact with one another. And beyond and above all, there has to be interaction between visitors and knowledges.

By removing objects from display cases and protective spaces and instead offering them to curious hands, this interactivity created an atmosphere in which engaged perception was welcomed rather than sanctioned by red ropes, alarms, or guards. We invited visitors to touch, change, and influence objects up to the point of mirroring their own activity in the collection of dust particles and the measurement of the temperature and humidity altered by their presence. Visitors became part of the exhibition, exhibiting their visit of the exhibition, in a sense. Their knowledge, opinions, and interests were constantly being integrated into the exhibition process. This allowed visitors finding their own points of connection and embedding themselves in an individual yet collective, interactive, and processual exhibition experience.

OSA focuses on the environment as a carrier of active, distributed agencies related to material activities, metabolism, or social and symbolic dynamics. The rotunda on the ground floor of TA T initially appeared as an empty exhibition space. In reality, of course, it was

FLOORPLAN

Tieranatomisches Theater Berlin



Projects

1. Sediments and Morphologies of Time
2. Matter-morphosis
3. Display Case as Exploratory Research Apparatus
4. Haptic Box And Haptic Hanbok
5. Weathered Stones and Cloud
6. Geological Performers
7. Wearable Matters
8. Scanning Probe Microscope
9. Virtual Sensing Knife
10. Haptic Hanbok
11. Inhabiting Textile Space
12. Stoff Anatomie
13. Cohabitation Matters
14. Inhabiting Textile Space and Haptic Hanbok
15. Enveloping Atmospheres
16. Algorithmic Weathering
17. Imagining Suspended Car(ri)ers
18. Elevator Platform
19. Column
20. Calibration Station
21. Willow and VR Meshes
22. Cloud and VR Sky
23. Device
24. Well-Tempered Hygrometer Part III

not empty but seemed so based on our usual experiences and current perceptions. The pandemic had markedly taught us that we inhabit spaces whose air is filled with microbial components (and where face masks were obligatory). Rather than inventing something for the experiential levels, we first had to understand what was already there—on a material and contextual level. We increasingly understood our role not as transmitters in a communication relationship but, first and foremost, as receivers of information from the exhibition space, matter, history, and visitors.

As we began incorporating active agencies and material exchange dynamics into our thinking, our task was to find tools and

methods that would render a seemingly empty space both active and interactive—populated with (invisible and visible, living and non-living) matter and continuously transformable. With an investigative, design-oriented, and performative set of methods, the act of exhibiting became comparable to a research process, in which our group members and the public participated in the exploration and documentation of formats for exhibiting as an open system. We call it *research exhibition* (Basu & Macdonald 2007).

Such a heterogeneous endeavor as *Stretching Materialities* required a focal point, a culmination that could align our thinking, activities, and experiments. After much deliberation, we found this conceptual focal point in the center of the rotunda of TA T: historically, the veterinary anatomical theater had housed a mechanical elevator, which, in keeping with the theater's historical titular activity, had transported animal cadavers from the former dissection cellar for research purposes to the lecture hall above for knowledge exchange. The physical center of the building, in which the elevator had been operated, was also a climatic focal point of dust, thermals, and moisture, as evidenced by the manifestation of an indoor cloud over the course of the exhibition.

The image of the research process emerged as follows: visitors enter the exhibition and put on a wearable that differs from everyday clothing and establishes a new connection to the exhibition space with haptic actuators. They then use a VR headset to explore the exhibition space virtually and step onto the central elevator platform, which is also represented virtually. A physical cloud palpable to their skin appears above them, which responds to every movement, no matter how minute. Large willow structures wriggle themselves throughout the room and invite the visitors to climb through and touch them. With a hand gesture, they select the first of several floors to which the Virtual Elevator will take them, each of which makes a particular, otherwise invisible aspect of active matter explorable.

The book proceeds as follows: the first chapter *Stretching Practices* by design researcher Clemens Winkler explores these forms of work that brought us together in the exhibition project. In order to realize such a multi-layered experience, our group had to consistently organize on an equal footing and in an agile manner, continously adapting to changing constellations over months. Over time, the collaborative figure of a five-meter wide tangible cloud emerged–a curatorial and epistemic form that invited proximity, intimacy, and a shared ethos attuned to implicit and complicit modes of exhibition-making.

The chapter *Stretching Virtuality* by computer scientist and German studies scholar Christian Stein addresses the virtual materials of modeling. For the virtual exhibition dimension, we remodeled and enhanced the real space with virtual materials that provided further insights into material structures. In the virtual realm, the smallest aspect can appear huge, the infinitely slow can be experienced, and the unattainably distant can be folded into the physical exhibition space and thus become accessible.

Stretching Spaces by architect Natalija Miodragović provides a novel approach to the multiscalarity of the exhibition space by discussing site-specific rattan and willow installations, which are digitally and physically interwoven into room climate and human movement. The responsiveness of these hybrid interweavings reveals the material-driven behavior of the exhibition space. In a spatial dimension, participants experience emptiness as meaningful and spatiality as an actor in itself.

Stretching Temporality by art and science historian Nina Samuel explores the question of the opposing forces in conservation practices of halting material activity and inherent material change in weathering processes. In a temporal perspective, visitors, as experimenters, focus on the slow but steady changes in the materiality of geological collections in the exhibition space. This kind of temporal extension also creates a memory and plays with the altering states of collection objects.

Stretching Senses by anthropologists and makers Yoonha Kim and Maxime Le Calvé presents two multisensorial case studies: a neurosurgeon's hand is re-imagined through the speculative *Virtual Sensing Knife*, probing cellular boundaries beyond algorithmic imaging; the *Haptic Hanbok* turns Korean sartorial heritage into an interactive wearable, allowing visitors to sense and reshape relations between body, garment, and virtual brain tissue.

By expanding the concept of working with materiality into five *stretching* dimensions–*practices, virtuality, spaces, temporality,* and *senses*–possibilities for interacting with the exhibition space as well as the roles of visitors significantly broadened. In a virtual dimension, visitors became aware of hidden zones of exchange within the building–between underlying technological, ecological, and social infrastructures as well as objects. These zones extended beyond what is normally perceptible, allowing to explore remnants, hybrids, and the boundaries between the physical and the virtual. All this is equally relevant for visitors and exhibition makers in their endeavor to *negotiate boundaries in exhibition research*.

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Natalija Miodragović, Nina Samuel

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Stretching Practices

Clemens Winkler

I. MEANDERING BETWEEN IMPLICIT AND COMPLICIT WAYS OF EXHIBITING

How can exhibition-making respond to an increasingly volatile present in which environmental exposure and collective vulnerability become unavoidable conditions of experience? In the *Stretching Materialities* exhibition at Tieranatomisches Theater (TA T), our research group Object Space Agency approached this question through a set of experimental practices that reframed the exhibition space as a porous medium—open to atmospheric conditions, to shifting proximities, and to the collaborative negotiation of density, materiality, and presence.

By treating the historical site not as a neutral container but as common ground entangled with environmental, technological, and social processes, we proposed new modes of spatial and epistemic cohabitation. Informed by current debates in feminist environmental humanities and posthumanist theory, we adopted the concept of weathering not merely as a metaphor but as a guiding curatorial ethos: to think with the layered exposures, durational stresses, and situated responses that constitute our ecological and institutional realities. As Christoph Holzhey and Arnd Wedemeyer have noted, »to insist that environmental damage is not looming past a future horizon but is already being weathered—and unevenly, unjustly so—means to forgo patent illusions of sustainability or resilience« (Holzhey & Wedemeyer 2020, 16). Within this framework, weathering becomes a mode of attending to what is already ongoing, sedimented, and yet materially transformative. → Stretching Virtuality, 92 → Stretching Spaces, 157 → Stretching Time, 215

Our approach thus oscillated between what we might call implicit and complicit modes of exhibiting. Implicit, in the sense that spatial arrangements, environmental forces, and material agencies were not always rendered explicitly visible, instead we activated them sensorially and affectively. Complicit, because our curatorial gestures acknowledged the entanglement of human and non-human forces, accepting our implication in the very ecologies we were seeking to observe, stage, or unsettle.

In this context, the twin themes of new proximities and new densities emerged as methodological anchors: proximity not only as spatial vicinity but as a practice of attunement and co-presence under the distancing constraints of the pandemic;

and density not as crowding but as the co-layering of temporalities, textures, and agencies in shared environments. The spatial and affective textures of TA T were thus not simply staged but stretched—through material translations, ambient interactions, and speculative mappings that foregrounded the manifold ways in which a space can weather.

Exhibition Space as Common Ground[1]—Over the course of ten months, TA T became more than a site; it became a shared medium of research, negotiation, and transformation. Entrusted with this neoclassical structure, we, the seven members of the research group Object Space Agency, asked ourselves: what would it mean to stretch our practices together, in and with this historically layered space? Amid the constraints of the COVID-19 pandemic, we explored modes of proximity that resisted isolation, finding ways to be present with and for one another through situated practices. Site-specific readings, collective listening, and sensorial mappings provided entry points into the architectural and atmospheric dynamics of the building. → Stretching Virtuality, 93 Our discussions spiraled from the rotunda—the former anatomical theater turned climatic and conceptual center—towards questions of temporality, material feedback, and virtual extension. → Stretching Senses, 317

1 As we immersed ourselves in the evolving dynamics of the exhibition space, we began to rethink our own roles within it—not simply as curators or researchers but as part of an experimental setup in which agency was shared, distributed, and continually shifting. Our official research group name, Object Space Agency, soon began to morph through conversation. Drawing on the philosophical tone of our work, we started to refer to ourselves, half seriously, as a Space Agency for uncommon grounds—a nod to our interest in unsettled terrain, both literal and conceptual.

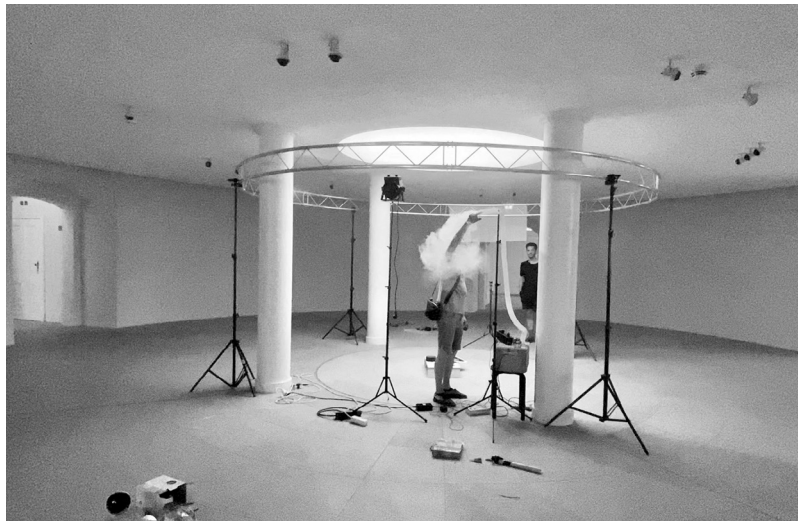


Fig. 1: First experimental setup in the renovated TA T and inspection of its surroundings 16.02.2021

Through a series of experiments—ranging from tactile VR installations to large-scale airflow interventions with local materials—we began to trace how spatial experience, bodily perception, and ecological awareness could converge in an exhibition context. These embodied investigations not only shaped our understanding of *new proximities* and *new densities* but also informed the curatorial strategies that unfolded throughout the exhibition.

2 Neimanis and Loewen Walker extend the New Materialist lens through the concept of »insurgent vulnerabilities,« proposing the notion of »thick time«—a nonchronological, durational temporality that foregrounds entanglement beyond the nature-culture divide. Their use of »weathering« signals a radical reorientation to global climate change, emphasizing shared immersion and implication in climate conditions: »We recognize our own implications in the climate conditions around us, thick with co-labored temporalities that we are also making possible.« (Neimanis & Loewen Walker 2014, 569)

Material Translation—At TA T, our curatorial approach turned toward the spatial textures and invisible dynamics of the building itself. Rather than treating architecture as static, we engaged in a form of real-time translation—reading walls like porous texts and tracing their mineral or microbial inscriptions. These translations made latent qualities perceptible: the building as a living archive, weathered and reactive, a habitat rather than a container (fig. 1).

This shift prompted us to ask: what will become visible through such translations—and how do they alter the space's role as an exhibition medium? Our investigations probed the boundaries between control and responsiveness, activation and passivity. In place of traditional displays, we experimented with environmental triggers—temperature, humidity, airflow—that could evoke new forms of intimacy, even in the distancing reality of the pandemic. What if social distancing could be retranslated into a sensory closeness—through remote touch, breath, or ambient participation?

Intra-Weathering—Central to this process was Karen Barad's notion of intra-action (Barad 2007), which challenges the view of discrete entities interacting from a distance. Instead, things—including bodies, atmospheres, and ideas—emerge through their entanglement. In our exhibition practice, this entanglement took on a specifically atmospheric and weathered form. Building on Astrida Neimanis and Rachel Loewen Walkers concept of weathering, we began to perceive space not as a passive container but as a dynamic, co-constituted climate: shaped by breath, temperature, humidity, and affect (Neimanis & Loewen Walker 2014, 558). Curating became a practice of weathering-with—not just reacting to environmental conditions but sensing their inscriptions in material and temporal terms.[2]

This approach aligned with a broader shift in ecological thinking, one that resists both dystopian future projections and naive narratives of planetary healing. Recent thinkers such as Anna L. Tsing, Timothy Morton, and Donna Haraway have instead embraced the fractured temporalities of environmental ruination, focusing on the diminished but still generative conditions of life in the ruins. Morton's hyperobjects stretch and disorient time, evoking an uncanny attunement rather than speculative salvation (Morton 2013, 160). → Stretching Senses, 309 Tsing's mushroom ethnographies, by contrast, cultivate curiosity

without futurist violence—attending to the aleatory entanglements of spores, soil, and gathering (Tsing 2015, 2–3). Haraway's compost heap furthers this ethos, offering a model of sympoietic cohabitation rooted in the thick, messy present (Haraway 2016, 31). Against the urge to narrate ecological futures, she urges us to »widen the present,« to stay with its tangles, traces, co-laborings, and trouble.

In this context, *Stretching Materialities* was not just an exhibition—it was an intra-active site of atmospheric speculation. Here, porous walls, breathing surfaces, and slow material degradation registered the entangled presence of bodies and climates. We did not exhibit weather as subject matter but allowed weathering itself to become a curatorial method: embracing the everyday ruinations, temporal loops, and shared vulnerabilities through which we co-constitute space and time. We weathered the exhibition as much as it weathered us. → Stretching Time, 209

Porosity—Despite its neoclassical grandeur, the building initially revealed itself to be a sealed-off structure—a restored, climate-controlled shell with a sanitized and carefully preserved interior. As we spent more time inside, sensing its temperature gradients, dusty corners, and material residues, a hidden porosity began to emerge. This quality of permeability—both literal and conceptual—proved to be a key to rethinking the space, not only as a site of containment but as one of exchange.

Porosity, in this sense, unfolded along multiple dimensions. On a physical level, it referred to how air, moisture, and microbial life subtly moved through boundaries—walls, vaults, and display cases—despite efforts to stabilize the building's climate. These material insights resonated with emerging perspectives on the microecologies of the built environment, which advocate for architectural designs that cultivate, rather than sterilize, microbial diversity (Krüger 2017). From this point of view, architectural porosity becomes a condition for ecological health. → Stretching Spaces, 160

At the same time, we began to understand porosity as a metaphor: for institutional boundaries, disciplinary divisions, and social structures. The site-specific encounters—between human and non-human actors, between bodies and airflows—encouraged us to think relationally. We drew inspiration from ecological health research, which understands human well-being as entangled with environmental conditions. The concept of the exposome emphasizes how our bodies are shaped by lifelong exposure to air, particles, and chemicals (Wild 2005); the holobiont frames humans as multispecies collectives, in constant

3 *TA Tour App*: http://tieranatomisches-theater.de/ta_tour

symbiosis with microbial symbiotes (Margulis & Fester 1991); and architectural initiatives like the MIGI explore how built environments can support microbial richness and diversity (Robinson et al. 2021). These relational perspectives shifted how we designed the space. Rather than treating it as a static container for exhibition objects, we approached it as a living environment—open to atmospheric conditions, multispecies entanglements, and forms of public engagement that move across thresholds.

Porosity, as both material condition and metaphor, thus became a guide for spatial practices that embraced permeability over control, participation over prescription, and ecological interdependence over isolation.

The Laboratory—This shift toward permeability laid the groundwork for a more experimental spatial logic: the exhibition space gradually became a laboratory. Here, material interactions were explored through observational methods, performative elements, and situated experimentation. We opted for a physical exhibition format grounded in an open, porous, participatory research approach—one that echoed the building's history as a site of scientific demonstration and theatrical staging.

The architecture of TA T, with its historically layered spaces—the laboratory on the ground floor and the lecture hall above—provided a generative setting. Central to this was the lifting table, originally used to transport anatomical specimens between floors, a functional element borrowed from theatrical set design. For *Stretching Materialities*, it became a platform for extending sensory, temporal, spatial, and symbolic perspectives.

Our curatorial strategies also extended into digital and atmospheric domains. The TA Tour app, developed during the pandemic as a freely accessible virtual experience, used 360° walk-in scenarios to translate the exhibition into a remote, yet immersive environment.[3] Through this virtual interface, we located and made experientially accessible the building's heating and electrical infrastructures—typically hidden systems that regulate indoor climates.

These interventions connected virtual environments with the inert materiality of indoor air, making the seemingly intangible perceptible. We further explored how external cloud formations—both real and simulated—could be linked conceptually and architecturally to indoor conditions. This did not aim to harmonize artistic and scientific modes of inquiry but rather, as

Elke Bippus suggests, to activate the aesthetic and sensory potentials for knowledge and research-based design (Bippus 2014). In this sense, *Stretching Materialities* became a stage where visitors became actors and actants, engaging with human and non-human materialities through hands-on experiments, immersive technologies, and situated reflection.

Other-than-human–Within this evolving laboratory of atmospheres, microbes and other-than-human actors emerged as central agents. The exhibition highlighted the microbial shaping of material surfaces, unsettling conventional notions of interiority, control, and cleanliness. Karen Barad's concept of »queer performativity« (Barad 2011) inspired us to investigate and experiment with dust, biofilms, and microbial samples–challenging dominant narratives around hygiene and object integrity.

We deliberately included infrastructural zones such as the heating and electricity control rooms in our spatial mappings, examining how machinic systems co-evolved with biological processes like dust accumulation or spore dispersal. In this way, new technological approaches–such as the VR environments in TA Tour–stood alongside close, embodied observations of ordinary phenomena: spider webs in windows, moss growth, dead insects. These became entry points for a reassessment of human agency. → Stretching Spaces, 173

Nietzsche's notion of truth from the perspective of a mosquito (Nietzsche 1873), Uexküll's studies on the tick (Uexküll 1934), Guattari's ecological thinking (Guattari 1989), and DeLanda's assemblage theory (DeLanda 2006) shaped our reflections on distributed agency and situated perception. What was particularly striking was that we posed these questions in the »empty space« of TA T itself–a place of resonance, echo, and spectral presence that implicitly shaped our inquiry.

We extended our exploration beyond the interior. TA T's biodegradable façade materials, nearby green spaces, and the Kleine Panke river formed part of our research terrain. We studied lichens as climate-sensitive indicators of air quality, and observed how exterior states of decomposition, adaptation, and liveliness seeped into the exhibition–transforming it into a porous, inhabited field (fig. 2).

Fig. 2: Lichen collection with symbiotic basic types—fructiose, foliose, crustose—alongside weathered stones and bark from around TA T

This methodological openness also reframed curatorial roles. Rather than fixed positions of authority, curators, artists, scientists, and visitors became entangled participants in an unfolding inquiry–situated among weathering surfaces, microbial traces, and atmospheric agencies.

Boundaries Between Inside and Outside–The walls functioned not just as physical boundaries but as active surfaces for experimentation–hosting microbial life, material weathering, and air quality data. Rather than enclosing, their porosity turned them into thresholds that facilitated exchange. By integrating porous design, we embraced inclusivity, fluidity, and transformation. Porosity here is intimately linked to *leakage*, which challenges the fantasy of closure. → Intermezzo 5, 344

Unlike abrupt ruptures, leaks are gradual, subversive events that expose hidden spatial, material, and conceptual interconnections. They dissolve the divides between artworks, audience, and environment–allowing sound, light, movement, or meaning to seep through. As both failure and force, leakage transformed the exhibition into a liminal zone where disciplines and perspectives mingled. It resisted fixed narratives, foregrounding vulnerability and interdependence as curatorial strategies. Porosity thus emerged not only as a spatial property but as a mode of resistance and care.

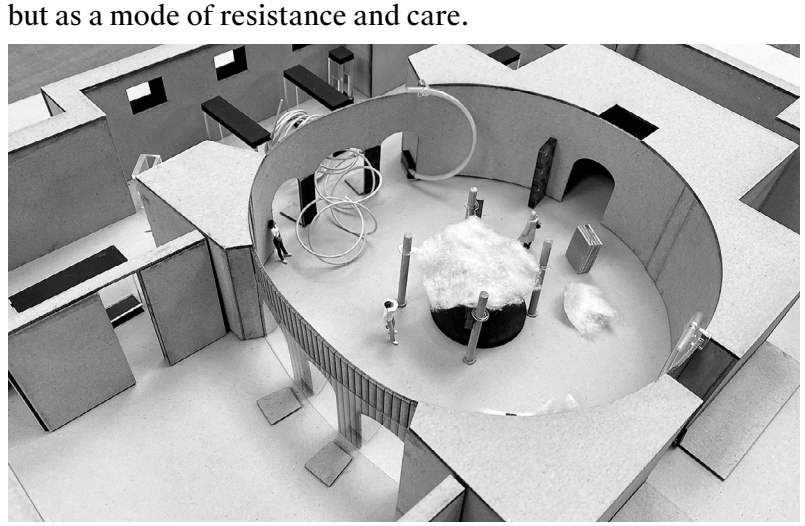


Fig. 3: Material model with early rattan designs, dust accumulations, cloud formation, and VR station at the rotunda's former lifting table—highlighting permeability of indoor exhibition space

At the exhibition's core, the rotunda–site of the former lifting table–became a space for performative and participatory engagement (fig. 3). This architectural center revealed a microclimatic phenomenon: thermal stratification and dust accumulation formed the »eye« of a subtle circular wind, five meters in diameter. Through participation and mediation, we sought to render this interplay of material, climate, and sensory experience perceptible.

In line with the concepts of intra-activity, contingency, porosity, and leakage, we explored techniques such as »bringing the outside in« and »allowing the inside to flow out« as methods which challenge traditional spatial dichotomies. Tracking the material activities of both the interior and exterior spaces—such as water, air, and energy consumption—redefined the boundaries of our exhibiting practice.

Fig. 4: Observations of TA T's water environment along the Kleine Panke riveras basis for interior cloud formation, adjacent to the anatomical theater

Water—The visible water infrastructure at TA T inspired a reconsideration of the building's interior. Historical accounts place the Veterinary Anatomical Theater in a curated garden, once elevated above the Kleine Panke river. Erosion and sediment shifts have since made it the lowest point on campus—yet the building's interior remains affected by riverine moisture. How could we render this ongoing entanglement of water and architecture visible? → Intermezzo 1, 62 → Stretching Time, 221

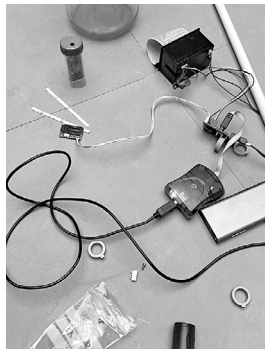
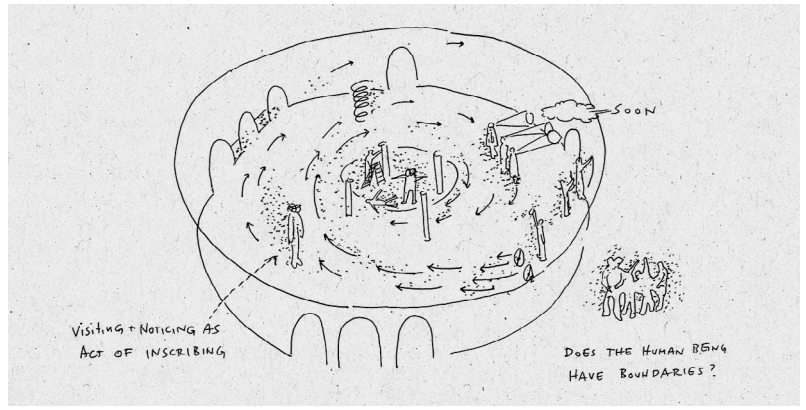


Fig. 5: Water filtration and measurements throughout the exhibition with Cluster member Dimitra Almpani-Lekka

Drawing on ecological and probiotic approaches (Krüger 2017; Neimanis & Hamilton 2020; Hengge 2024), we studied precipitation patterns and sampled the Kleine Panke river. With Cluster member Dimitra Almpani-Lekka, we measured humidity and temperature inside and around the exhibition. Water samples were tested for pH and minerals, then filtered for use in the space (fig. 4–5). From August 2021 to March 2022, this work made seasonal and climatic links increasingly perceptible. Diverting small amounts of river and rainwater indoors, we reintegrated the »outside« into the »watertight« architecture. Filtered water vapor formed an interior cloud, revealing human and non-human activity through droplet scaling, microbial movement, and air chemistry. As vapor spread, it became a carrier for microbial entities. Sulfur and carbon oxide reactions lowered the pH, prompting the appearance of soil bacteria and plant pathogens—direct consequences of indoor environmental conditions and human presence.

These processes were shared through walking tours and participatory formats. Protocol cards, field notes, and samples supported educational engagement around the cloud, the VR elevator, and other installations.

Air and Particulates—Introduced through breath, wind, and bodily presence—air became a central medium in shaping the exhibition (fig. 6). Drawing on Eva Horn's concept of air as an »environing medium« (Horn 2018), we explored its sensory, biological, and political dimensions. Air is not just a gas mixture—it is a dynamic, immersive force that connects bodies and environments. In *A Sense of Air*, Horn calls for an aesthesis of climate, emphasizing everyday perceptibility over dystopian abstraction.



Atmosphere, from *atmós* (vapor) and *sphaira* (sphere), holds a dual meaning: meteorological and emotional. This duality allows air to be both omnipresent and overlooked. The phrase »in the air« reflects this ambiguity—a carrier of moods, materials, and change. Lucretius's ancient observation of dust in a sunbeam led him to infer the activity of invisible atoms. Today, we continue to understand air as dense with life—dust composed of past bodies and environments (Lacey & West 2006). The exhibition extended this tradition, moving from historical dissection to a microbiological focus on clouds, air, and hygiene. Drawing from *meteorological medicine* (Horn 2022), we linked air to health, recalling miasma theories where disease traveled through contaminated air. Stagnant water, smells, dust, oils, exhalations—all were once seen as hazardous vectors. The exhibition revived this lens to explore air's entanglement with hygiene, ventilation, and exposure.

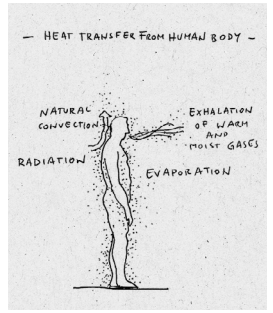


Fig. 6: Top: Diagrammatic drawing of the 13-meter wide central exhibition space with an experiential core, flanked by co-practices of imagination and mapping
Bottom: Diagram of human heat/sweat output and thermal movement; measuring interior climate as part of the weather

The pandemic reactivated this knowledge, casting air as both biological and social medium. Through airflow visualizations and breath tracking, we addressed contamination and

care. Following Tim Ingold, air isn't a container but a dynamic medium for locomotion, respiration, and perception (Ingold 2010). It shaped our being-in-the-world–and our exhibition.

This perspective becomes particularly relevant when considering practices within a novel proximity–situations in which the dynamics of vicinity and distance must be reconsidered in response to changing spatial, social, and ecological conditions. Bringing this further into epistemologies of designing practices in the exhibition, we examined how we experience air to become knowledgeable about our environment through it, and integrate sociality into our actions relating to it. We »perform« air through ventilation practices, and raised awareness of this constant exhausting of the atmosphere and breathing of air by building upon visualization techniques for air flow through Schlieren photography (Perraudin, Rešetar & Winkler 2021). With Tim Ingold, air–neither a static entity nor a part of a fixed network but a dynamic living hybrid, a medium that enables locomotion, respiration, and perception–became a vital element of our exhibition, a vital element of being-in-the-world, shaping both social and bodily experiences (Ingold 2010).

4 Museums for Climate Action, https://www.museumsforclimateaction.org/reimagine/exhibits/weathering-with-us.

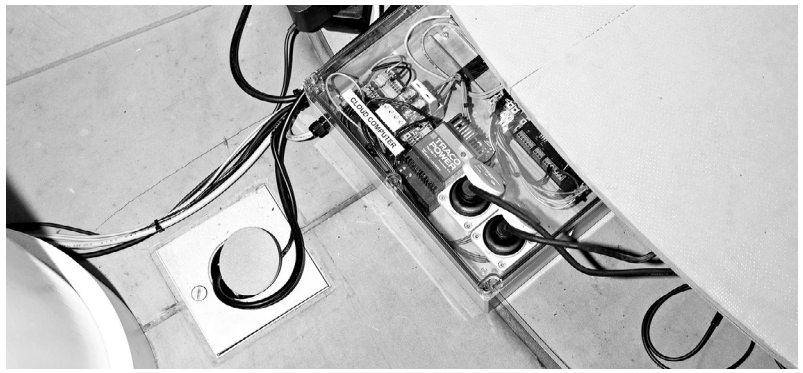


Fig. 7: *Cloud Computer* installed for daily climate control in the exhibition space—named after its aim to create ideal conditions for a physical indoor cloud

Energy Consumption–It should be noted that under today's technological conditions, it's nearly impossible to gain a full overview of the many material and energy cycles of an indoor space. However, it has been shown that new technological, »smart« solutions in society do not become more efficient by starting anew, but rather by building upon existing structures (referred to as »grey energy,« fig. 7). The integration of ecological and biological ways of thinking in other disciplines, which also recognize existing material resources and energy infrastructures as crucial, is increasingly evident in artistic practices.[4]

Through these intra-active practices with water, air, and energy, our research-led exhibition began with an awareness of using one's own resources and working conditions in the realization of set goals. → Stretching Spaces, 153 ❑ Exhibition, fig. 15, 137

5 Together with Léa Perraudin, I have explored the relationality of care, control, and proximity and reflected between the discourses of the humanities and research through practice-led design in terms of their shared and contradictory modes of investigative world-making (Perraudin & Winkler 2023).

II. PRACTICES OF NEW PROXIMITY

Through our investigative curatorial process, we engaged with spatial boundaries not as fixed demarcations but as zones of permeability and entanglement–between the hidden, the inaccessible, and the reachable. This shift allowed us to activate, rather than control, the space through exhibition elements. In navigating proximity and distance, our own positioning within the space became central.

Stretching Practices explored environmental techniques at the intersection of microscopic and planetary processes–changes we influence both consciously and unconsciously. Using air, weather, and climate as entry points, we developed new perspectives on material phenomena through collecting, embodiment, and engaging with the environment at TA T.

On a methodological level, our aim was to understand exhibiting as a form of research–particularly in relation to active matter and the bridging of disciplinary boundaries. Amid urgent ecological and social crises, site-specific, relational, and practice-oriented approaches gain relevance. These approaches integrate situated knowledge and new technologies while attending to practices of care, repair, and healing–always in relation to material flows and eco-social responsibilities.[5] Critical exhibition-making becomes a testing ground for the *what, how, where, and when* of these practices.

Rather than isolating disciplines, these new practices foster structural permeability. They do not seek singular, objectified outcomes but open-ended results. Central to this is the articulation of implicit knowledge, the organization of practice-based research, and the development of new modes of attitude, assertion, participation, and care.

Control, Care, Climatic Intimacy–In our curatorial work, we consistently returned to the question of how to reframe our relationship with nature–not only through control over fragile or fleeting substances but through a practiced proximity. Climate, increasingly rendered abstract through data and graphs, becomes something external–reduced to measurements: PM2.5 and 10, ozone, nitrogen oxides. Pollution becomes a value; weather a statistic. Yet concepts like tipping points, miasmas, emissions, and metabolism are also bodily, site-specific, and felt. They can be experienced–especially when localized, embodied events

(such as changing weather or breathing discomfort) are staged. Our work thus moved between effective interventions and the sensory incomprehensibility of ecological change.

At TA T, we proposed a situated and embodied airy practice—a design of new proximities. Positioned between critical and practical approaches (Mareis, Renner & Greiner-Petter 2022), we embraced the atmospheric ambiguity of »something's in the air.« Air, which flows through and beyond bodies, invites speculation, anticipation, and attunement. It mediates both risk and care.

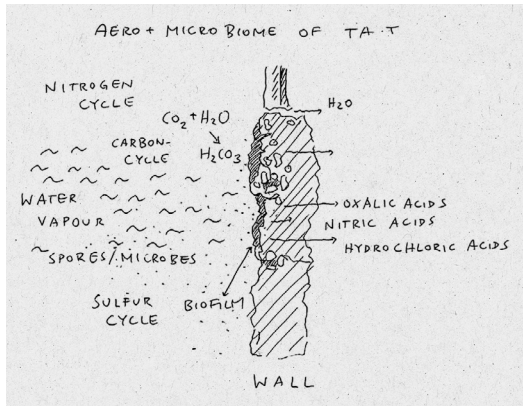


Fig. 8: Section sketch of the TA T façade—showing how renovation, conservation, and design coexist with ongoing biological, chemical, and mechanical weathering

Reconfiguring Cultural Techniques of Proximity—Air operates at the threshold of measurement and lived knowledge. In meteorological medicine, air was already considered both sensory and scientific (Horn 2022). In the Hippocratic tradition, health was understood as a balance (Eucrasia) of bodily fluids (humors) related to the four elements: air, water, earth, and fire. If one of these elements or its qualities, such as dryness, moisture, cold, or heat, was excessive in the body's environment, it would disrupt the internal balance. In his famous treatise on local climates, air, and water, Hippocrates emphasized the importance of understanding »the warm and cold winds, both those common in every land and those specific to a particular region«—at a time when climatology, meteorology, and astronomy were still intertwined (Horn 2022).

These historical insights resonate with modern climatology. While the IPCC (Intergovernmental Panel on Climate Change) defines climate as weather averaged over thirty years and across locations, weathering unfolds in specific places and times. As Astrida Neimanis writes, weather is an embodied, agentic force: it moves, scars, imprints (Neimanis 2020). In *Stretching Practices*, we engaged with these insights through embodied techniques—like breathing, meditation, and writing exercises—while

referencing the human body as a »barometer,« long attuned to atmospheric change before instruments existed.

From Indicators to Interventions—Our design approach opposed air-conditioning in favor of air *attuning*. This required reconsidering how air is sensed, materialized, and related to—reviving meteorological medicine and challenging the distancing logics of hygienic separation. Instead of abstract data, we used ecological indicators—moss, lichens, weathered stones, insect traces—as multisensory clues. These materials offered portals into the spatial critique of sustainability, resource cycles, and ecological cohabitation (fig. 8).

In architectural discourse, such shifts are mirrored by moves toward permeable structures and air-sensitive technologies (Gissen 2009). Air is no longer a passive backdrop but a dynamic, relational medium—one that mediates agency, risk, and connection (Horn 2022).

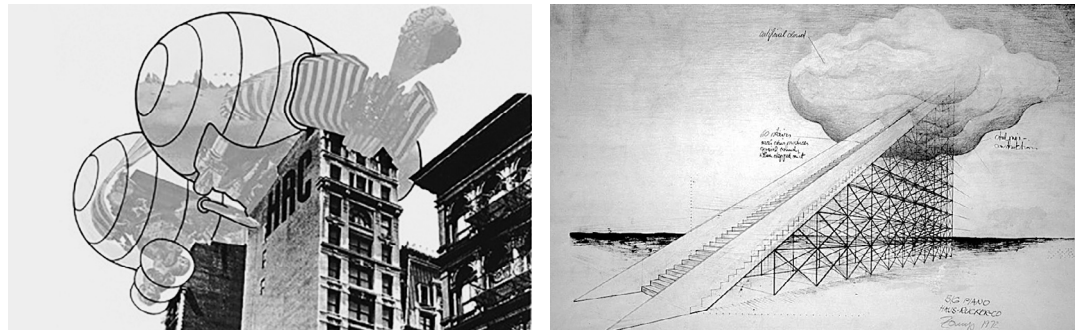


Fig. 9: *Rooftop Garden* and *Big Piano*, Haus Rucker & Co. 1972

Participatory practices at OSA included breathing exercises and scattering hygroscopic olivine basalt pebbles. These pebbles, while physically uncomfortable to walk on, reference planetary-scale geoengineering: enhanced weathering to bind CO_2. Such interventions tested the entanglement of bodily sensation, spatial design, and ecological speculation (Temple 2020).

Historical Echos—Human influence on atmospheric systems is entangled with long-standing political, scientific, and economic interests. Hans Haacke's Condensation Cube (1963–65) offered one of the earliest critiques of institutionalized control over air as a dynamic, self-regulating system (Jarzombek 2019). Around the same time, Haus-Rucker-Co's speculative collages, such as their *Oasis in the Urban Grid* project series (1972)—imagined inflatable, breathable environments suspended above urban rooftops (fig. 9)—called for spatial practices more attuned to the human body and environmental care.

These works resonate with our inquiry into New Proximities: how to live with, attune to, and co-sense ecological systems, not just represent or manage them.

III. MAPPING PRACTICES

Mapping—Observation and Technology

In our experimental exhibition, we used mapping and sampling techniques to capture airborne residues, examining their particulate and microbial presence in Petri dishes in relation to surrounding materialities, weather, and climate. We placed greater emphasis on biotic components, as microbial communities—linked to plants, animals, and humans—function like an extended genotype or *holobiont* (Margulis & Fester 1991) and play a critical role in ecological health.

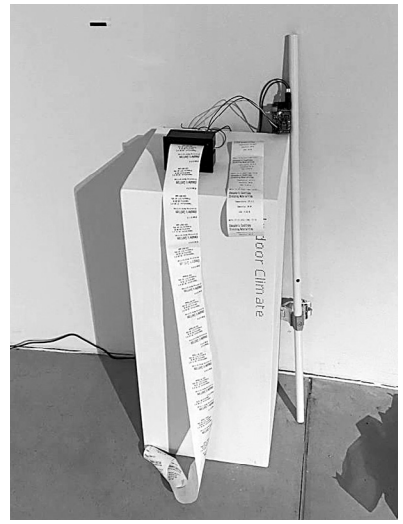
From a multidimensional perspective, our research traced how airborne particles—biotic and abiotic dust, aerosols, and trace gases—mediate between atmospheric, ecological, and perceptual layers. Water vapor and trace gases shape dust formation, which in turn influences cloud droplets and atmospheric currents. These processes were made tangible in guided tours and participatory formats at TA T, where visitors encountered the air's materiality and its subtle yet persistent influence on spatial perception. Engaging with dust, spores, and volatile compounds brought us into dialogue with emerging aerobiological research, calling for a rethinking of air as a metabolic, interspecies medium of exchange and care (Winkler 2024).

We termed these practices *algorithmic weathering*, emphasizing how instruments, bodies, and their residues continuously introduce new particles and energies into the space, thereby co-producing the environmental conditions they measure. Collecting indoor and outdoor samples allowed us to trace »invisible« climatic processes and translate them into tangible artifacts. Here, mapping is not a passive act of observation but an active intervention—every sample, fingerprint, or microbial trace reconfigures the spatial atmosphere.

These practices of tracing and noticing, far from being passive observation, became techniques of inscription—modes of writing into and with the ongoing atmospheric changes—thereby transforming algorithmic weathering into a lived, co-generated process of *algorithmic weather*.

Computer-assisted methods and custom microcontrollers with environmental sensors made metabolic activity in the air

Fig. 10: Circuit board for monitoring indoor climate and gas compositions



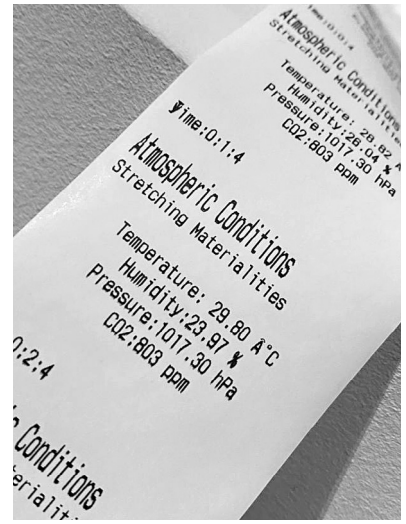


Fig. 11: First measurement results and derivations for the showroom at TA T, June 2021

measurable (fig. 10). Alongside physical artifacts, we gathered data on what was volatile or persistent, decaying or preserved. Distributed sensors visualized shifts in humidity, temperature, and CO_2 triggered by visitors, making atmospheric change a co-produced phenomenon within the exhibition process (fig. 11).

Collecting in a Metabolic Archive—The integration of measurement technologies with dust, spatial climates, and natural residues is well-established in urban infrastructures. Our aim, however, was to explore this fusion as a site of sentiment and speculation—through a growing cloud installation, linked to measurement devices which floated as a living archive. These formations created a material-semiotic language of air and dust, evoking Sharon Macdonald's call for recognizing the epistemic potential of dust languages to constitute architectural spaces (Macdonald 2022).

We relied on recent technological infrastructures to understand the intertwined ecologies and climate dynamics embedded in spatial design. ❑ Process, fig. 14, 276 Our space was intentionally shaped to reflect the intra-machinic genesis of environmental maintenance. Across scales—from microscopic imaging to satellite-based spectroscopies—we constructed a *metabolic archive*: a dynamic accumulation of residues—biotic, abiotic, anthropogenic—collected over time in settling dishes, environmental logs, visitor counts, humidity records, and sequencing data. This archive was not fixed; it evolved *in actu*, with each act of sensing, collecting, or documenting becoming part of the intra-active process of atmospheric transformation. ❑ Process, fig. 8, 272

Building on our earlier understanding of intra-weathering, we treated airborne debris and residues not as mere contaminants but as generative traces of biological, meteorological, and anthropogenic processes (fig. 12). A pivotal exchange with Regine Hengge and Anna Gorbushina revealed the vibrant metabolic life of indoor air at TA T. Drawing on microgeology and aerobiology (Gorbushina 2008), they showed how even in a seemingly inert exhibition space, airborne particles—ruptured willow pollen, soot, skin particles, plant pathogens—spoke of distant geographies and entangled ecologies.

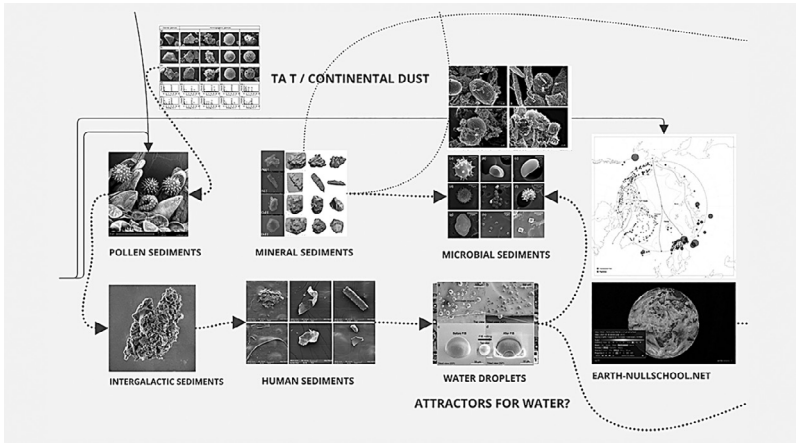
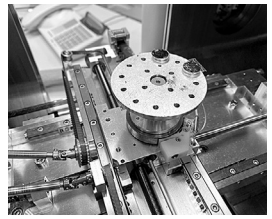


Fig. 12: Dust types/classifications, screenshot from Miro Board

Some of these life forms actively shape atmospheric conditions: the plant pathogen Pseudomonas syringae, for instance, induces rain in clouds by altering water's freezing point; phosphorus-rich aerosols fertilize far-off forests but also deposit contaminants, altering soil and water quality. These particles travel across vast distances, contributing to both ecological processes and environmental degradation. Even wildfire smoke boosts plant growth by diffusing sunlight but also adds pollutants to the air. These entanglements reframed the exhibition space as a porous, co-constituted medium, materially shaped by invisible yet potent flows.

The ecological and atmospheric dynamics we encountered aligned with Collins's (2020, 181) framing of intra-weathering as a co-constitutive process. Here, environmental phenomena and their reciprocal bodily constitution are inseparable, and the exhibition space becomes an active participant in the weathering process. Our early samples of lichens, mosses, biofilms, and rock residues acted as both indicators and collaborators—especially yellow lichens, whose colorations tracked sulfur levels from traffic emissions. Dust particles were archived using double-sided adhesive tape to capture ongoing exchanges between growth, decay, and presence. These traces became not just evidence but agents within a larger process of intra-weathering—transforming acts of noticing and collecting into modes of curatorial inscription within an ever-changing atmospheric milieu (fig. 13, 14).



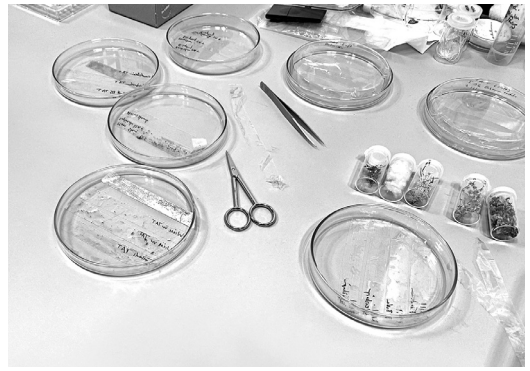


Fig. 13: Left: Electron scanning microscopy of residues in the interior entrance area of TA T. *Dust samples (textile fibre, soot particles, pollen, rock samples, microbial traces)*, March 2021. Right: settling dishes of dust samples from TA T at the Max Planck Institute of Colloids and Interfaces

Fig. 14: Three microscopic images of airborne deposits narrating their liveliness as miniature blasted landscapes hinting at skin particles, ruptured willow pollen by air pollution, and soot deposition by car traffic. Site-specific findings during our exhibition, 2022

An illustrative example of how atmospheric events can extend into cultural imagination is the 1815 eruption of Mount Tambora. The resulting ash cloud, which caused global temperature drops and crop failures, also triggered the »year without a summer.« This climatic anomaly famously inspired Mary Shelley's *Frankenstein*, a novel deeply embedded in the speculative interplay of weather, societal disruption, and human creativity. This historical moment, marked by intra-weathering in both the material and metaphorical sense, evokes a compelling lens for our embodied fabulation techniques, as we explore how climate events, like the eruption, spark new forms of cultural production and co-speculation. The layering of environmental factors with imaginative responses is central to how we understand the ongoing entanglements of nature, culture, and narrative in contemporary ecological crises (fig. 15). ❑ Exhibition, fig. 12, 134
❑ Exhibition, fig. 13, 135

In-between Scales/Forms of Collecting and Archiving in the Context of Ecological Practices—Airborne particles, such as dust, microbes, and pollutants, allow us to recognize the connections between different scales. Air carries traces of human and natural activities across various temporal and spatial scales, rendering

Fig. 15: Collection wall during exhibition period with images on the floor

visible hidden dynamics within the exhibition space. By focusing on the activities of particles in the air, we can track and understand their origins and interrelations across various scales. This perspective raises new questions about linking phenomena at different scales: how can the atmospheric scale, extending up to 12 km above us, be connected to those of soil moisture and vegetation? What happens on a smaller scale with molecules of trace gases or water vapor, and how do they influence the formation of dust particles and water droplets in clouds? How are these particles linked to air columns and turbulence, which transport them into the atmosphere and back to the ground? And how do these movements correlate with global wind and circulation patterns? With this understanding of multiple scales, we sought to make the liveliness of dust, which connects these different scales, tangible and accessible for participatory formats and tours at TA T.

Due to new scientific and technological insights, we now have a better understanding of material flows in the atmosphere, including their transcontinental dynamics (fig. 16). Interestingly, in 1854, Christian Gottfried Ehrenberg, in his *Microgeology*, announced the vitality of atmospheres and analyzed dust particles (fig. 17). He introduced the first categories of dust: biotic (pollen), mineral, and anthropogenic. Today, extraterrestrial dust is also measured. Ehrenberg established three principles for microbial development: they grow under suitable conditions, they can survive in the stratosphere up to 10 km, and they decay under unfavorable conditions[6]—a concept of liveliness that is also relevant for design practices, as materials also follow these same dynamics.

6 This was measured in studies on the microbiology of the higher troposphere and stratosphere with devices such as the Aircraft Bioaerosol Collector (ABC) system on the NASA C-20 A aircraft (Smith et al. 2018).

In a conversation with microbiologist Anna Gorbushina in March 2021, we talked about the vitality of the dust in our exhibition. She explained that human influence on Earth is as significant as the natural material of the Earth's crust. Biotic and abiotic substances now settle on human-made surfaces, often with a transcontinental history, as demonstrated by fungal spores. Gorbushina told me, »Airborne bacteria and fungi are taking over human-made surfaces, making them biotic. In the desert, where temperatures fluctuate from +70°C to -4°C, organisms settle under extreme conditions on the surface and can grow. These organisms are often called extremophiles from a human perspective, surviving temperature shifts from black smokers in the ocean to radioactive levels from nuclear sites.«

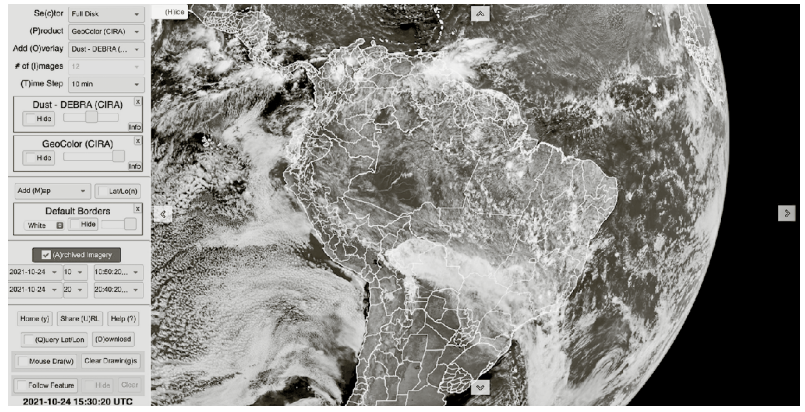


Fig. 16: Mesoscale Meteorology Branch at the Cooperative Institute for Research in the Atmosphere (CIRA) at Colorado State University, screenshot: https://rammb-slider.cira.colostate.edu

Fig. 17: Ehrenberg's illustration of airborne dust collected by Charles Darwin on the Beagle near the Cap Verde Islands, January 1833 (Gregory 1973)

She further explained, »A dust particle from the desert can travel long distances and land in an exhibition space. Our labs analyze pigments necessary for bacteria to survive in the stratosphere.« Gorbushina continued:

> Now the adventure begins—together with my colleagues, we have researched the color of airborne microbes and their travel routes, for example on mineral dust particles from the desert or anthropogenic particles. Due to specific color indicators referring to melanin or carotene, we can trace their travels. Imagine you are an air particle surviving in the crack of a dust particle, traveling from the desert in Africa to the rainforest in Brazil, and then from Florida to Europe. This happens under extreme UV radiation conditions that we humans would not survive without protection. Therefore, microbes have developed color layers to withstand and absorb these high radiation levels.

As described, at 8 km height, during a journey of about 11 days, a specific protective layer forms around the microbes, inhibiting their activities depending on weather and climatic conditions. These color pigments can even be analyzed to infer certain climatic events.
(Excerpt from our conversation)

Following the data of microbes and particles that traveled to us and will continue their journey onward, we began to envision forms of collecting aeolian dust that extend far beyond the institutional boundaries of our exhibition project (fig. 18). This process highlights the importance of understanding the curious liveliness of the air, imagining the formation of indoor clouds as metabolic processes—which accumulate at the center of our exhibition space, inside the rotunda (fig. 19). ❑ Process, fig. 13, 275

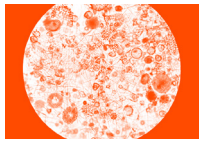


Fig. 18: Visit to the dust archive of the Leibniz Institute for Biodiversity Research, Natural History Museum Berlin

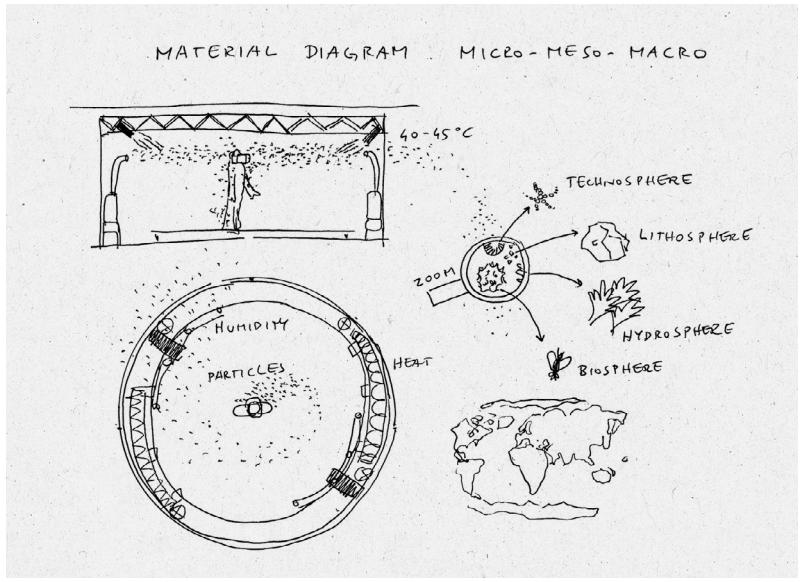


Fig. 19: This diagram shows the interrelation of scales between climate in the exhibition space and continental drift of particles.

IV. PRACTICES IN COLLECTIVE DENSITY

Practice of Experience Creation—»Watch out when walking in the water fields!«—this bit of mischievous advice was particularly relevant for the center of our exhibition space, the rotunda. Here, once home to the wooden lifting table that transported animal cadavers from the dissection room to the auditorium, a new climatic and immersive density was to take shape. On the one hand, this happened through the convergence of climatic, ephemeral, and material intensities; on the other, through the VR elevator, which invited speculative worlding beyond the material realm.

Through breathing, body heat, and physical residue, we engaged in a direct and ludic exchange with the climatic densities of the rotunda on an environmental scale (Choy 2021). Intimate, sensitive practices involving fleeting materialities—often seen as marginal effects in the present—will likely demand attention in the future as forms of »slow violence.« These practices call for a renewed awareness of warm vapors and formless smoke as elements in production processes within culture, business, and research, which are often overlooked, or worse, trivialized.

Collective Density—The concept of collective density framed the exhibition space as an emergent structure shaped by the interactions between objects, participants, and environmental factors. But what defines density? Is it the concentration of particles, people, ideas, atmosphere, or weather? What makes it collective? Is it the shared experience of the VR elevator, the collective act of breathing, or something else entirely? Where are the boundaries—who is inside, who is outside? How does one enter? How is it formed?

At the center of the space, a floating cloud created by thermal layers in the exhibition responded to these questions. A circular wind generated a vertical air curtain, maintaining a stable microclimate at the center of the rotunda. Building on previously collected air quality samples, the metabolic archive was linked to the embodied experience of this indoor cloud—an assemblage of particulates and energy states. This connection introduced participatory, speculative, and critical perspectives into the exhibition, aligning with the concept of Practice in New Proximity—an approach that neither maintains complete detachment from the cloud nor relies on direct interaction but engages through a *hands-through* design methodology.

Combining the capture of metabolic airborne activities with investigative, performative, and participatory-speculative methods (mapping, experiencing, speculating), we engaged with the space's historical context. The TA T exhibition space was originally designed to preserve animal specimens, with small windows and thick walls maintaining a stable climate. Over the course of four months under quarantine and six months open to the public, we studied the space's thermal conditions, tracking

how heat regulated the exchange between objects, materials, and visitors (fig. 20). A subtle circular wind formed an air curtain, protecting a stable microclimate in the center of the rotunda. Our next step was to create a stratified air environment: a warm, dry layer at around 40°C, a damp layer in the middle at 30°C, and a cooler, drier bottom layer at 15°C. Visitors were invited to engage with the pneuma of the space–feeling, playing, breathing, and reflecting within an artificially produced, tangible atmosphere.

Hands-on and *hands-through* workshops incorporated both natural and synthetic materials, allowing them to erode, crack, and weather. These practices critically examined traditional conservation methods, especially in veterinary medicine, where microecologies–such as the control of water absorption, temperature, and humidity–are crucial to preventing degradation. The micro-weather and cloud formations at the center of the space were not mere spectacles. Instead of dissipating after their peak, they were extended into a discursive space through participatory formats, eventually becoming part of the archive on the exhibition walls. »Since the cloud at the center could not be reproduced, the physical experiences could only be deeply personal. A continuously forming atmospheric event connected specific energetic, material, and residual effects with something invisible and dreamy, like the empathy of an expanded ›we‹.« (Winkler 2024)

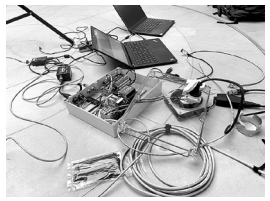
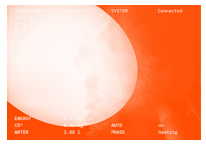


Fig. 20: Cable structure for cloud installation connecting infra-structres of the exhibition space



Through my previous work with cloud apparatuses (Winkler 2020), I am familiar with the conditions required to work with air, weather, and clouds as artistic and creative media within controlled systems. However, the rotunda–with its open hallways–posed a new challenge. How could the internal climate be made perceptible, even in a seemingly calm space where people and open doors continuously generated turbulence?

Confronting spatial densities reactivated a sense of what it means to let go–climate eludes control, urging a decentering of the human. Yet immersion reveals our constant entanglement: we never fully let go, as we ceaselessly leak into our surrounding environment. ❑ Exhibition, fig. 14, 136 ❑ Exhibition, fig. 16, 137

Aerial Metabolic Archiving–Within the framework of *New Proximity* and *Collective Density*, entering the cloud–literally immersing one's head or body–became a dense material experience. The cloud obscured some elements while revealing new flows and particulate densities. But how might these direct, affective encounters with microclimates contribute to a *metabolic archive*–an archive that reflects planetary cycles?

Particles, having traveled intercontinental distances, arrived in the exhibition space and continued their journey: settling on surfaces, entering bodies, or circulating in the air. Initially located on the wall, this archive was reimagined at the center of the space through a walkable cloud installation (fig. 21, 22). Activated by curators, researchers, and later visitors, it engaged air, water, microbes, temperature, and building materials as shared media. → Intermezzo 5, 344 The cloud became a co-enactment of the wall collection–an ephemeral, immersive archive of metabolic exchange.

Fig. 21: 5-meter wide scaffolding circulating the quiet center of the rotunda for cloud layering and building the Virtual Elevator platform

Fig. 22: Cloud condensation in the interior with Benjamin Maus (electronic artist) and Astvaldur Torrison (exhibition design)

This emerging microclimate functioned both as display and as process. By attending to and temporarily stabilizing intra-weathering, we revealed not only a designed microclimate but a shared process of atmospheric co-construction–between visitors, microbes, particulates, and space itself. The cloud's dispersal marked a turning point: a shifting spatial climate that invited research and play. Samples of lichens, weathered stones, and dust–collected throughout the exhibition–testified to what persists after weather's passage. ❑ Process, fig. 16, 277

Over time, the cloud installation evolved into a self-monitoring entity, revealing the resonance between the museum's controlled climate and global atmospheric dynamics. A faint, circular wind directed toward the center formed a moist stratification–5 meters wide, 2 meters high, weighing about 850 grams–constantly reshaped by visitors' presence. This indoor weather, hovering above the Virtual Elevator, became the dramaturgical protagonist. It responded to bodies and objects alike, establishing a fleeting, humid, metabolic archive.

Through walking, breathing, sensing, and gesturing, visitors contributed to the cloud's form—prompting a kind of *autonubeopoiesis*.[7] Transpiration, respiration, and perspiration enacted gaseous exchanges of nitrogen, oxygen, CO_2, and water vapor. Human body heat—around 80 watts per adult per hour—formed small convection openings, momentarily disrupting the mist like micro-ozone holes. Even spoken words and door movements sent ripples through the cloud. These metabolic imprints rendered atmospheric exchange visible and tactile.

On the floor, olivine basalt pebbles introduced planetary processes of carbon sequestration through enhanced weathering. In contrast to energy-intensive climate control systems, these hygroscopic stones slowly absorbed CO_2 and decayed into dust—integrating into the exhibition's microecology.

We do not merely exhale gas but emit particles that form ecological relations within the environments they enter. Using adhesive strips and electron microscopy, we examined airborne residues: textile fibers from previous installations, wind-blown pollen despite lockdowns, soot, mineral fragments, and red sandstone—likely carried in on shoe soles. Breathing and sensing became methods of material inquiry, revealing air as an archive of human and non-human activity.

Every breath, gesture, and representation contributed to shaping this metabolic archive. Through heat and humidity, microclimates and microbiomes emerged, settled, and co-populated the space. Air became not just medium but co-agent—active, spatial, and critical. Through spatial design, we cultivated something formless yet continuously evolving.

Fig. 23: Aerobiological measurements with Skander Hatroubhi and Regine Hengge twice per week from December 2021 to March 2022

Moreover, the cloud demonstrated that our work was not simply a neutral act of scientific measurement and analysis. Cloudiness, as something indeterminate, exists—much like the symbolic—within the material itself, in the density of water droplets, heat, and dust particles acting as nuclei. It manifests as active matter only through the collaboration of design disciplines, scientific analysis, and the discursive inquiries of the humanities. Every interaction continued to shape it, ultimately acting as a curatorial force. The process itself became a form of curatorial intervention—whether through setting up tripods to measure air quality, deploying air samplers, or scattering data sheets throughout the space (fig. 23). The wall archive, with its protocols, dust residues, and bioindicators, remained difficult to grasp. In contrast, the floating cloud—through its direct interaction with the air—enabled a continuous recalibration of embodied knowledge.

7 The cloud constantly stabilized itself anew through its high degree of constant self-organization, which can also be read as volatility. It had something autopoetic about it in the sense of Karl Popper (1990) and is understood here through the nubeological investigation according to Gerhard Lang's *Cloud Walks* (*Cloud Walk 10*, New York City, 2013) as a certain kind of autopoeisis, as is characteristic of clouds. This holds especially for initiating the project »Farming the Uncanny Valley,« speculating with air track 2018–2021 (Schwabe, Hülsen & Trübwetter 2022, 122–123).

Participation blurred the lines between observer, maker, and environment. Within the cloud, meteorological experiments on personal climate sensitivity became possible—experiments otherwise abstract in climatology. Artistic inquiry demanded we trace the untraceable: what has accumulated, what happens in situ, and what might yet occur. The steam system's base inputs—water and energy—were quantified and recorded via a *Cloud Computer* (fig. 7), folding technological processes into the metabolic archive as a new weather image.

The Petri dish in figure 24 and the diagram in figure 26 show the relative abundance of airborne microbial genera sampled before, during, and after the appearance of an indoor cloud on 1 March 2022, the day of an internal seminar. Among the dominant taxa were Proteobacteria, ubiquitous in air, water, and soil; Micrococcus, typically skin-associated and airborne; and Paracoccus, an organism linked to both soil and atmospheric nitrogen cycling. Together, these microbial presences reflect how human activity, movement, and indoor weather conditions co-shape the ecology of air and could be mapped with environmental parameters such as temperature, humidity, and visitor numbers in figure 30. ❑ Exhibition, fig. 23, 142

One striking example of air transformation emerged during a seminar on theatrical storytelling based on on-site scientific measurements. As participants moved through the cloud, microbial activity surged: human pathogens, skin microbes, lactic acid bacteria, and soil organisms introduced via footwear. Air samples even revealed plant pathogens typically found in Southeast Asia—especially those linked to Aloe Vera, a plant more cosmetic than climatic. The MAS-100 Eco Sampler confirmed: our single workshop day had left behind its own microbiome.

Co-Speculating Car(ri)ers in Suspension—At TA T, the microbiome and the air's layered composition served as co-curators, subtly shaping our exhibition space. The cloud, as a space of collective densities between microbes, humans, climate, trace gases, and particulates, became a central curatorial element. Collaborating with international art academies through seminars, we fostered a dynamic environment for exploring alternative life realities and desirable microclimate fictions (fig. 25).

Our approach of »teaching as research,« deeply rooted in TA T's tradition, emphasized the participatory opening of our exhibition. We stressed the negotiation of form between

Fig. 24: Aerobiological samples in the exhibition room to better measure the liveliness of the room environment. Residues from people can be detected for up to half a day with a MAS-100 from microbiology/forensics

Fig. 25: Further air measurements and external observations inside TA T

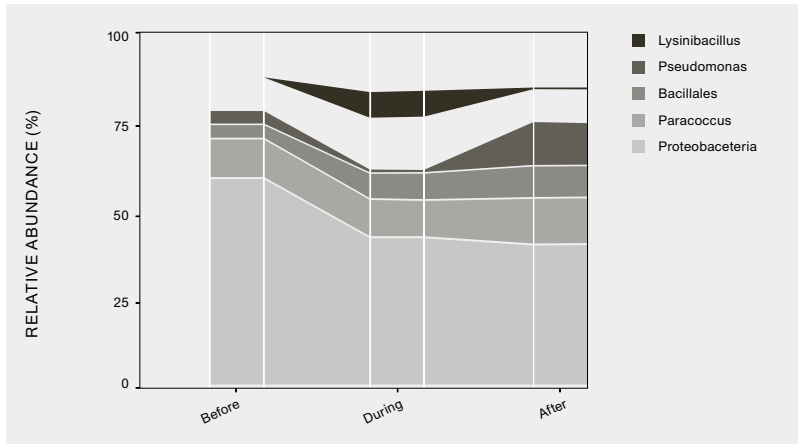


Fig. 26: Diagram showing airborne microbial imprints of the indoor cloud before, during, and after its appearance, combining metagenomics, temperature/humidity, and visitor numbers

measurement, physical experience, and fabulation. Drawing from non-Western narrative practices (Nyong'o 2019), we asked, »Have you ever felt the energy of the air? Walked on a cloud?« These questions encouraged the intertwining of speculative storytelling and embodied experiences, probing issues of form, control, and irreversibility.

Our methodology embraced a situated-empirical and performatively speculative approach. We sought to build shared belonging as a research collective within the exhibition space, while also exploring materiality through speculative actions across disciplines. Experimental design methods, particularly those involving weather, fog, and clouds, offered new dimensions in material design, connecting biological experiments, analog media, and electronic techniques.

Through ecological interweaving, exhibition practices became active participants in knowledge creation, a notion captured by a student during the *Speculative Objects* seminar: »Imagine a microbe curates this exhibition—what should be exhibited, and for how long?«[8]

Triangular Dance of Experiencing, Mapping, and Fabulating—The co-designing process led to a transdisciplinary dance between mapping, bodily experience, and fabulation (fig. 27). There was no clear direction of movement—each practice influenced the others.[9] Tracing and mapping air residues through scientific methods, coupled with creative-artistic methods like cloud installations, opened pathways for reflecting on futures and contexts. These practices merged the material-semiotic qualities of clouds with the dynamic interplay between disciplines, generating docking points for interaction.

8 The seminar »Speculative Objects« was organized together with the University of Theater Arts Ernst Busch Berlin in December 2021.

9 Andrew Pickering (2013) describes performative dance as practice of epistemic acting between the lab and the environment in »Being-in-the-Environment: A Performative Perspective.«

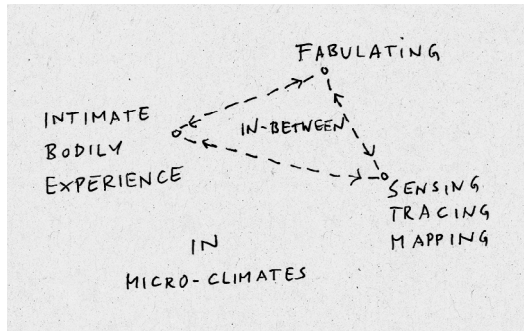


Fig. 27: Illustration of the three main figures of situated practice: mapping, experiencing, and fabulating, articulated in the exhibition space

An example of this dynamic emerged in a collaborative scene from January 2022. During a live exhibition, the cloud heated up in response to a tour group arriving. Behind-the-scenes processes, such as printing newly emerging exhibition texts on the VR elevator platform, brought to the surface the tensions between scientific documentation and audience participation, highlighting the unpredictable dramaturgies of exhibition-making.

Implicit and Complicit Forms of Knowing—The largest challenge in the project was to make implicit knowledge visible. We interrogated the fluidity of exhibition-making, navigating the intersection of artistic and scientific research. By embracing interdisciplinary engagement, we viewed the exhibition space as an intra-active entity that could negotiate new aesthetic experiences, complicity, and knowledge creation. Success was not defined by outcomes but by the experimental interactions within the space—how they provoked co-curation, empowered visitors, and facilitated exchanges across disciplinary boundaries.

10 One of the most significant ways in which speculative design has changed over the past decade is its opening up to more participatory modalities. »The days of designers dreaming on behalf of everyone have passed.« (Dunne & Raby 2013, 164)

This approach to exhibition-making positioned us not as specialists but as accomplices in a collective, generative practice. We aimed to stretch conventional exhibition roles, cultivating forms of engagement that transcended fixed categories. Through this fluid approach, the exhibition itself became a living document of co-speculated, embodied fabulation—inviting visitors to engage physically, emotionally, and cognitively with non-human agencies like air, microbes, and particles. As the exhibition unfolded, these intertwined methodologies fostered new forms of knowledge production and engagement.

Participatory Workshops and Speculative Design

The co-speculation seminars[10] »Imagining Suspended Car(ri)ers« raised several pivotal questions for design education: how can interspecies design offer more integrative ways to protect the climate? What can we learn through the lens of airborne particles in the environment? And, perhaps most fundamentally, how can we relearn to be in the air? These questions led us to explore speculative design concepts in the context of exhibition-making, focusing on bodily experience, materiality, and interactivity.

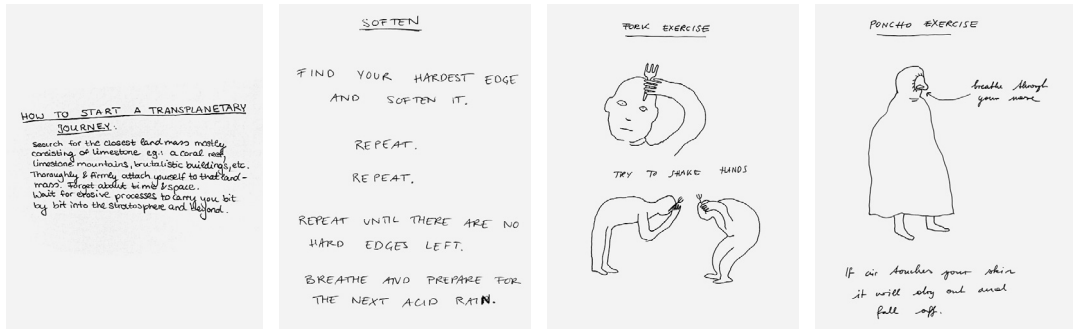


Fig. 28: Event Scores from the seminar »Speculative Objects« with University of Theater Arts Ernst Busch Berlin, 2021

We began with a central question from speculative design: what current phenomenon or social circumstance do we want to overcome in designing the space? This question prompted us to imagine aesthetic forms for future exhibitions and to reflect on the invisible barriers that might manifest within an exhibition space.

The first seminar took place at TA T, predominantly conducted remotely as part of the international Open Design Master's program hosted by Matters of Activity and the University of Buenos Aires, Faculty of Architecture. This seminar focused on producing short film essays that explored biological systems, algorithmic and poetic thinking, and bodily experiences. These »Micro Climate Fictions« allowed us to experiment with various media tools and techniques to reflect on the everchanging atmospheres around us. → Intermezzo 4, 257

In the following seminar, we partnered with the University of the Arts Berlin (UdK) in a class dedicated to process and product design. Here, we focused on modeling fictitious air particles as exhibition objects as part of the »Symbiotic Air Mutants« project. This seminar delved into themes of multi-species coexistence, polluted air, and planetary metabolism. Students created hand-sized models of speculative aerosols, combining natural, synthetic, and found materials. These models were then presented in the exhibition space, offering a glimpse into anthropogenic, probable, and damaged atmospheres. The aim was not only to reflect on environmental issues but also to transform these concerns into lively, resilient, and speculative forms of air particles—blurring the lines between art, science, and speculative design. ❑ Exhibition, fig. 26, 144

11 Yoko Ono, *Grapefruit*, 1964; from the cloud piece: »Imagine the clouds dripping. Dig a hole in your garden to put them in« first published 1963.

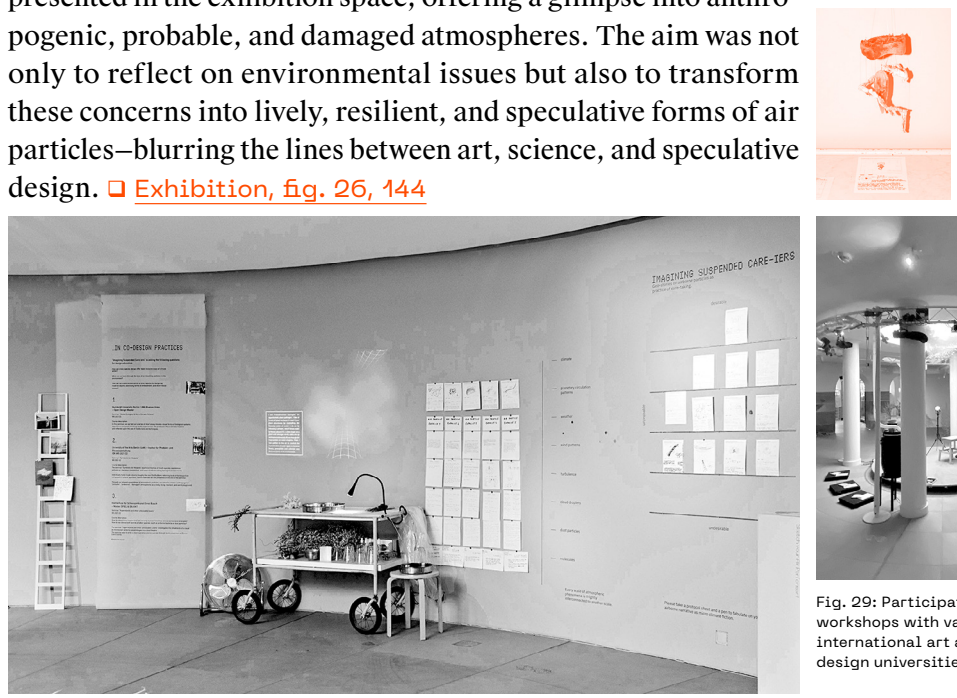
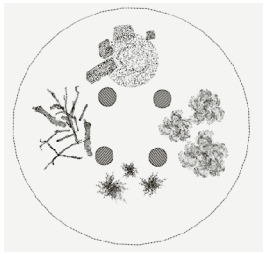


Fig. 29: Participatory workshops with various international art and design universities

The third seminar, »Speculative Objects,« a collaboration with the University of Theater Arts Ernst Busch Berlin. This seminar generated performative exercises and event scores—minimal instructions for action that echoed the works of artists like Erwin Wurm or Yoko Ono.[11] These exercises encouraged visitors to engage experimentally with the atmosphere while standing in the cloud installation. Standing in the cloud, visitors speculated through their own bodies (fig. 29). Visitors were invited to write short narratives and re-narrate them through bodily exercises, transforming their speculations into embodied actions. This process emphasized human involvement in indoor atmospheres and the biosphere, viewing bodies as both weathering agents

and weathered entities, shaped by and shaping the open weather systems around them. »Hyperobjects and Other Unkissable Lovers« explored the inhabitants of a cloud as microscopic airborne assemblages, creating a »cloud theater« (fig. 29).

Building on these ideas of speculative perspectives, we created a virtual experience through a 3D floor for a VR elevator, designed collaboratively with Swiss 3D motion designer Helen Galliker. The VR elevator allowed visitors to view the environment from the perspective of a feared airborne pathogen, asking, »How does it feel to be the pathogen? Where to go? How far can you travel through the air?« ❑ Process, fig. 25, 287 This immersive experience extended to the perspective of a cloud full of airborne microbes. How could these non-human perspectives be made accessible? This question echoed themes explored in multispecies ethnographies, offering an opportunity to follow airborne microorganisms across long distances (fig. 30, 31). We visualized this process through an artificial ecosystem in VR, where participants could trace the movements of airborne microorganisms over vast distances. Through this speculative lens, we explored how particles accumulate and interact with toxic materials and how our own bodily contributions, such as sweat, might influence these processes. → Intermezzo 4, 258



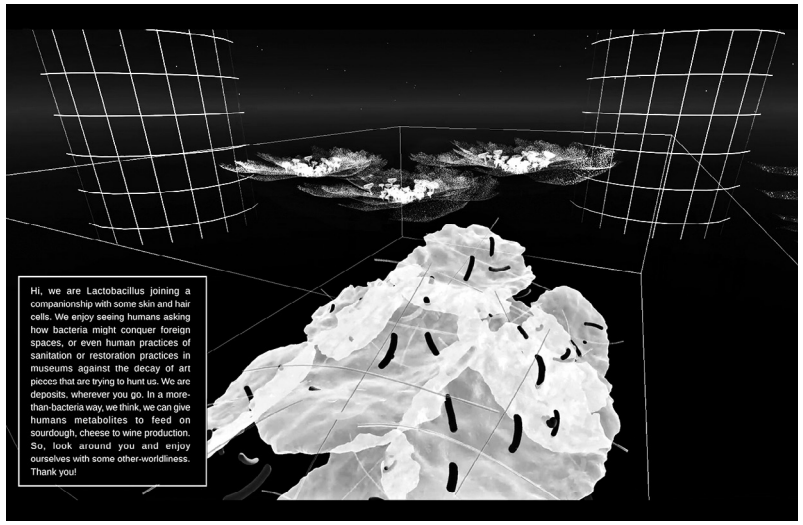


Fig. 30: Top: Floorplan of a VR tour through various ecologies connected to clouds

Fig. 31: Screenshot of the VR tour through microbial clouds in the exhibition space, emphasizing microbial perspectives on objects, spaces, and humans

Implicit and Complicit Forms of Knowing—Our publication explores the fluidity of exhibition-making at the intersection of artistic and scientific research, emphasizing spatial, virtual, temporal, new sensorial material design, and methodological aspects. It approaches the exhibition space as an intra-active

entity—one that negotiates new aesthetic experiences, complicity, collaboration, and interdisciplinary engagement for knowledge creation through design practice.

Throughout the exhibition, our inquiry integrated architectural, artistic, and scientific methods to examine the materiality of exhibition spaces and the dynamic interplay between objects, participants, and their environments. Central concepts like *practicing in new proximity* and *practicing in collective density* emerged as essential for understanding how research goals translate into lived, co-constructed experiences. Rather than focusing on predefined outcomes, we prioritized the situated experiments within the space. These experiments encouraged interaction, empowered visitors to co-curate and co-design spatial arrangements, and facilitated unexpected exchanges (fig 32).

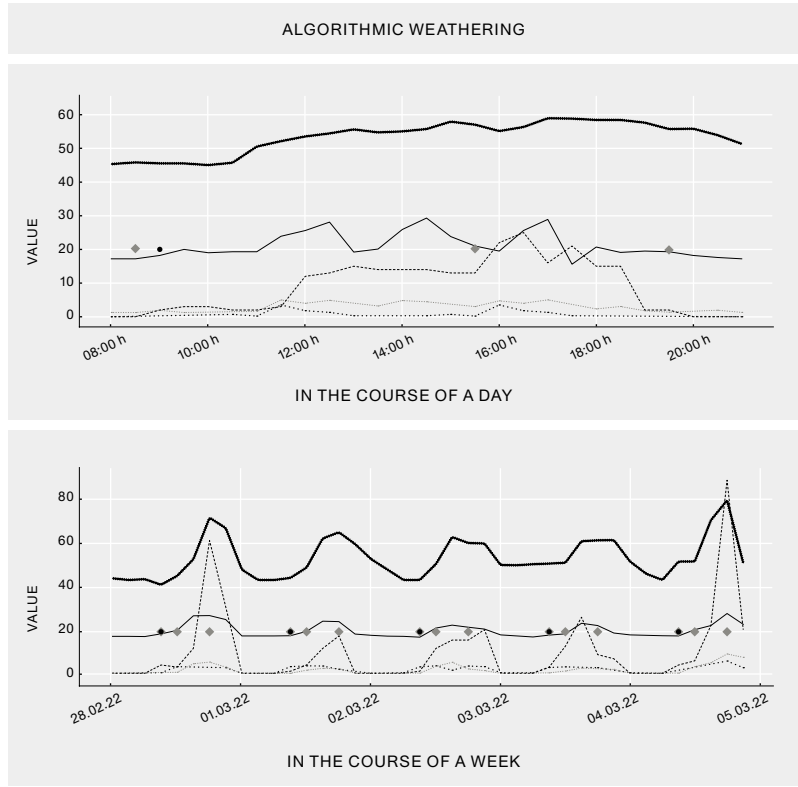


Fig. 32: Diagrams showing various tracked values throughout the exhibition space, correlating aspects of humidity, temperature, dust sampling, and visitor amounts, which all contribute to cloud formation in the space

The interdisciplinary working process within the exhibition space, which doubled as a laboratory, embraced an ethics of care. It interrogated scientific representations and methodologies, particularly concerning non-human entities—microbes, stones, algorithms, heat, moisture, and plants—positioning them not as passive subjects but as active participants in the research.

Beyond exhibition-making, we advocated for integrative approaches to education that foster critical thinking, multisensory engagement, and inclusive science communication. By challenging disciplinary boundaries, we explored how participation, sensorial experiences, and dialogue could be extended beyond the exhibition space itself. Creativity lay in the freedom to stretch conventional practices, whether implicit or explicit, cultivating forms of engagement that resisted easy categorization. Throughout the process, we positioned ourselves as accomplices—researchers, designers, scientists, curators, and exhibition-makers—understanding curation not as a specialized domain but as an open-ended practice of exchange. Rather than reinforcing fixed roles, we sought to create *docking points* between disciplines, inviting curators and non-curators alike into the evolving landscape of our exhibition-making.

Our aim was twofold: we wanted to exhibit something that engaged the various and diverse visitors, humans and non-humans included. We also wanted to keep track of and exhibit the visitors' engagement with the objects themselves in our exhibition. To this end we employed a dynamic, metabolic process of archiving, where the exhibition space itself acted as a living document of co-speculated, embodied fabulation. In this space, *new proximities* and *intimacies* were explored, allowing visitors to physically and emotionally engage with non-human agencies—air, microbes, and particles—while the *stretching of practices* transformed conventional exhibition roles. These intertwined methodologies created a fertile ground for unexpected exchanges and new forms of knowledge production, challenging the boundaries of scientific, artistic, and social frameworks.

❑ Exhibition, fig. 2, 122

CONCLUSION

Complicity as a Concept of Collaboration and Cooperation

In the course of the exhibition project, the concept of complicity emerged not as a predetermined framework but rather as a dynamic reflection of the collective process itself. Our collaboration within Object Space Agency was never rigidly fixed. Despite coming from diverse backgrounds, we found ourselves drawn together, unified—at least temporarily—by a shared passion, interest, and complementary creative methods. Over time, we realized that our bond was rooted not in a formalized plan but in a shared commitment to co-constructing an atmospheric ecology through experimentation, exchange, and mutual curiosity.

Complicity, as it unfolded, transcended traditional models of collaboration.[12] It allowed for flexible, heterogeneous encounters that adapted to the situated research interests of the moment. Our collective energy was not about a final, fixed outcome but about the ongoing, subversive power of creative engagement. This approach, driven by playful and constructive formats, cultivated new publics through our shared participation, fostering new forms of knowledge production and unexpected exchanges.

Clouds emerged as floating, illusory boundary-objects within the rotunda. »Being together apart« described the simultaneity of presence and distance, where particles, bodies, and clouds coexisted in a circulating condensation of fleeting perceptibility. The tension between proximity and separation, between the continuous and the discrete—between the analog and the digital—reflected how atmospheres and attendees mutually outlined, permeated, and dispersed one another. What remained when someone left the space? No footprint on the floor—but a suspended nutrient in the air.

In retrospect, complicity was not an abstract concept to be conceptualized at the outset but a lived experience, emerging from our shared actions and responses within the space. It embodied a temporary, yet powerful, alignment—allowing us to work together creatively, subverting hierarchies, and generating new possibilities for collaboration. In this process, we recognized that the strength of collective work lies not in static roles or expectations but in the fluid, responsive dynamics of collaboration that arise as the work unfolds.

12 Complicity is always characterized by energy, imagination, and subversive power—situated and contingent practices (Ziemer 2016). To achieve such a collective organizational form, we began by articulating our individual ideas and values—acknowledging where they aligned or diverged. This process of self-positioning helped us identify shared concerns and tensions. We remained open to experimenting with new technologies as tools of inquiry rather than control, while maintaining a critical ecological and social stance, as emphasized by Notroff (2007), rooted in awareness of material agency and the infrastructures shaping perception and practice.

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STRETCHING MATERIALS AS A SOUND INSTALLATION

Claudia Blümle in conversation with Anna Kubelík and Peter Fratzl

Intermezzo 1

• Claudia Blümle: Anna, for the *Stretching Materialities* exhibition, the third and latest version of your installation and constructive sculpture, the *Well-Tempered Hygrometer,* was shown in the object laboratory of Tieranatomisches Theater (TA T). ❑ Exhibition, fig. 9, 130 Together with drummer and sound artist Oliver Schmid, you developed a sonic performance in which Oliver brought both the components of the installation and the spaces themselves to sound and resonate through his playing. Dear Peter, as part of our Cluster Day, you were able to listen to and walk through Anna's sound installation. As a material scientist, which aspects do you remember and find surprising or fascinating with regard to your research?

• Peter Fratzl: I was very impressed by the combination of different activities in this work, both acoustically in terms of deformation and movement, as well as experiencing the various media components in one work. Of course, my own research work, which has a lot to do with wood and biomaterials in general—including hair—also appealed to me. In particular, the water-absorbing properties become topical, as is emphasized in the title of the work. While hair is at the center here, I would also name wood—perhaps not quite as directly. Both materials absorb water, which changes their properties, and all of this together naturally results in an image that places this work very much at the center of *Matters of Activity* (MoA).

• CB Anna, you are an artist and architect. What was it like for you to enter into dialogue in this panel discussion between the humanities, design research, and the natural sciences, and what reflections and observations from this conversation about your work during the Cluster Day are enlightening or irritating for you?

• Anna Kubelík: Well, yes, it's interesting for me because this exchange with these different disciplines opens up completely new perspectives that I, as someone who created this, hadn't even considered and I realize that science has a lot to do with knowledge and sometimes not knowing something and doing something on intuition. It's quite liberating, also to reflect on it afterwards with knowledge or to have the exchange. To reveal this to a whole collective of people who have incredible knowledge in different areas can expand my work itself and the reflection on the work greatly. I've realized that I've done things that were simply intuitive, and then I've also done things based on some kind of »pseudo,« shall I say, scientific knowledge because the work originally arose from a childlike fascination. For example, I still find these extreme scientific measuring instruments in museums really fascinating. Whenever I go to an exhibition, I always look for them, these hygrographs, and give them a quick breath touch to see if they really work. (A bit mischievous—I know.) From a design point of view, I have brought various aspects into the work. I have this fascination with the material itself and this movement that takes place in the material, and that goes beyond the horsehair itself and even affects the wood. Initially, this was something I wanted to control, but then I realized that I couldn't, and that's a good thing. I understand it as an artistic process: things are beyond my control. And in that respect, I think I'm more of an artist than an architect, which is my actual background. Architects want to control the material and make it their own so that it fulfills certain functions, while artists free themselves from this »functional« obligation and also allow things to happen that are not foreseen and not planned. In these conversations with various academics, I noticed that the artwork's shape for example apparently made references of which I was not aware from an art historical perspective in relation to this form of movement, the curved movement, which came from a completely different consideration. I actually looked at the sine curve and thought it was the representation of sound in a graphic sense, but in fact this curve was apparently also a reference to an art-historical emergence of form, of design, and I wasn't even aware of that. And I'm also sort of glad that I didn't know that. Even though I'm incredibly inquisitive, it made me happy not to carry this »weight« of knowledge—at least in the process of making it.

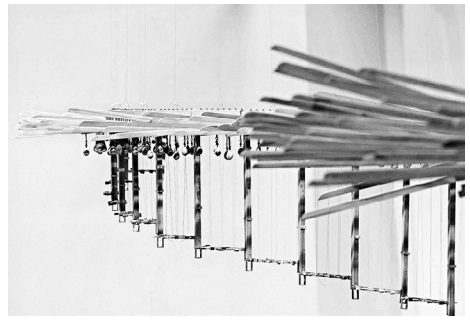


Fig. 1: *Well-Tempered Hygrometer Part III*, detail

I've realized that when I act as an artist and exhibit works—and this work in particular—, the various viewers have different associations. And what I was thinking is not really relevant in this work, but it is interesting for me to realize that everyone draws their own conclusions about the work based on their own wealth of experience, their own background of knowledge. I think that's crucial and wonderful in art, because everyone understands completely different things through their own references, their own cultural contexts, their own perception and yet, if the observer wants to, they can delve deeper into it and see what I was thinking. I gave a little hint with the title of the work, and the conversation with another scientist was also exciting because he gave me ideas on how I could continue working with other materials that also react to temperature and humidity. And that gave rise to completely new mechanisms. New works can emerge from this, which was also a very exciting, very intensive conversation.

• CB And what materials are these?

• AK These were metals, I think, which react to humidity. Fardin Gholami, my cluster colleague, told me about a material that could be used that would have completely different mechanical properties in order to perhaps create a new kinetic work.

• PF You talked about the architect's control and the freedom that you can give this active material as an artist. And that's what I wanted to touch on, what connects the two, which is cooperation. So it's neither control nor complete freedom, yes, but I don't think you gave the materials freedom, you rather cooperated with the material because you had expectations. Yes, the hygrometer is not controlled, but it is predictable; that is, if we know how the hygrometer will react because the horsehair expands with humidity, then that is a kind of cooperation. Nobody forces the hygrometer to do this, but we know that the hygrometer will do it. I find that much more interesting than the two extremes of full freedom and control. I would also say that knowledge has an impact on art. Indeed, the knowledge about the expansion of horse hair is a prerequisite for what you have done. Knowledge about how wood changes with moisture could be another prerequisite. To illustrate this: in the timber industry, logs are cut in a very specific way, because different parts of the wood expand differently with moisture, which could lead to unwanted warping. I think this knowledge can of course be used

in the same way as the knowledge about the expansion of horsehair, and that is effectively done in architecture, for example when Achim Menges uses self-shaping of wood components in the Urbach Tower. I could also quote Horst Bredekamp, who talks about the cooperation between the artist and the object in the making.

• AK Perhaps I can add something to that straight away: the project was preceded by the fact that I didn't know whether horse hair in particular would react to humidity like in hygrographs. I was told that there is human hair in hygrometers, which is degreased and reacts correspondingly strongly, blonde hair in particular. Scale and musical instruments interested me, so it was a combination of things that perhaps didn't seem to belong together. I think that's something that I learnt from my architecture studies, but that I tend to implement in my artistic work: I put things together that don't really have any connection at first. I replaced human hair with horsehair simply because I was interested in scaling it into something bigger. Horse hair is much firmer, much stronger, it can be stretched for bows. First, I did a lot of experiments, to see how it works and how it can be realized mechanically. Is there a mechanism that can set a lever in motion, and can the horsehair do it at all in terms of statics, in terms of its reaction to moisture? So I used a hairdryer and water and sprayed it. That actually worked. So this cooperation had to come first, for me to see if it worked at all with horsehair. I also looked at lever mechanisms first—I had no idea how levers work—and then slowly approached that until it took on a larger form or took on a larger shape and perhaps this process of experimentation was a prerequisite. Then with the wood, I was under the circumstances that I had to take whatever wood was made available to me for these wooden levers, and some of them are quite bent, so I simply took what was offered to me and I couldn't consciously make this selection because I didn't have the means to do so. I was in the USA in upstate New York and they simply made something available to me, I needed wood and I couldn't choose. If I were to do it again now, I would of course be much wiser and know much more specifically what I would take where and which pieces of wood I would take, but perhaps that will come in the next project.

• CB I would like to take up these questions of »what can be controlled?« and »what is left to chance?«, as they relate to the relationship between order and disorder or chaos in the context of entropy and thermodynamics. I first got to know your work as an immediate performance and not as an installation. What I found interesting about it is the level of rhythms as beat on the one hand and noise as noise, which was closely linked to the acoustics of the materialities on the other. At the same time, each musical performance was different from the other. I remember that at one point all the wooden elements collapsed and the entire structure, which also has something geometric about it, was just lying messily on the floor. I would be interested to know how you—Oliver and yourself—proceed with regard to the activity of the materials, the unpredictable changes, how you weave them into your composition and improvisation? When do you integrate chance via the materials, temperatures, humidity? And how did this compare for you, because you've put on an enormous number of performances. In comparison, this probably also took on the character of an experiment for you, from which you were also able to draw your conclusions. Add to that how Oliver struggles with the weight of the material, such as the wooden boxes, or when he drops them. Perhaps you could also tell us a bit about this cooperation between the materialities, their environments, and the two of you in the sense of a multiple cooperation?

• AK The *Well-Tempered Hygrometer* was the third part of a development. The first part was the kinetic work itself with the horse hair and the wood. In a second step I developed the boxes for it and let the whole kinetic work play through the influence of water. That's when the tonal element was added, because that was actually missing before. It is a big and strong reference to a tonal piece by Johann Sebastian Bach and at the same time there was no sound in the first part of this work, so in the second part, the sound was added but played through water.

• CB Could you tell us more about the role of water?

• AK I actually arranged a water hose through the work until drops of water continuously flowed through the sculpture, dripping through and turning the boxes, originally used for transporting the work, into resonating bodies. (Running through the work, the water again caused a deformation that I couldn't control.) There were sound bars in these boxes, which the drops hit, creating an uncontrollable but perhaps a certain structure of sound by simply not using any minor tones. I only used quasi-pure, harmonious tones and the drops fell as they fell. Depending on the water pressure and the place where it was set up, I could make it more or less fast or more or less intense. But in the end, this sound was like a carpet of sound created from sounds that came out of these boxes, through the drops that dripped down from the sculpture: a controlled, uncontrolled carpet of sound.

Fig. 2: *Well-Tempered Hygrometer Part III*, with drummer and sound artist Oliver Schmid

• CB There is also the other variant in which the recording of the performance and a composition by Oliver was pressed onto a red vinyl disc, which in turn was inserted into a box. If you hang this object on the wall as a picture, you can see the floor plan of drj art projects' gallery in Berlin on the cover of the record. This shows the exhibition view of the *Well-Tempered Hygrometer,* its installation of the hanging sculpture, and the boxes from above. However, this is not completely flat but designed three-dimensionally as a model relief. This cover can then be taken down as a picture to remove the vinyl disc in bright red, which was previously the colored background of the model relief of the cover. This is not only about different medial transfers of space, sculpture, and materials as an installation but also about the relationship between architecture, performance, installation, and music, both of which take the activity of the material as a starting point for artistic work in the same way but by different means. Would you like to elaborate a little on this connection?

• AK Yes, it's always exciting for me to work in an interdisciplinary way. And even if they are both within the artistic field, music and visual arts are as far apart from one another as other scientific fields and that's why you can speak of transdisciplinary work in this case. Because we have transcended our disciplines. I was suddenly involved in this musical performance, going beyond my boundaries as a visual artist. When I was invited to exhibit in the gallery, it was clear that I wanted to develop this work further in a form that perhaps removes the water as the main protagonist again and brings a person into it instead. So Oliver replaced the water. It was interesting for me to consider the context. The gallery had a certain context, and it was clear to me that water didn't play a role for me but perhaps people again, people in a narrower space. How do people react with their density? Well, this was before the pandemic, so originally the idea was that many people would then have this influence on the sculpture, but it all turned out differently after COVID-19. Actually, this performance was only supposed to take place at the beginning of the exhibition opening and at the end, but then the performance became a supporting structure for the exhibition and for the work. I think if you had experienced the performance with an audience of twenty-five or thirty people in this small room in the gallery, it would have been something completely different, but this way we actually did it every weekend exclusively for two visitors, there were only four people allowed in one room. We worked with this restriction, not even the gallery owners were present because that number of people wasn't allowed. We did one-to-one performances with masks, and of course it was heavily ventilated and so on. And this created a structure where booked gallery visits were possible, exclusively for people who had booked a time slot, for an hour, where the work was discussed, a performance was shown, and a follow-up discussion took place, and as a result there was an incredible number of performances. Instead of two, there were over seventy performances over this entire corona period and people experienced these performances in a completely different way. First, they had the chance to experience something live and not via a monitor, which was already a strong deficit in the corona period, and that became very, very clear to everyone. And secondly, there was this intensity of experiencing not only the sound but the sound in combination with the material, the material that moves this whole experience of space, sound, and material. That was very tangible for everyone as it turned out in the follow-up discussions. If I can go back to the structure, the structure suddenly became very, very important in the context of first getting an idea of this work but then also getting this experience of the controlled uncontrollable.

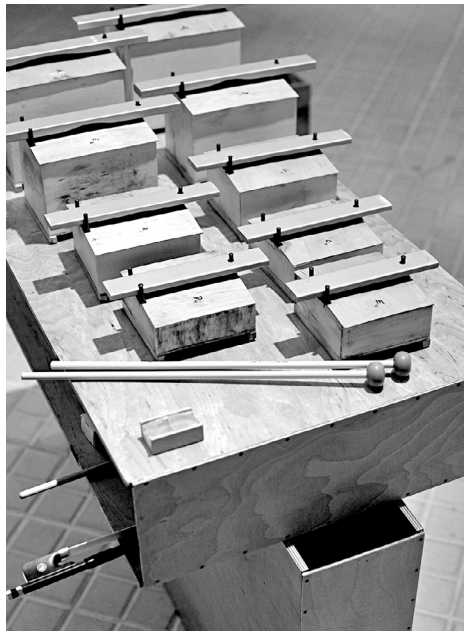


Fig. 3: *Well-Tempered Hygrometer Part III*

• PF What fascinates me now in retrospect, and what I wasn't aware of, is that the work was created independently of the Cluster and our conversations. I initially thought that it was conceived specifically in this context.

• CB I'm happy to pick up on that, as it was actually the point of reference for the invitation to Anna Kubelík. I discovered this sound installation by Matthias Seidel and Christiane Bail at Galerie drj art projects during the pandemic. We could only be a very small group of people in one room to experience the performance by musician Oliver Schmid with the sound installation. It made the experience quite intense, especially hearing and perceiving the materialities, the relationship of water in different states, and the resulting change of form of the whole installation. The title, which recalls the hygrometer, the measuring device that records the humidity in museums to ensure that the artworks do not disintegrate or are destroyed, also evoked materialities. I found it very convincing to use this as a productive starting point for an artistic work. The same holds for the wooden boxes as a means of transport, which at the same time reminded me of the hygrometers as objects in the rooms' corners in museums. After the sound performance, I immediately realized that we should get Anna and Oliver on board for our Cluster and especially for *Stretching Materialities*. The sound installation is also about the question of stretching, and the activity of the material only becomes visible, tangible, and perceptible the moment it changes. This also happens in a very delicate way when the rods in the hanging scaffolding shift or the hair of the violin bow when it tears during Oliver Schmid's performance as he tightens the bow again or relaxes it at the end. All that is part of the performance. For *Stretching Materialities*, we were looking for a position in which the acoustic level of materiality can be experienced.

• PF I see similarities to our scientific work. All life is a reaction to unknown external conditions, all living materials—plants, or even hair—need to react to the environment and adapt to it. This aspect has been partly forgotten in certain areas, where materials are actually enslaved or dominated, which is partially why we now have all these huge problems related to the Anthropocene. That is precisely the failure that arises from the fact that we have tried to control and optimize everything, but since the environment changes, these processes turn out not to work anymore. That means we have to find ways of dealing with conditions of the environment in a reactive, in a more adaptive way.

• AK That's actually extremely important for me as an artist because I have noticed two things: I move in different worlds and time scales, let's say. I work a lot with musicians and improvised music and I find it extremely exciting that they react so immediately, that is, so to speak, in the hundredth of a second. Then in a completely different world, I am a professor in a faculty of architecture and I am constantly confronted with wanting to master material in a way that is functionally oriented so that we think that architecture is something rigid and inflexible. That is actually a big mistake! This is a completely different (time-)scale, because these are scales of hundreds of years and not the »same-moment-reaction.« Perhaps we humans are not even capable of this translation, which is so important today, namely the action and reaction time, that this translation must actually take place immediately, that one must immediately understand what my work is when I do certain actions and this

work is exactly not that! It challenges the patience of the viewer because horsehair moves so imperceptibly slowly and yet one has this expectation that it must react immediately. I've often felt, when I've been in conversation with observers, that they say it doesn't move at all, and yet it does, but you have to be patient, and that's exactly the time span between the solid building that also reacts but very slowly and over many years, perhaps even centuries, and then perhaps not in the way we want it to. I am fascinated by what effect you have as a viewer on the material. The air that we breathe out, the moisture, and everything that we emit through our bodies, which then reacts immediately with the room. Moisture is undesirable for art in museums »because it destroys the art work« and at the same time we want to look at it. We're in this constant conflict with time spans.

• PF I can give you a hint: adaptation must be considered on all these time scales, because if we only look at our living organism, evolution is an adaptation on the scale of many generations. If I train my muscles to a high level, I can change an organ on the time scale of days or weeks. That applies to all our organs. All these time scales are relevant. We also have to bear in mind that time scales are also important for the Anthropocene problems that we have discussed just now. The human-made changes to the environment simply happen too quickly for natural systems to adapt, so the time scale really matters. This is something we also discuss in our research cluster. So things can be too slow, but they can also be too fast.

• CB I would like to pick up directly on the last point, which on the one hand touches on the location of TA T, built under the direction of architect Carl Gotthart Langhans in the period from 1787 to 1790, and on the other hand also touches on the prehistory of materials science. TA T originally was a place where dead horses were dissected. Anna's installation was installed in the original slaughterhouse for horses, today's Gerlach Building, an extension from 1874 and today's laboratory of the Hermann von Helmholtz-Zentrum für Kulturtechnik (HZK). Around 1800, the separation between the organic and the inorganic, between death and the living, became a matter of debate. With dissection and anatomy, one is on the side of death and on the threshold of the physiology of the life sciences. In the *Hygrometer,* one can see a skeleton in the hanging sculpture, while at the same time the question of life and growth is at play with the material of the hair. And it's not just any hair but horse hair. I also found this reference intriguing with regard to the location of the work. It was the place where live animals arrived and were slaughtered to be dissected afterwards. Against this background of the history of science, I am interested in the extent to which anatomy, life sciences, and physiology, including the physiology of plants, are seen as a prehistory of materials science. To what extent is this context used alongside physics, chemistry, and other fields? I would be interested to know to what extent you, Peter, draw a line from the life sciences to today's materials science.

• PF Materials science as a discipline is not that old, probably from the 1950s. Before that, it was either mining and metallurgy or chemistry. The discovery of plastics happened around 1900. The discipline of materials science was actually invented because people realized that there are definitely connections between different types of materials that were previously considered separately: it makes perfect sense for someone who deals with plastics to know how steel or ceramics work and vice versa, and so they need to be studied together. For example, I used to be a professor at a mining university. I taught about steel and iron-carbon diagrams before I got involved with biological systems. Some time ago, I didn't think it would have occurred to anyone in biology to say that materials science is needed there, but today, it's all coming together through an understanding of the significance of structure. Through anatomy, for example, you see how the organs are arranged in relation to each other and from this arrangement you can draw conclusions about their functionalities. That's also something you just mentioned, something you don't actually see, but which is behind what you see. How do the organs communicate with each other, what happens where and why? In a tree, structures may be very different, but they tell us about how the organism functions. The use of materials science concepts in biology is really only twenty to thirty years old. Of course, all our organs or the organs of a tree have biological functions. But these also require specific material properties, which means that materials have a role to play in biology. And I believe that this realization now leads to all these subject areas inevitably growing together.

Because we have talked so much about wood, there is one thing from our research that is just really funny to tell you. When a young tree grows, it starts with a long, thin stem and grows as quickly as possible to get towards the light. You have to remember that plants are in a constant competition with their neighbors, with other plants, for light. And such a thin and long trunk faces the problem that it can be bent incredibly easily, which means that it must be flexible, it should not be like a glass rod. Later on, the problem is different. The stem will have a large load to carry and should not bend under the load and must therefore be stiff. This means that the tree needs to change its material property in the stem as it grows into a trunk. Since the history of growth is stored in the annual rings of the stem, the wood in the stem's center is completely different from the wood material in the outer parts. This reaction to the environment, which means the growth of different wood material at different moments in time, is performative in a certain way, because it incorporates the environment and builds a structure, whereby its history inscribes itself into the stem. A tree invests so much to build incredibly complex structures, from the cellulose molecule to the 12 meter high trunk. Everything is adapted, the structure at multiple scales and the properties, so that burning it in the end simply appears like a crazy waste. This means that we have to learn again how to use every part of the tree in the best possible way, which is mostly to not just burn it. There is a lot of traditional knowledge that has been partially lost, but of course we also have to process this through our type of knowledge, namely through scientific documentation, then this traditional knowledge can also be used with our current methods.

• CB I would then like to ask how you, Peter, work with visualizations and images and also deal with the question of abstraction, which has a graphic dimension. In our *Stretching Materialities* exhibition, it was important to us that visitors could touch and pick up objects. Seeing was therefore not the only possible way to gain knowledge or to perceive. How do you translate and convey the materiality of your object of investigation into images and what role do they play in exploring materiality?

• PF Perhaps the last point is about how to communicate these issues. I'm not talking about outreach, but I'm talking about communication between scientists

from different disciplines and backgrounds. It's not that easy when the background knowledge is very different. Communication needs to be translated into a language, both textual and figurative, that is understood by colleagues so that they can build on it. And the more disciplines there are, the more complex the task becomes. What are we actually communicating? We actually only communicate models, model concepts of something very reduced, descriptions of something incredibly complex that can then be made comprehensible, so to speak. And then you can ask how much truth is in there? Just a certain amount? Which part of the research in one discipline is actually relevant for the other? These are all difficult questions.

• CB Just a quick question about the relationship between images, models, and communication media within science. I was recently in conversation with John Nykatura who told me that when he gets into dialogue with a group of colleagues, from science to science so to speak, paper and pencil immediately come into play and they always draw in the scientific exchange and also communicate through drawing. However, these drawings are all destroyed afterwards and not kept at all. They have no intrinsic value, not even in the sense of outreach, as we know it from the covers of *Nature*. These are also mostly diagrams, abstract drawings that are about describing functions, perhaps cycles or other connections. I would be interested to know whether this is also a practice you employ? Do you also draw in communication or bring illustrations with you in order to be able to enter into scientific dialogue and joint research?

• PF Well, we're not in my office right now, but it looks like this: I have my own desk and then I have a round table for meetings. Behind it is a large screen and a whiteboard. In all discussions about scientific data, the screen is there to call up data and to be able to look at it. The whiteboard is there to make a quick sketch when needed. The really exciting thing is—I'm not very good at erasing the board—that the sketches from the previous conversation may still be around for the next. That's scary but sometimes also stimulating. Such schematics are absolutely essential for the discussion and sometimes people photograph them with their mobile phones, so they don't disappear completely.

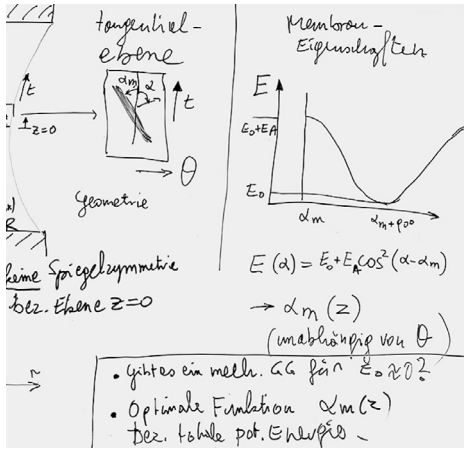


Fig. 4: Scientific visualizations in Peter Fratzl's office

• CB The question of images and visualizations has brought us back to Anna's artistic work. Dear Anna, the exhibition tried to not only show the work but also what actually takes place in secret, during the preparation, in the images and communication beforehand. This is also revealing in terms of the reference to the location. There are still old showcases in the object laboratory and you used these as a display from the laboratory situation to show different stages of your work. Would you like to say something else about the showcases and the reference to the location and perhaps also about these prehistories from anatomy to materials sciences?

• AK Well, I found it incredibly fortunate that you happened to be curating the exhibition and invited me. I didn't know *Matters of Activity* at all, I had no idea of all this research. You just said, this work fits in perfectly. I didn't realize that—it only really revealed itself bit by bit in the course of the exhibition, the conversations, and in the course of my participation in the various activities and exchange opportunities with *MoA*. Each time I was increasingly amazed at how fitting it was to be there with my work: it started with the location of the object laboratory and its connection to horses. The acoustics of the laboratory were also extremely beneficial for our performance. Of course, Oliver took incredible care in setting up these various performance stations in connection with the question of the acoustic effect in the space. It's not a concert hall and yet acoustically, it was able to support us for this performance. Of course, we still had a limited number of people there at the time due to the pandemic, but it was more than just a one-to-one performance. We could accommodate up to fifteen people, or was it twenty?

• CB Twenty, and five were allowed up on the gallery.

• AK Exactly. That was really extremely beneficial for the installation. The way the work was installed was also new, so every time it's reinstalled, it has to adapt and that's perhaps where my architectural heart beats, where I really had to respond to the space, the light, the acoustics, its context, its history, and its current function as a laboratory. It made sense to utilize this space in its entirety. And the display cabinets then allowed me to exhibit the various materials I used, from straps and hair to various different clamps. Suddenly it all became one single object, an art object in itself, which stood in a larger context. And perhaps this question of notation, which I also ask in my degree program in architecture, is also interesting in that I challenge the students in the second semester to write down and draw their everyday life in abstract form, which is extremely challenging. I'm trying to show them how to think about their activities in a new way and to manifest them in a two-dimensional form. But actually there are many more ways of noting things down, there is the incredibly important process of noting things with pencil and paper, notating things in the process of conversation, there is the vinyl you mentioned earlier that records the sound, and not just as a musical score. (By the way: it wasn't pressed like usually in a large quantity of records, but each one was individually inscribed, so actually each of these vinyl discs is unique. This was the result of a limitation of possibilities, but it turned out to be a logical consequence.)

There is the two-dimensional notation, and I also asked a pianist who of course knows the *Well-Tempered Clavier* very well, András Schiff. He has recorded the *Well-Tempered Clavier* several times and worked with an artist who did the cover. Very often the *Well-Tempered Clavier* is recorded in two-dimensional notation by color theory, for example, and I asked him: is there also a three-dimensional notation, a physical manifestation of this score in three dimensions? And he wasn't aware of anything. I said to myself, perhaps I can strive for a three-dimensionality of Bach's *Well-Tempered Clavier* and put it also in relation to the question of the origin of the piano as an instrument. I simply followed the logic of the tonal scales, which came into being at the same time as the *Well-Tempered Clavier* and the piano as an instrument, and I followed this logic in the creation of this object. In other

words, the object did not arise from my intuition to create a spine but from a logic to create a frame with eight horsehairs that have a certain length, which started at a length that is used for hygrometers and the classical measuring instruments and went on to the maximum length, which is a bow (for a string instrument) but can also be the maximum length of a horsehair. And I worked through the scales from C major to A major and so on and translated it into black and white horsehair, so that's the logic I followed, from which the form then emerged. So the form itself emerged by following this logic. That's also why I don't have that many sketches, and that's perhaps also interesting for this discussion: when you have conversations and make notations, you naturally also make a lot of sketches in the artistic or design or architectural process in order to understand how you have to deal with details etc. I wouldn't necessarily publish them, because they are simply scribbles that lead me to this goal, so it's a valuable work process but an active one that remains internal. I have collected them in my sketchbook and also organized them. So I don't throw them away, although I don't actually use them, I would never go back to them. That's perhaps the distinction between all these different forms of notation.

• CB As with the drawings, can you tell us how this work came about and what starting points were decisive for you in terms of the activity of the materials?

• AK Thinking about the origin of the *Well-Tempered Hygrometer,* it has become clear to me that it stems from my family background. I spent a lot of time with my grandparents, who were both musicians and farmers. So for one part I had musical training in my childhood and for the other part I spent a lot of time in the forests and learning how to draw. At the moment the farm with its forest is a big topic in our family. Climate change has hit the forest hard in these last decades. So wood, time scales, »well-tempered« climate are ongoing topics for my practice. For instance on the time scale, there's this saying: you plant the tree under whose shadow you'll probably never lie, the shade of the peaking of time spans and time scales. Currently we are trying to re-forest our woods that have been greatly damaged by climate change. I can't help but wonder to ask myself: is human intervention necessary? And I think these are extremely interesting questions. Is it possible to answer this scientifically? Ethically? Biologically? From a materials science point of view? Is it a question of generations, a socio-cultural question? My great-grandparents planted monocultures and the generations after them were living off them. What we plant now could benefit the generations after us. So the future depends on the decisions we make now. For example: we have a lot of beetle-infested wood that can't be used, can't be sold, can only be used as firewood.

• PF In fact, the question of whether beetle-infested wood can be used in a more sensible, sustainable way will be addressed.

• AK Yes, actually, we have already taken Pelin Asa, a civil engineer in the Cluster, to the farm. We showed her various sawmills.

• CB Thank you both very much for this conversation.

DEVICE BY SABINE HUZIKIEWIZ

Claudia Blümle

Intermezzo 1

Fig. 1: *Device* by Sabine Huzikiewiz

The art piece *Device* by Berlin-based artist Sabine Huzikiewiz operates between design and art, between commodity and object of observation. A double picture frame opens up an intermediate space in which pictures can be hung in a sliding manner on white or black grids. Alongside the wooden frame runs a perforation similar to a 35-mm film strip, created with the help of a 3D printing program and a CNC milling machine. The multiple flexibilities of *Device* allow an open structure for working with images that can become visible and invisible next to each other and one behind the other. As an apparatus for art historical research and as a collection piece, *Device* has now been relocated to Tieranatomisches Theater (TA T). For *Stretching Materialities*, it is the mobile site of exhibition documentation in transition or the starting point for performative situations at TA T. In this sense, *Device* is an object that creates a milieu in which action takes place. The manner of framing or structuring accompanies the practice of inviting other thoughts and involvement—both for purposes of documentation as well as in the sense of an extension of *Stretching Materialities*.

One starting point for this installation was the art-historical work with images, often on a computer, where several open windows and images can overlap. Another starting point was the grid: a group of six grids without purpose, leaning against a wall. A wooden construction, which the artist simply calls »box,« allows them to stand upright. The box consists only of edges, which conversely consist of two types of frames. In this box, the grids are fixed at a set distance from one another, but each grid can slide in its own rail. They are stable yet mobile so that the overlap of the grids is variable and can thus expand and stretch in space. There are two further possibilities for movement. First, the entire frame box can be rolled because it has four wheels. Second, it is possible to remove the grids from their rails or slide them to another location to return them to their slanted position and set them up. These grids can thus remain in the frame, i.e., in the picture frame, or be taken out as an object itself and freely distributed and used in the exhibition space.

Following the idea that these grids contain several frames, they have been given permission to serve a purpose: pictures can be hung within the grid so that images can overlap in the box. The overlap brings together different places and topics, allowing images to be viewed simultaneously. In the context of *Stretching Materialities*, images from various projects are taken and presented in an overlapping way. *Device* is intended to be a movable object that shows its mobility but also an empty space that can be occupied. Accordingly, when the exhibition space of *Stretching Materialities* was almost entirely empty toward the beginning of the project, it took on more of a protagonist role. In the course of the changing situation, the work was more strongly integrated in its use of shifting and rearranging, becoming a commenting and documenting perspective outside of, as well as inside, the exhibition. The constellation of Object Space Agency is thus presented as an installation.

Stretching Virtuality

Christian Stein

Deconstructing the Exhibition

If we are to believe Daniel Tyradellis, Deputy Director of the Helmholtz Center for Cultural Techniques, and examine his polemic »Tired Museums,« museums and exhibitions can be seen as »places of resistance against the impoverishment of thought« (2014, 14), »laboratories of the social« (15), and media that »restore a certain corporeality to thought« (17). However, as he continues, they frequently remain trapped within their rigid and self-referential hierarchies, unimaginatively reproducing the same formats over and over again. They shy away from risks and, in their safeguarding maneuvers, strip themselves of societal relevance. The professionalization of curating poses the danger of positioning itself within the field, aligning with standards, and fulfilling the expected, rather than seeking the unexpected. In light of such a diagnosis of the German museum landscape, I argue that non-professionals from other disciplines, with different experiences, can productively engage with the format of exhibiting and, first and foremost, deconstruct the exhibition.
→ Stretching Spaces, 184

As Object Space Agency (OSA), our interdisciplinary team has done exactly that. Our attempt to bring the complex topic of active matter into a tangible, interactive format did not begin with professionalization in curation and exhibition design. Rather, we asked ourselves what exhibitions might achieve if we did not conceive them as mere showcases of established results but instead as laboratories, where the experimenters dare to step into the view of the visitors, ask questions, inspire, experiment, provoke, fail–and take risks.

»Exhibitions are not mediated–they are mediation,« Tyradellis further asserts (2014, 87), and indeed, exhibitions can become the space where knowledge is exchanged–not unilaterally, not in one direction, not in a simulation of listening but in a truly mediating dialogue. → Intermezzo 5 For it is not only the interested public that stands to gain much from listening to academia (rather than merely admiring or criticizing it in a generalized manner), but academia itself also gains perspectives, questions, connections, and alternative forms of knowledge only when it opens itself beyond disciplinary boundaries.

Our project's predecessor, the Cluster of Excellence *Image Knowledge Gestaltung,* adopted this expansion of disciplinary boundaries as its guiding principle. Its interdisciplinary lab, as

its subtitle »the interdisciplinary laboratory« suggested, lived up to its name, involving over forty disciplines. In this spirit, OSA worked, combining individual and disciplinary perspectives from physics, computer science, design, architecture, cultural studies, art history, German literary studies, and game design. As such a heterogeneous team of curators, it is hardly possible to develop a single, unified narrative line that runs through the exhibition's concept. Thus, a different path was taken, leading to a different conception of both exhibition and curation.

→ Stretching Practices, 49

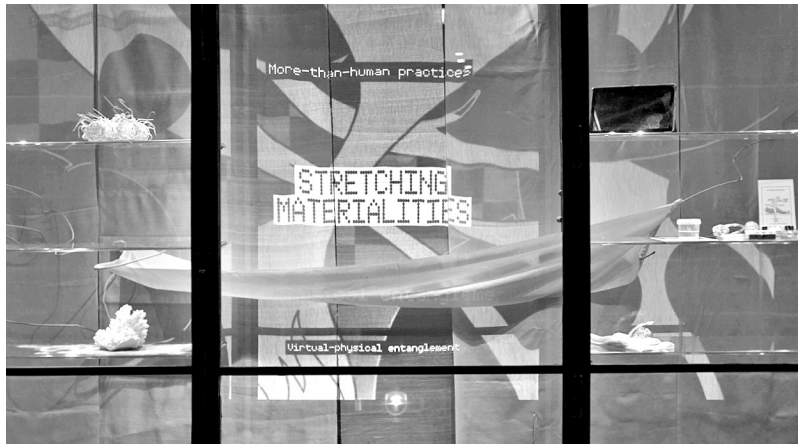


Fig. 1: *Stretching Materialities* logo

The positions, preparatory work, and interests of the curators could not have been more divergent. Whereas the theme »active matter,« which was to serve as the focal point of the exhibition, was set, its individually selected aspects were so varied that the map of ideas quickly filled entire tables and walls. A competition of ideas ensued, each beginning with its own prerequisites, evolving internally, and converging with other ideas. The more concrete the work became, the more productive the collaboration grew.

We each asked ourselves: which aspect of the overarching theme »active matter« can I best illuminate with my expertise? Can I create something special and unexpected? Can I present something that is conveyed better through showing than through explaining, something that opens up a space for individual discovery? How can I present this in a way that does not exhaust itself in a singular interpretation or statement but includes the unknown and the open-ended? What interactions can I enable with the exhibited objects that allow exploration and experience, play and learning? How does the exhibited object connect with other objects, what relations can be built, and how can these be shown? How does the exhibition space, the context, and the coexistence of other objects alter my object, and how can

I embrace this transformation? What questions do I have about my object, and how might the exhibition help me answer them?

❑ Process, fig. 5, 269

Our idea of an exhibition deliberately did not seek to compile the status quo of knowledge on a subject, to make it visually accessible through objects, and to present it as a »presentation of knowledge.« Instead, we sought to take subjective approaches seriously, aiming for less objectivity and completeness. The exploratory experience was meant to be central, making an exhibition visit a highly subjective experience that would not follow a singular narrative thread. The exhibition space with its architecture, history, and materiality thus became a vital experiential space and a central part of the exhibition itself. The conception evolved from very heterogeneous points and perspectives, converging rather than radiating outward from a single theme. The most important strategy for creating the exhibition was the principle of searching and attempting—for the curators as much as for the visitors. One could say that the exhibition thus became a dynamic experimental arrangement, a series of experiments in the laboratory (fig. 1). And the public served as crucial experimental material.

Merging Virtual and Physical Realms

Museums do not merely house exhibitions; they are exhibition spaces. The spatial aspect enables the juxtaposition of objects and artworks, an arrangement, a dialogue with space, light, perspective, and neighboring elements. In many contexts, it is particularly important that the objects on display are originals. The magic of the exhibit lies in the fact that it is genuine—not a copy or simulation but unique, often historical, and physically present. It is the idea of the object's aura, of the irrefutable presence of the authentic. Walter Benjamin defines the aura of a work of art as »the unique phenomenon of a distance, however close it may be« and attributes it with »inaccessibility, authenticity, and uniqueness.« His essay *The Work of Art in the Age of Mechanical Reproduction* (1935) is nearly a century old. In it, Benjamin explores the question of what remains of the original when mass-produced copies begin to replace it, and how art has developed and will continue to evolve under these conditions.

Today, the technological tools used in and for exhibitions go beyond mere reproduction machines. They have become

production tools themselves, enabling the creation of original artworks and objects that could never have been realized without them. The virtual, understood as simulation, as something not real, as an object in an »as if« mode, has been added to the physical. Many significant artworks and objects in museums have already been replaced by replicas to protect the original from the potential risks of exhibition. This does not bother visitors usually, as long as the exhibition environment still manages to highlight the object's uniqueness and offers an enhanced experience that can only be achieved in that particular context.

The original, which we still regard as the most valuable, is also the object that increasingly deteriorates, requiring more elaborate conservation and restoration, and which, due to the need for protection from light, air, and touch, becomes ever more elusive to viewers—not only remaining inaccessible but becoming increasingly difficult to perceive. The relationship we can build with the museum object is hindered by the protective layers of its exhibition.

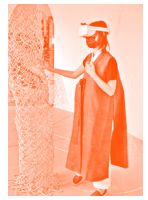
The virtual steps into this gap. The deeper insights it offers increasingly compensate for the fact that it is not real but »merely« virtual. Whether it is through film, which shows an object in activity and its natural context, a 3D model that enables the exploration of all its details and internal structure, or through a reproduction that can be observed and even touched without protective barriers—wherever the original moves away, virtuality comes closer. The knowledge of the originality of the object still retains its value, but the process of appropriation, engagement, and subjective inquiry with eyes, hands, and questions has become ever more important through our daily interaction with media. ❑ Exhibition, fig. 6, 126–127

Just as in an orchestra, where the musicians on stage are only seen as small dots, and the audience's gaze shifts to the large monitors, the exhibited object is divided into the original, contributing its uniqueness and specialness, and the virtual, enhancing visibility, subjectivity, and interaction. Together, they form a new contemporary mode of perceiving objects in exhibitions.

The concept of the virtual is broad and refers to anything that exists in a different form than it appears. Today, when we speak of virtuality, we often mean digital representations of physical objects, processes, or structures. However, exhibiting itself inherently contains something genuinely virtual: the objects on display are removed from their original context and arranged in an artificial space. → Stretching Time, 227

This creates new proximities and with them, new narratives, interpretations, comparisons, and oppositions, which largely determine the reading of the object more than what the object itself inherently expresses. No object can »exist in itself;« its relationships to its surroundings define its meaning, message, and value. → Stretching Practices, 33

Saussurean structuralism emphasizes this relational, structural property of meaning within semiology: *valeur*, the value of any sign—whether spoken word, written symbol, or object—arises through its proximity to other signs. Saussure calls this the »nullité du sème en soi,« the worthlessness and meaninglessness of a sign in itself (Saussure 1967). Meaning emerges in language, society, and the art space of an exhibition through the opposition, proximity, position, and difference of the displayed objects in relation to one another. → Stretching Practices, 27 This fundamental observation shifts the focus away from the object toward the space, from the individual to the relation, from the singular to the plural. In exhibitions, we experience guided interpretations; the object in the arrangement of other objects seems different from how it would appear in other contexts. Virtuality is already present in these arrangements of original objects, in the impossibility of isolated observation.



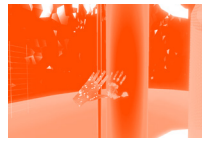
When we speak of virtuality in exhibitions, we often refer to the use of technologically generated virtuality. ❑ Exhibition, fig. 25, 143 The distinctive feature of virtual objects compared to physical ones is the high degree of freedom in their presentation, interactivity, visuality, and level of detail. Virtuality follows different logics than the physical, as virtual objects are created in a completely different way, have different dependencies and gaps, and thus bring their own digital materiality. This digital material, shaped and animated by digital tools, pushes the boundaries of what is designable, offering insights that cannot be reached through physical originals or replicas. The goal is not to replace or displace the original but to create specific insights that occupy a particular position within the exhibition context and would otherwise be unattainable. ❑ Exhibition, fig. 12, 134

A 3D model of an object, for example, can scale up tiny structures to human proportions, making them visible, or reduce enormous formations to a more manageable size. Extremely slow changes can be sped up, and very fast movements slowed down. → Stretching Time, 211 Objects can regain lost activity,

providing glimpses into their interior that would destroy the physical object. They can be observed from every angle and as closely as desired. Visitors can interact with them—opening, moving, activating, or disassembling them. All these possibilities are perfectly suited to explore objects that, rather than withdrawing and needing protection, invite interaction. It is the playful, exploratory character, free from the fear of breaking something, that makes these virtual elements of exhibitions particularly rich. → Stretching Senses, 317

Playing in exhibitions is, in this sense, a highly desirable practice. Play creates a protected space where experimentation and exploration are free from the pressure of potential consequences. The materials used for play are designed for this very purpose, and the players engage with them accordingly. The fear of damaging something, behaving ignorantly, being judged as foolish, not doing the right thing, or failing to meet expectations is greatly reduced in play. Everything that happens in play remains without consequence in the realm outside play. No one fears mishandling or dropping a virtual object. The virtual realm already carries with it the markers of play and invites interaction. The act of interacting itself is the process of creating relations. Just as objects in a room derive their value through their relations to one another, so too do they derive value for visitors through the relations that the visitors are able to draw. A factually correct and objectively written object description fails in this regard: it may withstand the scrutiny of an expert, but it reaches less-informed visitors all the more poorly. The approach of museal objectivity often misses the visitors' need to connect their experience to their personal lives and world. Play, by contrast, does not explain, does not instruct but instead allows for experience and discovery. ❑ Exhibition, fig. 11, 133

Mediated experiences can engage with a wide range of sensory perceptions. One can listen to a story and relive it through inner imagination, touch an object and delve into its form and function, bring forth memories and associations through scent, or move through a room while absorbing its atmosphere. Sensory impressions coalesce into a more or less convincing image, a surrounding world within which individual perceptions are placed. The quality of this immersion into another world—whether ethnological, biological, scientific, technical, or artistic—greatly determines what visitors take away from the exhibition, what they learn and remember. It is no coincidence that the high art of curation includes not only the selection and arrangement of objects but also the design of the exhibition space. Display cases, flooring,



visual design, pathways, and lighting play just as significant a role as they help visitors step out of their everyday perception and fully immerse themselves in the exhibition.

When considering how to combine spaces, atmospheres, and playful interaction within virtual environments, we cannot avoid the advancements made in virtual reality (VR) over the past ten years. Head-mounted displays (commonly referred to as VR headsets) represent a new medium because they allow users to entirely immerse themselves in a virtual space, without showing any »remnants« of the real environment. Unlike large screens or projectors, the virtual world in VR completely surrounds the user. This drastically alters perception, as there is no longer any visible difference between the virtual and the physical space to disrupt immersion. A space of experience can be created where users not only observe from the outside or are led by the camera's movement but are free to fully explore it. ❑ Exhibition, fig. 18, 138

At present, virtual reality is used only sporadically in museums. However, this is likely to change soon. VR is fundamentally a spatial medium. No other medium can render space so intensely and palpably. The combination of virtual and physical spaces in a museum offers an expansion of the exhibition space, the possibility to enter inaccessible spheres, and the ability to explore gigantic or tiny virtual objects and artworks. It removes the inertia of physicality, opening up a realm of expression and experience that allows content, spaces, and works to be explored and experienced. It is anticipated that museums worldwide will soon make significantly greater use of VR, with art being created within VR, and entirely virtual museums finding their way into homes.

The idea behind *Stretching Materialities* was not to integrate a purely virtual experience at a specific point in the exhibition but to layer the physical and virtual exhibition spaces. This overlap was intended to encompass the entire rotunda, allowing visitors to move freely through the space using virtual reality headsets. Rather than a stationary VR application, the VR headset allowed for movement in the virtual world that was achieved through movement in the physical world. Visitors should be able to walk freely through the exhibition space, both physically and virtually, gaining layered impressions of the exhibition's levels. The application was designed to immerse the entire body in the virtual world and, conversely, link the physical with the virtual.

1 This included use of a Virtual Reality app developed for the exhibition. Its source code has been published under an open source license (Stein 2025).

To achieve this, we had to virtually recreate very precisely the rotunda, including passageways, columns, walls, objects, and the central elevator. This model was then aligned so that the virtual rotunda exactly overlapped with the physical one. A step taken in the physical space corresponded precisely to one step in the virtual space, and the distance covered in the virtual rotunda matched exactly that in the physical one. As visitors walked through the rotunda with their virtual reality headsets, they would reach the opposite end and see a virtual wall exactly where the physical one stands. Visitors could stretch out their hands and touch, feel, and explore the virtual wall as if it were the physical one—a merged perception between both dimensions.

Given the basic geometry of the room, several possibilities arose to alter it within the virtual space. Instead of a wall, for instance, there could be an abyss in the virtual world, signaling that the user should not proceed further. The marble columns would maintain the same dimensions and positions in the virtual world but might be made of a different material, perhaps transparent and stretching endlessly skyward. Thus, we could create different virtual spaces using the same geometry, all walkable and each distinct. The physical space defines the possible, sets the boundaries, while the virtual world shapes these potentialities. Using this spatial geometry as the foundation, we created six distinct floors that the exhibition visitors could explore.[1]
→ Stretching Senses, 307

Virtual Physical Exhibition Elements

Elevator Platform—The central elevator connects these floors. Because of the exhibition space's circularity, it has an exact center, surrounded by four columns. → Stretching Practices, 29 We located the Virtual Elevator in this central area, linking the different floors and allowing visitors in Virtual Reality to switch between them. In the physical space, the elevator consists of a round wooden platform on a metal frame, elevated about 12 cm off the ground. A regular step leads onto the platform. The wooden platform is equipped with vibration motors that can set it into a vibrating oscillation. The step that visitors can feel underfoot, combined with the vibration of the platform, makes using the Virtual Elevator a more intense experience, and the transition between floors is accompanied by a physical sensation of movement. In VR, the elevator appears with glass walls extending to the ceiling. Inside, there is a virtual panel where visitors can select the desired floor. With an intuitive hand gesture, one can press a button, the elevator doors close, specially designed elevator music plays, and the platform moves up or down.

VR Headsets—For this purpose, we selected Meta Quest 2 headsets as our hardware platform. These are standalone headsets that function without being connected to a computer, as they include an integrated computer. This allowed using the headsets wirelessly, enabling free movement throughout the exhibition space in the rotunda. The selected headset also offered inside-out tracking, where position and orientation in the room are determined by four built-in cameras. This system tracks head movements through the shift in camera images and their comparison, eliminating the need for an external tracking system, such as those typically using infrared stations. These technologies combined created a large walkable area within the museum space without requiring further modifications, limiting movement, or restricting the number of headsets used. Additionally, the cost of these standalone headsets is about one-fourth that of a computer-based system with external tracking. This cost-effectiveness allowed for the provision of more headsets for parallel use.

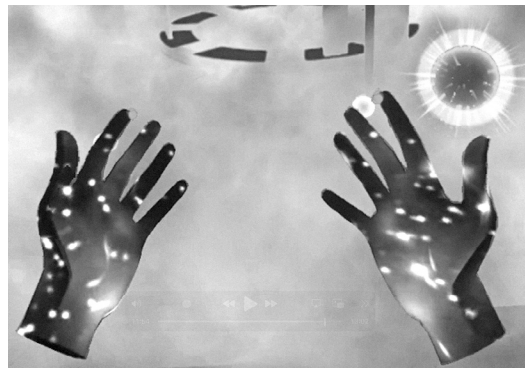


Fig. 2: Camera based hand tracking with »cosmic hands« within the VR headset

Hand Tracking—A significant obstacle to using VR headsets in museums and exhibitions is the need for controllers. While gamers across generations typically have no trouble using VR controllers and quickly become accustomed to them, non-gamers require an adjustment period. ❑ Exhibition, fig. 25, 143 This adjustment can distract from the actual experience and may be perceived as a technological barrier, drawing attention to problems with the technology rather than the experience itself. To avoid this, a controller-free setup was chosen. The Meta Quest 2 headsets have integrated hand tracking, allowing for an alternative control system using the user's own hands (fig. 2). When the hands are within the field of view, they are captured by the

integrated cameras and their position and orientation are accurately transferred to a 3D hand model, which is then represented in the VR headset. Thus, users can see their own hands despite wearing a VR headset. The virtual hands can visually differ from the physical ones. For *Stretching Materialities*, a blue-green pulsating surface was chosen, giving the hands a fascinating, almost »magical« appearance. Due to the system's high accuracy and responsiveness, users immediately recognize the virtual hands as their own, even though their surface looks entirely different. This deliberate alienation effect enables a »re-seeing,« where users are fascinated by their own hands and unconsciously explore the relationship between identity and representation: their own hands are displayed, they feel like their own, their position in space and relative to their body is precisely represented. Users can intuitively press virtual buttons with their fingers or touch objects without needing to learn how. At the same time, their arms aren't visible; the »skin's« virtual representation is entirely different, and the display is still mediated through the integrated screen. Without making it explicit, the experience of one's own body raises questions of virtuality and physicality, material and surface, function and simulation, which are playfully explored. There is no task or explicit discussion of the theme; the reality of the experience itself invites experimentation, exploration, and discussion.

Laser Pointer—A particular challenge was to calibrate the system, which is not designed for mapped use in physical environments. Typically, the starting point in a virtual environment is dynamically set based on the user's current position and can be reset during use. Not only the position but also the neutral orientation of the headset is usually set independently of its location in the physical space. For the scenario we envisioned, however, we needed to achieve an exact overlay of orientation. For this, a custom solution was developed to ensure high calibration precision. While the headset's position could have been determined sufficiently accurately using simple floor marking, this was not enough for orientation. Deviations in the sub-millimeter range would have already caused significant shifts between virtual and physical objects across longer distances. Therefore, we attached a laser pointer to a 3D-printed mount onto the VR headset and used wall markings on the opposite side (fig. 3). This allowed us to align the headset consistently and precisely position

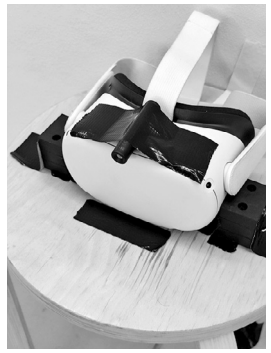


Fig. 3: Custom setup of a VR headset with mounted laser pointer for exact directional calibration

it using the laser point and wall marking. Since the surface of the headsets is rounded and lacks clear edges, attaching the 3D-printed laser pointer mounts differed slightly on each headset. To compensate for this variance, we used color-coded markings on the wall corresponding to the colored markers on the headsets. Thus, each headset was aimed at its corresponding colored mark to achieve exact positioning. For this purpose, we built a specific calibration station on the edge of the rotunda. This station had to be immovably attached to the floor, as any change in position would have rendered the markings and calibrations useless. The station was equipped with firmly mounted perspex blocks, onto which the headset could be pressed despite its rounded shape. The fine-tuning of the calibration was then done manually using the laser point. Once the headset was precisely aligned, its position was reset by pressing a specific button on the controller.

Recalibration— In theory, the headsets remember their position and orientation, restoring this information after deactivation and reactivation. However, in practice, the headsets would often lose their position and automatically reset to the defined center of the experience. The reason for this were the technical limitations of the system, which we used in an unconventional environment, marking one of the first usages of this kind. As previously described, the system determines its position based on four built-in cameras that capture the ceiling and floor. This exhibition scenario posed difficulties for this type of tracking: the lighting in the exhibition area was rather dim, reducing contrast, and both the floor and ceiling were very uniform, offering few visual anchors to serve as distinct positional markers. Additionally, the continuous movements of visitors within the exhibition area created further visual instability. Moreover, the internal Guardian system of the headsets, which restricts the available physical space, was deactivated in a special developer mode to render the entire rotunda walkable. Occasionally, the volume of visual information would overload the internal memory and reset the latter. When this happened, the alignment between virtuality and physicality would break apart, making it impossible to spatially orient oneself.

Using these systems in such an experimental setting, we had to contend with these challenges. Although newer technological developments might have resolved these issues, our goal was to push the boundaries of what was technically possible and offer

an experience that exceeded the current state of the art, accepting potential technical glitches along the way. As a result, visitors often reflected on virtuality's functioning, and the constructed nature of their experience became a topic of discussion.

To ensure the exact overlay of the virtual and physical environments, everyone working in the exhibition had to be able to recalibrate the headsets. This knowledge was passed on not only to the project team but also to assistants and museum staff. Therefore, the headsets were typically recalibrated after each use, or as needed, even during use. Occasionally, systems would fail entirely, as they were not designed for such large-scale environments, and the use of unsupported developer functions could cause system errors at the operating system level. In these cases, the entire Guardian system had to be reset, and the internal memory wiped and rebuilt. In some instances, a factory reset of the headset was required. This exploration of the limits of what was technically feasible and operating with very recent, untested developments benefited the exhibition's character. While visitors generally enjoyed a highly immersive experience, occasional errors caused breaks that triggered valuable reflection processes, often leading to conversations with and questions to the exhibition creators, guides, or museum staff. This greatly added to the impression that visitors were not interacting with a finished exhibition product but part of an experimental research lab where they could actively participate and even provide valuable feedback.

Glass Elevator—The central idea of the exhibition design was the glass elevator located in the middle of the exhibition space. Entering and exiting the elevator, as well as the journey within it, was intended to make the transition between different layers of experience palpable, preparing visitors for a new level of perception. The elevator also referenced the historical, mechanical elevator in the very same spot that used to transport animal carcasses from the lower floors of the slaughterhouse to the auditorium. It connected the preparation and storage areas with the presentation rooms. This connection serves as a metaphor for the exhibition, as here, too, process and preparation are linked with presentation and perception.

Inside the virtual glass elevator, visitors would experience a physical sensation that once again made the convergence of the virtual and the physical tangible (fig. 4). The first design element was the platform. Entering the elevator involved stepping

Fig. 4: Inside the virtual glass elevator

up onto a small ledge, which resulted in a slight change in height. The immersion effect was particularly enhanced by feeling the edge with one's foot, as the physical sensation supported the sensory information from the visual experience. Additionally, this created a situation of slight imbalance: trust in the virtual perception was challenged and put to the test. If the visitor felt confident walking around virtual space, stepping up onto the platform could once more challenge one's trust. This moment of testing is crucial, and overcoming it increased the visitor's confidence in the virtual environment's navigability. In the virtual world, the step onto the platform was marked with a large warning sign in yellow and black, drawing attention to the obstacle. Nevertheless, we ensured that this critical moment was typically accompanied by an assistant to prevent falls in practice. → Stretching Senses, 294 Luckily, no one fell or tripped during the exhibition's entire run.

Physical Elevator Button—Initially, we had envisaged a physical elevator button to overlap with the virtual one, offering a tactile element when selecting a virtual floor. This button was produced and mounted on the elevator platform. Inside it, there was a presenter that could send various signals to the server via Bluetooth. We disassembled the presenter and connected its button signals to external buttons. Technically, this setup worked perfectly and would have added another immersive element to the elevator ride. Unfortunately however, the setup was dependent on

a millimeter-precise calibration of the headsets. If the calibration was only slightly off, the physical and virtual buttons would be misaligned, leading to irritation rather than increased immersion, ultimately eroding trust in the virtual environment. Despite numerous attempts, we were unable to achieve the necessary precision, so the setup was not used in the end. In the future, it is expected that the inside-out tracking of the headset will be able to detect objects in its environment, allowing for precise alignment. For now, our scheme was ahead of the current technological capabilities (fig. 5).

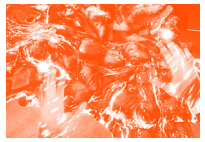
Fig. 5: A physical control station for the Virtual Elevator platform—later replaced by a virtual avatar interface to allow greater freedom of movement with material samples, cloud formations, and dynamic virtual objects

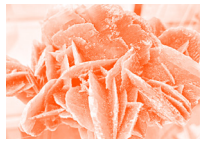
Bass Shaker—We added yet another immersive element beneath the elevator platform. When the elevator »moved« (i.e., pretended to move), four bass shakers were activated, causing the platform to vibrate slightly. This enhanced the sensation of standing in a moving elevator. The vibration started gently and transitioned into a fluctuating pattern that accompanied the »ride.« The bass shakers were activated by an additional server located in the exhibition space. This server was connected to all VR headsets via multiplayer functionality. When someone pressed the elevator button, the server triggered the bass shakers. This was done via a Bluetooth sound connection from the server to a splitter, which divided the signal into four outputs, sending them to four amplifiers, which were in turn connected to the bass shakers. As a result, a uniform vibration was distributed across the entire platform, starting immediately with the elevator's movement.

Object Tracking—For the exhibition, we intended to integrate additional tactile elements. However, at the time of implementation, the Quest 2 headsets were only capable of tracking hands. As a result, we opted for a different tracking system. We wanted to track a 3D-printed stone, which was also physically present in the exhibition for visitors to see and touch, using it as a control element in one of the levels. To achieve this, we created a 3D scan of the stone and printed it in its original size using a Prusa i3 MK3+ in bright green polyactide. This replica was then fitted with a VIVE tracker attached to its backside. The associated Lighthouse system tracks in a manner entirely different from the Quest 2 cameras. Here, detection is based on photodiodes built into the tracker, which are activated by an infrared grid continuously emitted by two base stations. These stations are mounted overhead, ensuring an ideal line of sight between the base stations and parts of the tracker at all times. This setup allows the system

to determine the tracker's position in the room by evaluating the infrared grid information. The system updates 60 times per second, enabling very precise tracking without noticeable delay, usually called »latency.« → Stretching Time, 227

Finally, the Lighthouse system's position was integrated into the inside-out tracking of the headsets by connecting the tracking server, so we could place the position data of the 3D-printed stone on one of the virtual exhibition's levels. The stone itself was placed on a pedestal at the edge of the exhibition and became active in the level »Geological Performers.« On (and in) this level, visitors could see, grab, touch, and move the stone both physically and virtually. ❑ Process, fig. 12, 274 The movement of the stone was then translated into the weathering processes of the rocks displayed in the level. Physical movement thus became a control mechanism for a chronological progression. → Stretching Time, 226 ❑ Exhibition, fig. 20, 140





In hindsight, this experimental integration of two different tracking technologies posed a significant technical challenge, as they were never designed to be used together. The proper coordination of the positioning systems, the balancing of discrepancies, the calibration, and the correct activation of all hardware and software components required a complex series of manual steps. As a result, the system was rarely used in practice, and most visitors experienced the exhibition without utilizing this unique tactile component.

Room Configuration—It soon became clear that mapping the space with all its architectural positions was not possible using the building's architectural drawings alone. For an accurate virtual-physical representation, we needed the exact positions of walls, columns, and entrances. When it turned out that the measurements were not accurate enough, we had to initiate a manual correction process. The four columns—seemingly geometrically placed at the exact center of the room—proved particularly challenging. Since our lead developer Marco Garcia was working remotely from Mexico, we connected one evening and spent an entire night in (virtual) TA T, correcting these deviations step by step. With voice communication and a webcam, I moved through the space, noting the necessary corrections in position, edge, diameter, and orientation, which Marco adjusted live in VR. Using this procedure, we were able to precisely adjust each level, while I verified and sensed discrepancies in VR (fig. 6).

Fig. 6: Room configuration at TA T

Material Communication

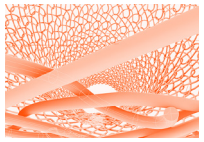
Particularly during the process of adjusting the virtual room model to the actual deviations in the physical space, it became clear that the connection between the virtual and the physical ultimately required meticulous manual work and tedious adjustments. Planning and realization often diverge, just as physical materiality and representational modeling do. When it comes to the details, as in our example, one's perspective on architecture changes: the illusion of geometry becomes questionable, and the shifts and compromises inherent in construction—which permeate any building—become central elements. Some of these deviations are due to measurement inaccuracies, others serve as corrections for certain existing deviations, and yet others respond to circumstances that were not, or insufficiently, considered in the plan. A building no longer appears as the mere realization of a plan but as a flexible framework of materials reacting to and compensating for one another. These materials communicate with each other: they transmit, filter, or block light, acoustic vibrations, electrical charge, pressure, temperature, liquids, and even molecular connections. Similar to verbal communication, material communication can only succeed if it incorporates and bridges ambiguities.

Any material object—and any configuration and spatial arrangement of objects—can be understood as such material communication. The configuration of materials, then, represents a communication network that combines various materials, positions them in relation to one another, and directs their interactions in specific ways. ❑ Process, fig. 7, 270

Materials with different surface textures can have a kind of conversation that materializes spatially. Red sandstone, as seen in the exhibition space's columns and walls, borders against polished granite, creating a material correspondence—a relationship that neither material could achieve on its own. Looking at these surfaces, one can recognize continuities and ruptures, proportions and relationships. Every material present in the space appears differently with other materials present, taking on a role assigned by their configuration. We know this from optical illusions: a gray tone appears lighter when contrasted with dark gray and darker when contrasted with light gray—even when placed directly side by side. Thus, we always perceive materials in context, assign them properties relative to their surroundings, and listen to their intermaterial dialogue. This process occurs not only visually but also haptically and even acoustically. Even though we are rarely conscious of it, we hear spaces and materials and have an unconscious sense of how material spaces sound. Perception happens through the perceptible properties—the surfaces. Just as a thin layer of paint can cover the underlying surface of a wall and create an entirely different material impression, so too material surfaces can deceive. For the exhibition, we chose a red sandstone that would be placed alongside the columns to represent the building's material and make it accessible through touch. We found a particularly treated and colored concrete, whose surface properties closely resembled the real sandstone of the column. Here, the similarity of the surface played a more significant role than the actual materiality.

Specific reactions to external forces can emerge when combining rigid and flexible materials, for instance. Materials such as rubber, fabric, or elastic plastics symbolize adaptability and movement. They can bend, stretch, and deform, visually conveying dynamism and liveliness. In contrast, materials like stone, concrete, or metal represent permanence and immutability, conveying visual calm and stability. The combination of these materials can create a visual tension that makes the space feel vibrant and interesting. The flexible willow structures atop granite in the exhibition space created precisely such tension. Similarly, the cloud, as a highly flexible and ephemeral structure, contrasted with the rigid frame of the Virtual Elevator.

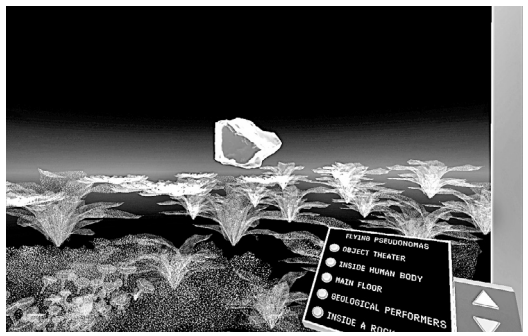
❑ Exhibition, fig. 15, 137 ❑ Exhibition, fig. 19, 139



Virtual and Physical Willow Structures—This form of material dialogue was reflected in virtual space. With the willow structures, however, an element of dissonance emerged for the visitors: while the willow in the physical space was not only flexible but also deviated from its ideal form due to storage, movement, and shifts, its counterpart in virtual space was geometrically perfect. Visitors who, as intended, crawled through the large structure on the floor, feeling it with their fingers and entire bodies, saw it in the virtual space as well but transformed, as it took on its ideal, computer-calculated form in the virtual world. ❑ Exhibition, fig. 17, 138 This dissonance was intentional. It represented the dialogue between the physical material, with its flexibility and adaptability to various factors, and the virtual material, whose structural properties were explicitly calculated and chosen. This material dialogue between the physical willow and the virtual willow was immediately perceptible as a tactile-visual experience. The structural similarity between the two remained apparent, visitors kept identifying them as one and the same structure, yet the differences provoked questions about material identities and specificities.

Any material wears the inscription of its environment(s): temperature, humidity, pressure, and time all exert their influence on its structure and leave their mark. The physical structure, laid out in the exhibition space for several months, was no longer the one that was originally planned and produced after it had absorbed this duration, its location, and the many people climbing through it, showing its transformation over time.

Fig. 7: In the virtual cloud—travelling between microscopic cloud particles in VR



Virtual and Physical Cloud—The cloud also reappeared as a virtual exploration space, with steaming wisps of fog rising up. There was a similar shift between the physical cloud and its virtual twin. When taking the Virtual Elevator to the top floor, one found oneself inside a cloud. The physical cloud was highly

reactive—responding to every movement of air, human presence, temperature fluctuations, and even breath, forming unique and unrepeatable shapes—while visitors in the virtual space had been shrunken and were surrounded by large, flower-like cloud particles (fig. 7). Some of these particles hovered dynamically and could be pushed away by hand. The change in scale resulted in a changing perception of the cloud's flexibility and adaptability. Here, in the small-scale virtual environment, the dynamic cloud became rigid; its large particles exhibited a distinct aesthetic. Flexibility and rigidity, as revealed here, are properties that depend on dimensions and relative proportions. How a structure appears, how it moves or can be moved, how it reacts, depends on the observer, their size, and position. In the virtual realm, it is possible to not only alter material but also adjust the observer's position. Scale and perspective can be manipulated, so as to bring what is invisible to a human, tangible scale. Visitors could see, feel, and grasp that material is not merely passive, the execution of a plan: it is living and adaptive matter that reacts, to varying degrees, to countless factors.

Fig. 8: VR-Multiplayer with physical and visual cloud combined on the virtual glass elevator platform

As the physical cloud condensed on the visitor's skin, brushing against their head and becoming palpable, visitors played with cloud particles in the virtual world. Their hand movements, in turn, stirred the physical cloud, changing its shape and form. This interplay was perceptible to an external observer, someone watching from outside the virtual space, who saw the hand movements—seemingly grasping at thin air—and the physical cloud's reaction to them (fig. 8). The swirling, abrupt movements, the

currents, and the partial dissolution of the cloud were all visible. The virtual cloud, as seen by the visitor, invited hand gestures, which in turn moved the physical cloud. In this back-and-forth of perspectives and materialities, of observational positions and interactions, a complex set of questions turned experiential, questions that do not easily resolve. → Stretching Practices, 40

Virtual and Physical Wall—Most walls of the rotunda are plastered, but in certain places, the original exposed red sandstone from Saxony is still visible. This sandstone has a unique surface texture, which feels pleasant to the touch and reveals a rough, detailed structure. After touching the wall, one can smell the mineral scent on one's hand, adding an olfactory dimension to the material perception. The wall opens up beneath the usual plastering, offering a kind of insight into the building's material. This material is highly active: it absorbs and releases both temperature and moisture. Thus, the cloud interacts directly with the stone. Every touch of the hand transfers warmth to the wall, which is perceived as pleasantly cool. Through the overlay of the virtual space onto the physical space, this already existing interaction was further expanded.

Technology As a Partner

Typically, we think of technology as a tool, a means to an end that helps us achieve our goals. Technology must not become an end in itself but rather serve a higher purpose. When technology becomes too central and captivates more through its effects than its content, it risks being flashy or used for its own sake. Museums and exhibitions, in particular, strive to place technology in the service of communication, carefully selecting and designing its use so that it best supports the content without becoming too visible in its own right. The tool in this sense is receding into the background as a medium.

In *Stretching Materialities*, we developed a different relationship with technology. Just as the exhibition was meant to reveal the process of exhibiting itself, we also wanted to make the influence and participation of technology as a co-creator visible. Inspired by Actor-Network Theory, we aimed to contextualize the role of the curators, relativizing their absolute position and considering the broader network of human and non-human actors. Technology—or rather, technologies—played a crucial role in almost every aspect of the exhibition. From video installations, measuring devices, and cloud machines to VR headsets and tracking systems, the exhibition consisted of numerous technological arrangements.

Virtual reality was applied here in an experimental mode, with few prior experiences and no reference projects. Working with the technology involved a process of tentative learning, experimentation, failure, rethinking, and letting ourselves be guided by the technology itself. One could describe it as a dialogue with technology, where the outcome was not simply the realization of a vision, but the development of that vision in tandem with the technology.

Technology as a partner in development should not be regarded as a mere instrument that executes human will but as an evolving entity, following logics resembling biological evolution. Technologies emerge, adapt, and sometimes wither, and this process is rarely linear. More often, it unfolds in hidden layers, revealing qualities only when a particular environment appears. Just as an organism's traits may remain invisible until challenged by new conditions, technologies display contradictions, strengths, and weaknesses that lie dormant until circumstances activate them. An interface that seems seamless in one context may turn fragile in another; a function that appears secondary may suddenly become central when conditions shift. Technologies cannot be fully understood in isolation but only in relation to the environments that test and shape them.

To take technology seriously as a partner requires a shift of perspective. Instead of imagining it only as a servant to human ends, we must attend to what it allows and resists. Resistance is not an obstacle to overcome but a signal revealing the technology's internal logic. Rather than pushing against it, it can be more productive to follow it, to ask what it discloses, and to allow it to redirect our plans. The same applies to errors and glitches. What is often dismissed as failure can guide us to hidden structures or overlooked potentials.

Technology is not a transparent medium that disappears behind its effects. It becomes part of the experience, part of the dramaturgy of an exhibition or installation. This reframing makes visible the porous interfaces between human and non-human actors and highlights that we are already engaged in a subtle but profound co-evolution with technological systems. While dominant narratives still present humans as the ones in control, bending tools to their needs, reality is more entangled. Technologies themselves participate in shaping intentions, behaviors, and meanings.

To recognize technology as an active materiality is to acknowledge its dual character. On the one hand, it presents polished features, often marketed as seamless and intuitive. On the other, it harbors concealed architectures, hidden dependencies, and improvised or hacked-in solutions that surface only in particular circumstances. A headset may feel like a gateway into another world, yet behind its sleek design lies a fragile mesh of sensors, code, updates, and workarounds. Such tensions are not flaws to be erased but characteristics to be explored. They remind us that technology is both made and making, both a product of design and an agent of transformation.

Placing technology on eye level requires more than technical skill; it demands a readiness to reconceptualize our ideas in response to what the technology reveals. It involves listening to its rhythms, learning from its resistances, and accepting its capacity to surprise. In experimental VR installations, this means treating the technology not merely as a display device but as a collaborator in meaning-making. The process becomes less about imposing a vision and more about developing that vision in tandem with the possibilities and constraints the technology introduces.

Such an approach embraces uncertainty. It accepts that outcomes may not match initial intentions and that unexpected results can be as meaningful as planned ones. It foregrounds the shared terrain where human intention and technological affordances collide, creating a space of co-authorship. Here, technology is neither background nor spectacle but a participant in the dramaturgy of the exhibition. By acknowledging its evolving, sometimes contradictory character, we allow it to contribute actively to the narrative of active materiality, showing the inseparability of human and non-human forces in shaping experience.

Exhibition As a Game

Exhibition spaces are no longer about displaying pre-existing objects but about dynamic, not fully determinable interactions. When applying this approach, one relinquishes control, risking misunderstanding, failure, or frustration among visitors. The narrative becomes fluid, interpretations multiply, and the points of connection become harder to predict. However, the connections with visitors might also become more intense, personal, and interesting. This shift reframes the exhibition space as a playground, and the visit as a live game with content that can be different each time and with each visitor.

In this sense, curators can learn a great deal from game designers. When designing a game, the focus is on interaction. It's not about telling a finished narrative in a linear way as opposed to film. Rather, it is about creating a specific, characteristic, and unique space that invites exploration, experimentation, and interaction. A game is not successful because the solution is reached; it succeeds when the path to that solution is engaging and interesting. The game designer sets the conditions where motivating interactions are likely, but they leave room for the observations, strategies, interests, and decisions of the players. In this sense, a game is not so much »designed« as it is an open system and a play space where play can take place through the interaction between the player and the game environment.

Similarly, an exhibition visit can be seen as equivalent to playing a game—it is not a predetermined sequence of events but a unique occurrence. How good or intense that occurrence will be depends on how well the play space and the visitor (or player) fit together and what can happen between them. In this sense, visitors, like players, are not static entities to be treated uniformly. Even the classic division by age groups falls short here. Rather, it is important to identify the characteristics of groups as they emerge and manifest within the interaction space—whether it is an exhibition or a game. In some exhibitions, prior experience with digital media may be irrelevant, prior knowledge, conversely, forms different groups. In other exhibitions, reaction speed or the social relationships between visitors might be more decisive. It is essential to recognize different audience groups based on their environment. Once this is achieved, the exhibition can better respond to these varied groups.

There's a notion in game design—»the game looks back«—which means that digital games do not offer a static, unchanging environment. Instead they can subtly adapt to the player's behavior. Games do not simulate a given world; they create a world that adjusts to the player. The difference between simulation and play lies here: a simulation strives to model an external reality as accurately as possible. The quality criterion is realism, the alignment between reality and the model, rather than the player's experience. A game, by contrast, draws parallels with reality primarily on a narrative level, borrowing from experiences with other stories or the physical world to create a world that feels familiar and manageable to a degree. Games often have

a physics engine through which virtual objects behave in ways that feel like they adhere to physical laws. Players recognize the similarity with the real world and can therefore interact with the game world more intuitively. But since it's a game and not a simulation, the parameters are often adjusted. The avatar moves faster than in reality to allow for quicker exploration. Objects can be thrown farther or break apart more dramatically to enhance the interaction with the environment. Reality is not the goal; it is an inspiration, and deviating from it is not only allowed but intended.

If we apply these considerations to exhibitions, we see that representing reality is no longer the primary goal. Instead, the aim is to create spaces where access to knowledge can become an individual process, where visitors can find subjective points of connection, and where new questions arise. Even in traditional exhibitions, the curatorial narrative rarely fully comes across. One might wonder how many exhibitions are curated for curators rather than for the average visitor.

Designing exhibition spaces is less about delivering a fixed narrative or a linear progression of knowledge. Instead, the focus is on facilitating an open-ended experience where visitors can engage in dynamic interactions and form personal, subjective connections with the content displayed. This transformation of the exhibition space into a game-like environment allows for a diversity of experiences, where each visitor creates their own journey through exploration, curiosity, and play.

Exhibit: Visitor

From the earliest stages of its conceptual development, one central idea for *Stretching Materialities* had always been clear: it wasn't just about the exhibits themselves, their selection, or their arrangement. Instead, the focus was on placing visitors in the spotlight and making them, and visiting an exhibition, a thematic part of the exhibition. An exhibition without visitors isn't an exhibition. Thus, the act of exhibiting happens in the in-between space, it comes about in the dynamic interaction between objects and visitors. The visitors' knowledge, their expectations, their gazes, their companionship, and their paths through the exhibition all contribute to shaping what is perceived, what leaves an impression, and what proves to be engaging.

Yet, visitors themselves are also observed by others. How crowded is the exhibition? Who is visiting? How do the other visitors appear? What do they focus on, where do they pause, what do they discuss? Visitors might not be aware of it, but they themselves are a part of every exhibition and, in turn, transform it—not only for other visitors but also the space itself. Each person brings vibrations into the room, micro-tremors that affect the exhibition space. They introduce fine particles and matter, which are released into the air, they leave behind dust or material carried in on their shoes. Visitors increase the temperature and humidity of the room, impacting the objects within it. It's a continuous give-and-take, a process of bringing in and taking out, of concentrating and dispersing matter, energy, and meaning. The exhibition space becomes a *trading zone*, a site of ongoing negotiation of meaning and atmosphere.

This concept redefines the exhibition as a shared experience not just between visitors and objects but between all elements in the space. It highlights the fluid interaction of materials, bodies, and perceptions, where each visit is unique, shaped by the visitors who inhabit the space and the way they move through it. Each individual's presence is imprinted onto the environment, both physically and symbolically, creating an evolving network of exchanges between the tangible and the intangible, the seen and the unseen.

Branching

With *Matters of Activity*, the focus has been on rethinking how we perceive matter, especially through the concept of »active matter.« Since 2019, scientists from over forty disciplines have worked together to challenge the traditional view of matter as passive, acted upon only by living agents. Commonly, we think of tools, for example, as inert objects that become useful only in human hands. In reality it is more complex: tools, and non-living matter in general, have their own agency and reactivity, influencing our actions as much as we shape them.

Active matter suggests a view where both living and non-living things are seen as highly dynamic, though these interactions are often too small, large, slow, or fast for us to notice. Rust forming on iron in the presence of water and oxygen is an example of this constant transformation—what we call »matter« is in a continuous state of flux. This also applies to digital matter: enormous data structures constantly grow, react with algorithms, and shape our digital environment, often invisibly. Virtual matter, like physical matter, is active and »alive,« reminding us that we should understand matter as a network of structures that exist and interact in both virtual and physical ways.

One of the key takeaways is that we can no longer maintain a position of simply opposing technology, especially in the arts. Technology is ubiquitous, an inseparable part of postmodern human existence. There is no going back to some idealized »natural« state free from technology. We can only have preferences for one technology over another. A paintbrush is as much a piece of technology as a 3D printer, and a sketchbook is no less artificial than an AI tool. The role of art is to reflect on and repurpose the technological landscape we live in. Technology is not synonymous with its appropriation by capitalism—it is a symptom of our world and it opens new avenues for artistic expression. Art and technology have always been interconnected, and today, this connection is bringing forth fascinating new art forms.

→ Stretching Practices, 36

Fig. 9: Visitors in the Museo Sivori in Buenos Aires, to which the exhibition had traveled from 15 March to 15 April 2023

This exhibition *Stretching Materialities* was a symbolic experiment—an experiment that continued and shifted to an adapted exhibition in Museo Sivori in Buenos Aires (fig. 9). It provided insight into cutting-edge research on active matter, presented through a VR experience that spatialized knowledge and perspectives. It also connected the physical and the virtual. The woven willow structure, made in Berlin, was placed in the center of the exhibition in Buenos Aires. Willow is a particularly active material, responding to pressure, moisture, and temperature, adapting itself to its environment. This willow structure, designed algorithmically and woven by robots, was interwoven with intricate weavings by the Argentinian artist Daniela Castillo Cortez that extended throughout the room. Beneath this, visitors in VR interacted with their surroundings, and their movements and gazes controlled virtual structures that grew into the virtual space. These virtual actions were translated into instructions, which Daniela wove into her physical works. The virtual reached into the physical, and the physical entwined with the virtual. Together, they formed a tapestry of symbolic and material connections, inviting visitors to reflect on how the world truly works.

At Humboldt University, we asked ourselves how we could open up the scientific discourse to the public—in Berlin and internationally. We realized that such global and important questions as those surrounding active matter cannot remain confined to academia. That would be disastrous. Scientists need connections with society and non-academic knowledge, and we must create shared spaces for dialogue. Often, scientific discourse is abstract and incomprehensible to non-academics, leading to its isolation. This can change. We need active dialogue between science and society. Our exhibition experiments are an attempt to give research a different surface, to make it more accessible. In Berlin, we work directly in exhibition spaces that are suitable to engage with the public. Our exhibitions are works-in-progress, invitations to participate in ongoing questions. They intend less to present conclusions and more to encourage inquiry. They are branching out, across borders of mind and space, and connect places on the globe as much as discourses and disciplines. Exhibiting in this sense means opening up, becoming vulnerable, experimental, perceptive—and revealing more than the polished results.

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THE ALCHEMY OF ELEMENTS: Fusing the Organic with the Inorganic

Nina Samuel in conversation with Lena Dues

Intermezzo 2

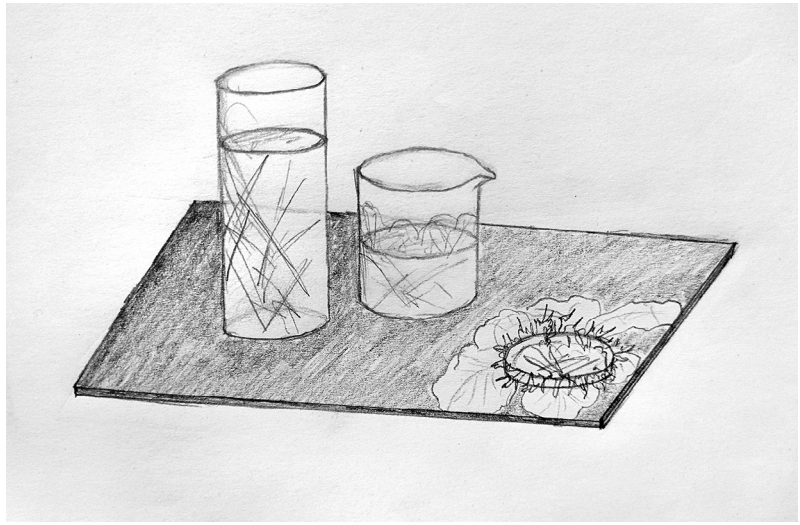


Fig. 1: Lena Dues, sketches in preparation for the installation *Auturgy of Carbamide*, 2021

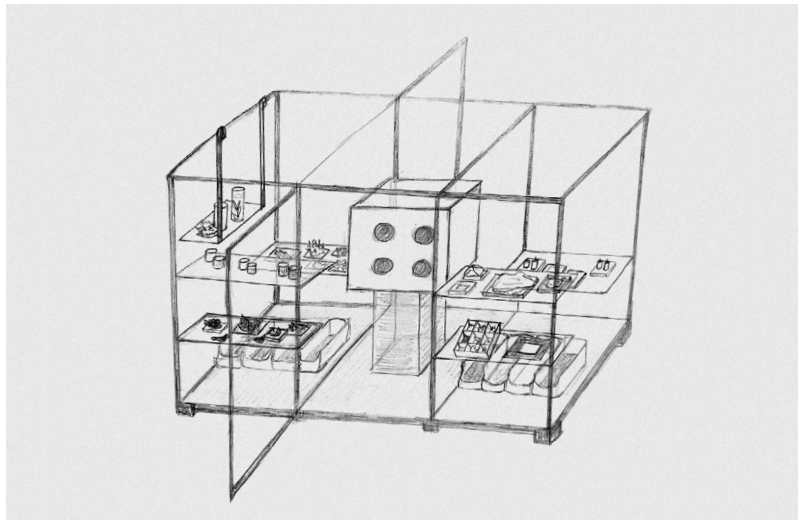


Fig. 2: Lena Dues, first draft for the installation, 2022

• Nina Samuel: The integration of your work was part of our processual development of the exhibition. ❑ Exhibition, fig. 21, 282 What was your first impression of the exhibition? Where did you spontaneously find links to your own work? What did you find particularly exciting?

• Lena Dues: During my first visit, I was incredibly fascinated by the exhibition. The location itself was captivating, and the geological display quickly caught my attention, especially its focus on the activity of rocks and their various forms, which resonated with my artistic interests. I particularly remember clothing items related to the skin's microbiome and bacteria. Also notable was a tiny microscope capable of detecting minuscule things in the body and performing minor invasive procedures. The cloud work and the concept of »scaling« from large to small were other fascinating aspects. They made me think about how we are constantly surrounded by matter, either within us or around us, and how a single movement can set matter into motion or even contain it within us. The combination of these varying perspectives in the exhibition was truly intriguing. And there was also another aspect that appealed to me. I understand the concept of caring for the various forms of life in the exhibition space as an expression of democratization—also in the relationship and interaction between artist and material, and between exhibit and visitor, who act as equals on the experimental platform.

• NiS Let's talk specifically about your work *Auturgy of Carbamide*. It consisted of two glass cylinders and two Petri dishes filled with a urea solution. During the exhibition, crystals formed through evaporation: the urea material formed crystalline sculptures without any further human intervention, thus referring to the self-activity of materials. Can you tell us something about the work and its genesis/creative process from your perspective (fig. 1–2)?

• LD The first thing I did was to find points of reference in the display case with the things that change. The material that changes always plays a role in the creative process for me. I had already worked with various aqueous solutions that form crystalline structures after a while. In particular, the desert rose and the calcite in the display case inspired me because they are also created through a crystallization process.

They illustrate growth as part of material activity. These minerals are formed over thousands of years by the crystallization of lime, gypsum, or barite deep underground. So crystallization as a growth process was already a theme here. I was able to pick up on that perfectly. At the time, I was driven by the question of the sculptural potential of these crystallization processes. I wanted to find out whether I was more interested in the form or the process. And I also wanted to consciously expand the question of the display case in the direction of the crystallization of an organic material.

What also fascinated me was to think about the display case in a different way. It was no longer presented in the exhibition as a closed entity that excluded me as a viewer and that I was not allowed to touch under any circumstances. On the contrary, the display case was opened, I was allowed to come into contact with the objects and to understand them by touching them. There was also something very experimental about the showcase—for example, the experiments with stones and acid, where you could try out processes of dissolution. The processual, the experimental is also very much in line with my own way of working. My work is often processual, and unexpected things happen.

• NiS How did you go about developing an artistic work from these initial approaches?

• LD Out of theoretical interest, I started extensive experiments (fig. 3): on what different materials can the urea solution grow? How does the growth behave? Does it migrate, does it flow in the beginning? What mixing ratios of the solution do I need? What is the effect of temperature? Can I add other substances, such as grains of sand?

Over time, I realized that I wanted to use what was already there: Petri dishes or vessels in which sand or stones were already displayed in the showcase. This was the ideal artistic language for me to pay more attention to the moment of growth or change over time. Hence its presence in the display case as a silent guest—or perhaps better: as a growing guest. And the finished work remains formally at the level of the experiment.

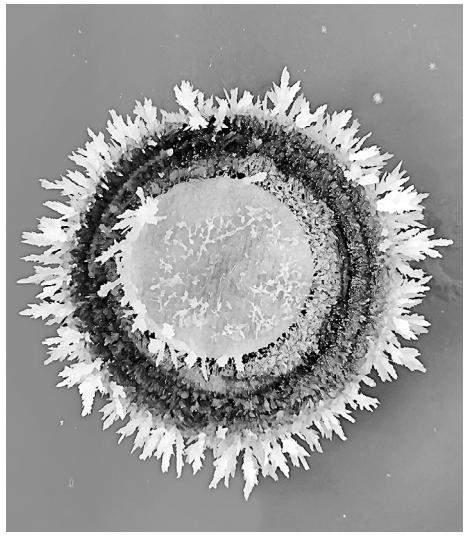


Fig. 3: Lena Dues, experiments on the crystalline growth of urea on various carrier materials, 2021–22

• NiS So could we say that the work is an extension of the idea of the activity and self-activity of material—an experimental extension, or *stretching*?

• LD Following on from the exploration of rock as an active material that is always in motion, the work extends the installation in the showcase to include the moment of the temporally tangible activity of the material as an independent formation of a crystal structure. Depending on the prevailing climatic conditions, this process of transformation should be comprehensible to the visitor within hours or a few days. The change of the exhibition in relation to time is reflected in the change of the urea solution in the glass vessels—the more urea crystal has grown, the more the exhibition has grown as a system: new ramifications have emerged, new connections between contents, people, times have formed…

The idea of the work as an extension is also reflected in the form of the intervention: at first, I thought of attaching the work to the outside of the display case (fig. 2). However, as I experimented and explored the theme, I became increasingly aware that the work needed to be placed in close proximity to the desert rose and calcite because the connection to the stones was so strong. For me, the work is primarily an extension on several levels, rather than a completely new position.

• NiS Why did you choose urea as an artistic material?

• LD Organic urea plays a special role in chemistry because its synthesis in 1828 demonstrated that a metabolic product could be produced in the laboratory without biological starting materials, blurring the boundaries between animate and inanimate nature and ultimately leading to the fall of the doctrine of vitalism. Living organisms produce a large number of inorganic substances, while almost all organic substances can now be produced in the laboratory. The first life forms on Earth were (inorganic) sediment particles metabolizing (organic) microorganisms, which gave rise to the oldest fossils, the stromatolites. The aim of the exhibition was to build a bridge between animate and inanimate nature on a material level and to highlight the inseparability of minerals and life on Earth.

• NiS The connection between organic and inorganic matter has also fascinated you in your earlier work. What is so exciting about it? How have you become interested in exploring the overlap between organic and inorganic matter?

• LD I have a shrimp aquarium at home, and I have always been fascinated by substances or minerals that our bodies or animals have to form, armor-like substances that are a strange in-between thing, on the one hand belonging to the body but also somehow having a different materiality—like fingernails, hair, or even teeth. I explored this for the first time in a work in 2017 and started to recreate natural things—for example, stone druses made of epoxy resin and plaster (fig. 4).

Fig. 4: *Aquarius*, installation, 2017. RADAR, Galerie der Gegenwart, LWL-Museum für Kunst und Kultur, Münster

I am interested in the material or chemical level but also in the question of what is natural and what is artificial. For example, if I use plaster as an »artificial« material to recreate something that nature has made, then I am ultimately using a material from nature. What does that mean for the classification of the object between natural and artificial? During this time, I also bred alum crystals and prehistoric crabs for the first time, which also hatched in an exhibition. I've always been interested in processes that allow you to create your own worlds, which you can then control to a certain extent.

• NiS For many people, stones are initially not something processual and instead represent the eternal, the unchanging, the solid. What are stones to you, and why did you find inspiration in this particular showcase?

• LD At first, I wondered what would fall under the category of stones. I've been working mostly with minerals and it's a little easier to think about their processual aspects. Minerals always have a crystalline structure, as we know from chemistry class. But ultimately, even rocks are not immutable, as the showcase demonstrated very impressively. The desert rose is the best example of this, as well as the weathering processes in which solid material is finely ground. Processes everywhere show us that what seems unchangeable is actually very mobile. These were all aspects that I had not been aware of before.

• NiS How did you hope viewers would respond to your work? Is there a particular feeling or thought you wanted to evoke?

• LD What sometimes takes a back seat in terms of content but is very central to me is the aesthetic aspect of the work. Ideally, the visitor comes to the exhibition on the second day after the installation, when some crystals have already formed, and is initially fascinated on an aesthetic level and wonders what they could be. This is also the reason why one of the solutions was slightly bluish. What could it be? So first of all it's about the fascination of the aesthetics, the look, the form. And then he or she should ask questions about the content,

like, »why is this here in this display case, it's just stones, why is it a liquid?« But for me, too, aesthetic questions were at the very beginning, for example about the sculptural character of the work.

Fig. 5: Lena Dues, *Galaxy S9+*. Glass plate, galaxy fabric, rock crystal, celestine, glazed ceramic, metal, 2018

expression of a continuous search process and an exploratory approach to the behavior and aesthetics of materials. The interplay of control, planning, and letting go of control in the sense of following the material properties is central to this. I usually start by collecting a lot of a particular material, building up a kind of material cosmos, and conducting material studies (fig. 5). My favorite materials are silicone, plaster, glass, epoxy and polyester resin, ceramics, bismuth, gallium, minerals, home-grown crystals, water, and plants.

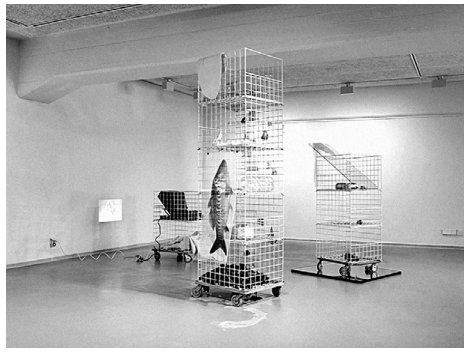


Fig. 6: Lena Dues, *holistic device*. Three-part installation, mixed materials, 2019. *Artificial landscapes in domestic habitats*, Kunstverein Ahlen

• NiS You have mentioned several times in our conversation how important the sculptural character of your work is to you, i.e., your engagement with the medium of sculpture. How would you describe the relationship between control and the stubbornness of the medium in your installations, sculptural works, and prints?

• LD Compared to my other works, in *Auturgy of Carbamide* I have significantly reduced the sculptural element and given more space to the idea. In general, however, I always take the material as my starting point. What material fascinates me, what appeals to me, what feels good? I call this an aesthetic exploration of everyday life. I am interested in materials and surfaces that are present in certain subcultures or on Instagram, for example. My work is an

• NiS What is most important to you in your work? How would you describe your artistic practice?

• LD I am interested in transformations, in becoming and growing, in changing consistencies, colors and forms, and in the relationships between large and small, between naturalness and artificiality. The spatial installations are often reminiscent of laboratory situations in which the boundaries between natural processes and artificial manipulation become blurred. Scientific images such as anatomical drawings, chemical structural formulas, astrological unicodes, or symbols of subcultures are often part of the installations and graphic prints, which are accompanied by narratives between scientific fact and fantastic invention (fig. 6–7).

• NiS You have worked a lot with minerals and crystals. Where do you see potential and inspiration, for instance for creation and design?

• LD Crystal structures are regular, very stable atomic or molecular lattices that can serve as models for the construction of stable structures (materials engineering, architecture, medicine, design). An example is diamond, the hardest natural substance. What is interesting in this context is the tendency of atoms to arrange themselves in a specific crystal lattice. In steel processing, for example, the formation of particularly stable crystal lattice structures is achieved by adding alloying elements, thereby fine-tuning the character of the steel. Similarly, crystal structures that can be adapted to specific requirements and environments could be systematically investigated for design strategies.

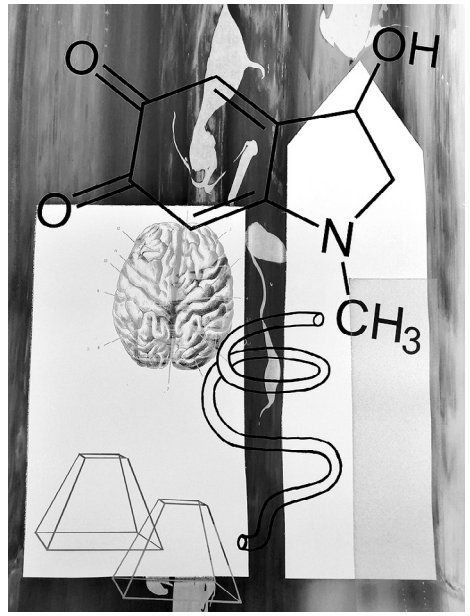


Fig. 7: Lena Dues, *Adrenochrom*. Screen print on Bristol carton 308g/sqm, 50x70 cm, series of 40. Part of the Alumni screen print edition of Kunstakademie Münster, 2021

• NiS Even though your work was in the stone display case, it was connected to the exhibition as a whole. What larger connections do you see between your work and our exhibition?

• LD I can think of three connections off the top of my head. First, there is the exhibition's approach of presenting big questions that affect entire ecosystems on a small scale, which could perhaps be called »scaling.« This is also a central idea of my approach. Maybe that's where my fascination with the aquarium theme comes from, because again, you're putting an ecosystem in a small box and then into a different environment. It was similar with the cloud in the exhibit.

Second, I liked the 3D printing of the stones. The interplay between nature and artificiality and the reproduction of objects that exist in nature are themes that play a role in my work. The fact that the stone could also be seen as a natural stone in the display case reinforced this effect: it seemed like a strange »glitch« in the matrix.

Fig. 8: Lena Dues, CH_4N_2O. Glass plate, urea, dental impression, petrified oyster, mineral (pyrite, quartz), polyester resin, 2019. *Materialisations*, thenationalmuseum, Berlin

And finally, I see the general concept of the exhibition as a unifying factor. By seeing itself as a public platform for the interweaving of theory and practice, it also rethought the concept of exhibiting. The showcases, which normally protect the exhibits from the visitors, have opened their doors and the objects are not located in optimally air-conditioned rooms; instead, visitors are allowed to interact with them. This is also where my works come in,

as it interacts with its surroundings and sometimes even depends on changing climatic conditions, e.g., an installation with gallium that melts at temperatures above 27.5° Celsius in the exhibition space, or salt crystals that form during the exhibition and disintegrate when the humidity increases, or water that evaporates and leaves lime patterns (fig. 8).

• NiS Finally, I'd like to know where you stand now. It's been almost two years since you participated in the exhibition. Do the questions from the exhibition still concern you today? Do you still work with urea?

• LD Yes, the urea hasn't left me yet. What I find very exciting at the moment is the question of residues. So what happens when the urea forms larger crystalline structures and then dries? Then you can pulverize it again and make a solution out of the powder and grow crystals out of that solution. It's like an eternal cycle (fig. 9).

Fig. 9: Lena Dues, *Petrification*.
Mixed materials, 2021

But I find the structures that dry out after the waxing particularly exciting because they also offer new possibilities to work sculpturally. I actually plan a little more and exercise more control. At the same time, I have turned my attention back to more everyday aesthetic phenomena and am planning more sculptural works in this direction, such as a column piece.

• NiS Thank you so much for giving us this glimpse into the Lena Dues universe.

SCATTERED DIFFUSION

Natalija Miodragović in conversation with Maria Mascha Kobylenko

Intermezzo 2

• Natalia Miodragović: Your interactive performance *Scattered Diffusion* used the ceiling of the rotunda as projection screen and aligned visitors' bodies on the floor, stretching the collective auditorium space of TA T's amphitheater into the exhibition space of *Stretching Materialities*. The video of the performance shows how focused participants were on collecting information with their phones, almost dancing while generating sounds, and then lying down or sitting together on the floor. There is a sense that the visitors are a community. Was there a similar sense during the mediation sessions with exhibition visitors, which you also conducted?

• Maria Mascha Kobylenko: To contribute to the tangibility of the liveliness of matter, I developed the interactive audiovisual performance *Scattered Diffusion* with sound artist Siamend Darwesh during the course of the exhibition (fig. 1). It was an invitation for visitors to explore the materialities of the exhibition and to create a shared audio-visual experience. Theoretical reflections by philosopher Jane Bennett on New Materialism were played back as auditory fragments. The installation consisted of two parts: sound and moving images. Four microphones were installed at four stations (stone collection, *hanbok*, willow, cloud) to create four different sound layers. Visitors generated the sounds, for example, by touching the haptic stone box, the silk of the *hanbok*, or the rattan and willow structures. The sound layers overlapped and were translated into an atmospheric soundscape. In parallel, microscopic material recordings were collected by visitors in the exhibition room and sent to the live video manipulation software Touch Designer. Through microscopic magnification, pumice stone transformed into a crater landscape, and tiny grains of sand appeared as large as rocks. The video recordings were also layered and manipulated by the sound input. The video transmission was projected onto the central round white fabric of the light element on the ceiling, conceived as the reminiscence of the elevator that used to lift animal bodies into TA T's amphitheater from the rotunda, the exhibition space. Now, the floor surface of the rotunda became the auditorium. With pillows scattered throughout, more than a dozen visitors could sit or lie underneath the projection.

Fig. 1: Interactive Performance *Scattered Diffusion* at TA T

To answer your question about mediation: for me as a visual artist and VJ focusing on experimental animations, the role of mediator for spatial narratives and performances during *Stretching Materialities* was a lot of fun. However, the interactive, audiovisual performance is also a form of mediation for the exhibition topics. My biggest challenge during the mediation was the diversity and complexity of the topics, which brought together various disciplines, ways of thinking, and approaches. To better convey the larger context, I tried to communicate in a playful manner. The notion of »touch« was a major component in breaking the barrier between visitors on the one hand and the material and knowledge on the other. In this sense, it was unlike a conventional, classical exhibition that prohibits touching. I also used many (counter-) questions to encourage active engagement on the participants' part. This often led to enriching exchanges, as this method also brought strangers into conversation with each other. The sense of establishing community was important, also for the performance. Such exchanges could be simple questions like »What do you associate with a stone?« or »Can a stone be a memory carrier, like a USB stick?«

• NM You say that the complexity in mediating originates in interdisciplinarity?

• MMK This multidisciplinary collaboration provided insights that usually occur behind closed doors, in laboratories, industry halls, archives, or collections in research facilities or development departments. The visitors showed great interest and were enthusiastic about discussing current topics in the context of the exhibition. There were also skeptical reactions from visitors who did not understand how the individual areas were connected. We were gradually able to resolve these issues thanks to mediating conversations and explanations. Participants included different people from *Matters of Activity*, students, artists, people from the Charité campus stumbling upon the exhibition, as well as larger groups and interested individuals. Participants from the *stretching senses school* were also often present, conducting various field studies. → Intermezzo 5, 343 Additionally, there were many different events like the *Berlin Science Week*, *Club TransMediale (CTM)*, and lectures and performances, which further enriched the exhibition.

Fig. 1: *Leaking Stones*. Installation revealing the exchange between geological and human timescales, as stones »leak« moisture and meaning, exposing their living materiality

Fig. 2: Experimenting with stratification of cloud layers and structural properties of interlaced willow structure

Fig. 3: *Stretching Materialities* opening, 16 September 2021

Fig. 4: View from inside the *Virtual Sensing Knife*—final VR experience.

Fig. 5: Workshop result, *stretching senses school*, March 2022

Fig. 6: *Stretching Materialities* opening, 16 September 2021

Fig. 7: Expanding the exhibition space into the virtual

Fig. 8: Display case shelf »Colors of Time« with a collection of differently weathered soils from around the world

Fig. 9: Anna Kubelīk, *Well-Tempered Hygrometer Part III*. Sound installation, 2021

Fig. 10: Display case with zoological creatures made of willow

Fig. 11: *Haptic Nest*. Immersive willow installation inviting visitors into a porous habitat linking movement, material response, and collective sensing

Fig. 12: Metabolic archive with microscopic images, 3D scans, dust samples, and sequenced biodata from the air, collected monthly, December 2021

Fig. 13: Metabolic archive, December 2021

Fig. 14: Cloud condensation in the center of the exhibition space

Fig. 15: Hands-on, hands-through, hands-off: small gestures sensing the cloud cause airflow shifts

Fig. 16: *Cloud Computer* display. Thermal and moisture data reveal the room's stratified, machinic climate

Fig. 17: *Willow Reality*. Tactile willow and its virtual twin merge material and digital perception

Fig. 18: Inside VR: hands touching a column, leaving a visible heat signature

Fig. 19: Inside VR, active hand tracking with specially textured hands and a light orb to activate speech overlay

Fig. 20: 3-D printed stone as activation tool for VR experience »Geological Performers«

Fig. 21: Desert Rose, Geological Collection, HU

Fig. 22: *Leaking Bodies* project, installation view, June 2022

Fig. 23: Aerobiological sample of the air after a seminar day, 24 January 2022, 6 pm

Fig. 24: Close-up of the stratified cloud layer in the exhibition space

Fig. 25: Experience through touch: merging the virtual and the physical willow column

Fig. 26: Model of an airborne lichen spore

Stretching Spaces

Co-Inhabiting the Exhibition Space as a Base for Transdisciplinary Research

Natalija Miodragović

The singular, infinite space of the universe is continuously stretching—expanding itself, becoming even more infinite. This does not mean the universe is growing into pre-existing space but that the fabric of space itself is changing. Cognitive space has never been singular, as human experience has always unfolded within multiple interconnected spaces that are all contributing to our perceptions of reality. What we perceive to be happening around and to us is a dynamic network of environments and signs. Recognizing this multiplicity is a way to acknowledge more-than-human modes of existence and to overcome dichotomies such as »nature–culture,« »analog–digital,« »human–non-human,« »growth–decay,« »conservation–waste,« or »social–scientific.« Rather than understanding space as a container for matter, the exhibition *Stretching Materialities* involved experimenting with the interactions with the space-time of matter activity and »understanding humans and nonhumans in their mutual constitution, as integral parts of the universe—not as beings in the universe« (Barad 2003, 169).

What is the meaning of the plurality of »stretching spaces« when the elegance of outer space lies in its unity and continuity? Space can be defined as the infinite, non-computable, multi-dimensional realm in which all matter and events occur. It is not simply a void; it accommodates matter and events. Space provides room for movement and, through a multitude of possible movements, carries memories and potentialities. Portions of this same space (*spatium*[1]) are all around and within us, while the porosity and filamentation of matter allow spaces to interconnect.

The exhibition *Stretching Materialities* conceptualized some of these in-between spaces—such as the space found inside the cell, in between plaited willow tree branches, around a droplet of fog, within the zero (0), or along the ridge of a stone. Making these designated spaces accessible for an immersive, attentive dwelling within and through scales and speeds—from atmospheres to cells and back—reveals the hidden activities of matter. The exhibition space itself thus appeared as a larger, continuous common space where these activities simultaneously occurred. Sensing events at different magnitudes unfolded a multitude of possible spaces and created opportunities to grasp their intrinsic interconnections.

Architectural space, like the vastness of outer space, is a concept, a model, a construct in constant flux—a framework for

1 From the Latin spatium for »room, area, distance, stretch of time«; also a portion of space (Deleuze and Guattari 1987, 481).

interpretation and articulation. To make the multiplicity of spaces more palpable, we can approach the exhibition space that organizes, affects, affords movement, and moves as a shared habitat: the object-space; the habitat of collected matter; the culture-spaces for collecting and archiving; the experiential space for participants in motion; the habitat for indoor air, stones, plants and micro-animals, for employees and researchers. Thinking about matter and exhibiting through inhabiting and *becoming*, rather than just visiting or existing, revealed mutual interdependencies and temporalities within the exhibition space (fig. 1). → Stretching Practices, 43 In this way, biographies of research processes and materials, experiences, and environments—such as laboratories, willow fields, and server infrastructures—were introduced into the realm of the exhibition. ❑ Process, 284

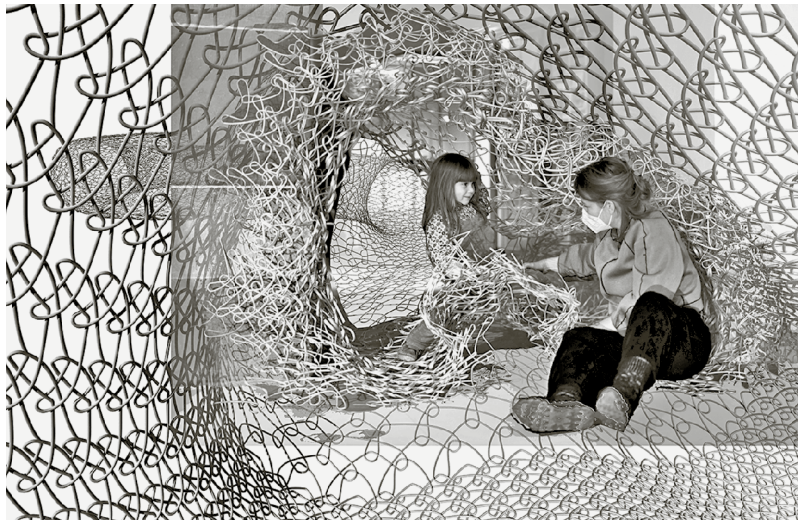


Fig. 1: Co-inhabiting the exhibition space: the accessible space knitted transdigitally allows for inhabiting the fold between the analog and digital

Researchers from different disciplines created spatial constellations that revealed possible ways of inhabiting the exhibition space and invited visitors to enter and co-act in this realm of potentiality. These spatial constellations became an apparatus for revealing the societal value of matter and reimagining futures. Visitors became, potentially, actors—participants. → Intermezzo 2, 116

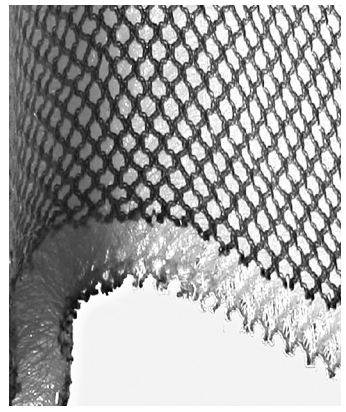
Exhibiting, in the context of object conservation as a spatial practice, engages one into rethinking the making of spaces. Architecture—built, grown, computed, woven—can be considered a multi-scale homeostatic, collective self-preserving practice, a semipermeable layered membrane between objects, bodies, materials, and environments. → Stretching Time, 222

Like a cell membrane that separates the internal contents from its surroundings while affording the flow of matter and spaces at the same time, the lower atmosphere shields us from cosmic radiation. The biosphere accommodates life, conditioned by urban tectonics and coated with clothing, creams, and other regulatory interfaces. Through technology, prosthetics, clothing, carpets, buildings, and pavements, we extend and stretch our organisms, engaging in new modes of inhabitation. The architectural process encompasses weathering and intra-weathering—metabolic and dynamic forces where all designated »things« are in constant exchange and in inseparable intra-action with the environment (Barad 2007, 141).

2 Self-reflection used in critical theory is revisited using Donna Haraway's term diffraction to include different ecologies.

Textile Spatiality

The concept of *Textile Spatiality* explores these exchanges through accessible, filamentous, wearable, and sonic climate-responsive architectures, created in a transdisciplinary context. These experimental structures have the potential to become immersive apparatuses for self-reflection and *diffraction*[2] or mirroring, while allowing another kind of critical consciousness, making explicit the material, social, and spatial entanglements of diverse ecologies (Haraway & Goodeve 1999, 102). Historically, while relating greatly to textile knowledge, the word *textile* is avoided both in architecture and philosophy. The relational and processual materiality within digital and social realms and natural sciences calls for change. The void in the textile is as fundamental as the material itself—its emptiness affords interactions, making it palpable. Filamented structures are open to weak interactions with space and matter, intra-actions, and becoming, forming a tool for what Haraway calls *tentacular thinking* (Haraway 2016, 32; Barad 2007, 151), a mode of understanding that emphasizes the connection and relationality across species, systems, and timescales and resists individualism and fixed boundaries.



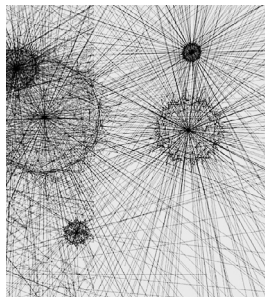


Fig. 2: Textile spatiality in the weaving code (a), between spatial filaments (b), and in-between double-layered spacer textile research (c)

Textile spatiality thus redefines simultaneously spatiality and materiality, engaging with the interplay of material, immaterial, and spatial, presence and absence. Together with the textile and digital realm, the sonic aspect–polyphony–offers a means to grasp the complexity and multi-scalarity of planetary processes such as climate and resources. As an architect, the concept of textile spatiality is rooted in years of my practice, experiments, and exhibitions between art, architecture, and sustainable building, from the EXPO 2010 Shanghai pavilion City Code (fig. 2a), and large-scale installations toward a lighter-than-air city (fig. 2b) and multilayered textiles, so-called spacer textiles (fig. 2c) at Frankfurt University of Applied Sciences, and the sonic design of sculptural organ instruments KLANG, LUFT UND LICHT with the art collective *dreidreidrei*). → Stretching Senses, 296

Influenced by the urban imaginaries from art and architecture of the 1960s and 70s, these spatial experiments draw from physics, mathematics (bubble and geodesic geometry), biology (water distribution, filamentous fungi, spider webs), and textile structures (symbolic and technical). They extend beyond biomimetics, where principles from nature are applied in design addressing relational processes such as adaptation, growth, and cohabitation.

The plasticity of materials and environments as habitats and human awareness as habits form the foundation for teaching and research methods toward a new culture of spaces and materials. The focus is on planetary resources and trans-digital–simultaneously analog and digital–spatial sensing. The experiential architectural scale is needed to activate this plasticity through action–the hands-on space making and experiencing through bodily movement.

Exhibiting opens up the research to the public, and thus to further generations and disciplines. Starting from the progression of textiles as hierarchical structures from fiber to yarn (entangled fibers) to fabric, new stances are introduced (Eadie & Ghosh 2011, 761–775): the filament becomes an interactive form for growth, flow, and movement, enclosed or layered fabric that forms textile space.

Textile spatiality stretches into new scales–from the nano-scale of metabolic processes (Miodragović et al. 2024, 63) to the inhabitable scale of *Stoff* (fabric) as architectural mediation. While analyzing filamentous propagation across

ontologies, we explore how networks and textiles act as human *extended organisms*. The concept emerged through the investigation of exhibiting as an architectural research method, *Stretching Materialities*.

Structural Textiles–Plektonik is a situated architectural work of research into self-supporting material systems and planetary resources made from warp-knitted fast-growing woody plants like rattan and willow (rather than timber). Conducted at *Matters of Activity* (MoA) in a transdisciplinary manner, it brought together architects, artists, microbiologists, and material scientists. The research is twofold: the architectural material system and exhibiting as a research method.

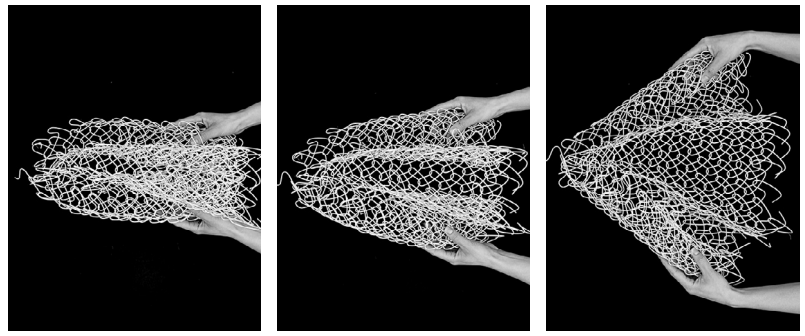


Fig. 3: Unlike weaving, knitting the surplus of material during fabric formation allows for adaptive geometries

For the exhibition *Stretching Materialities*, responsive rattan and willow installations, plaited digitally, industrially, and manually, acted as both exhibits and living spatial instruments. The meta-types–ever-evolving prototypes–from the Structural Textile research became models for material porosity and spatial affordances, allowing to investigate how spaces from different scales can be accessed, inhabited, and engaged (fig. 3). Engaging with the exhibits, by wearing and accessing them, these plaited installations challenged the boundaries of the exhibition space itself, reframing it as a habitat rather than a location. This research employs a warp-knitting technique and wooden branches generating complex geometries that remain stable under compression, breaking conventional limitations of textiles. The use of both imported and local biomaterials brought other places and ecologies into view: rattan and willow possess a healing capacity, remediating troubled landscapes, soil, groundwater. → Stretching Practices, 33 These plants, or materials, are the livelihood for their communities, and, as anthropologist Stephanie Bunn argues, basketry, as a mind-body operation even has healing capacities.[3]

3 »While a person is ostensibly doing one thing when basketmaking, they are actually integrating many areas of life and many ways of using the mind and body in that one task–spatial, rhythmic, memory, sensory, emotional, communicative, mind, mood.« (Bunn 2019)

The exhibition-based research allowed us to examine the very structure of architecture as a discipline. Situating knowledge is not a new form of architectural research, but it is becoming increasingly integrated within teaching and research methodologies. Critical spatial practices, a term developed by Jane Rendell, explore the »in-betweens-theory« and practices, art and architecture, and evolve through transdisciplinarity and specific situated engagements (Rendell 2006, 30). Together with established exhibiting methods in architecture pavilions, installations, digital fabrications, material exhibitions, and prototyping, by engaging with transdisciplinary spatial practices, exhibiting itself became a research method—not merely a constitutional element of architecture but an epistemic tool—one that actively contributes to the production, questioning, and dissemination of architectural knowledge.

Relational Mediality of Textiles and Lightweight Architectures

A concept needs a precept. Accessible installations provide an experiential grounding by enabling embodied engagement and mediating immersion in material and environment. I grasped this when a sociologist reflected on entering the spatial art installation that I was working on at the Venice Biennial in 2009 (*Galaxies Forming along Filaments, like Droplets along the Strands of a Spider's Web* with Tomás Saraceno, fig. 2b):

> […] you can take it, as I do, as a model for social theory, but you could just as well see it as a biological interpretation of the threads that hold the walls and components of a cell. […] No visual representation of humans as such, separated from the rest of their support systems, makes any sense today. (Latour 2011)

While gaining momentum in architectural research, the relational mediality of threads and textiles has become a focus in numerous contemporary art exhibitions—even a decade after the *A Survey on the significance of textiles in contemporary thought and praxis* was published in *Texte zur Kunst* (Buchmann and Frank 2014). Fiber art and textile sculptures that were historically overlooked as media of abstraction have been revisited in major exhibitions such as Art & Textiles (Kunstmuseum Wolfsburg 2013), Fiber: Sculpture 1960–Present (Institute of Contemporary Art/Boston 2014), Freespace (Venice Biennale 2017), Taking a Thread for a Walk (MoMA 2019), Women in Abstraction (Pompidou 2021 and touring), and Milk Dreams (Venice Biennale 2022). Philosopher Yuk Hui suggests that relational materiality is made visible and explicit under digital conditions. The term »relational materiality« is a contemporary response to Jean-François Lyotard's »the immaterial material« and »… [a]gainst the conventional conception that relations are immaterial and also contrary to a substantialist analysis of materiality« (Hui 2015), expanding on the notion of intra-action by Karen Barad.

Mathematician and weaver Ellen Harlizius-Klück traces how Ada Lovelace established weaving practices and the Jacquard Loom as precursors of digital calculating machines, reflecting on the interdependencies of textile and the digital: »We may say most aptly that the Analytical Engine weaves algebraical patterns just as the Jacquard-loom weaves flowers and leaves.« (Lovelace 1843, 696, cited by Harlizius-Klück 2017, 176)

Only recently, established digitalization of practices resulted in integrating textiles into architectural education and research.[4] The turn toward sustainable materials has intensified interest in filaments and fibers, as fibers are main motives in nature (Fratzl & Weinkamer 2007). The heterogeneous, structured material calls for a radical rethinking of materiality. The hierarchical, polyphonic, material distribution in nature—the same material defines densities, structural and dynamic areas as in bones—is also achievable with computed additive techniques such as 3D printing by structuring and material distribution. Citing Neri Oxman, architect Professor from MIT Lab (Oxman 2010), Wolfgang Schäffner sees the possibility for a different, transdisciplinary structuralism coming from architecture and design (Schäffner 2016). To contribute to these thoughts—based on studies where heterogeneous material is achieved through digital fabrication—it can be suggested that such heterogeneity is also achievable through textile structures. These structures follow the logic of textiles, from fibers, filaments, and weak interactions to yarns, fabrics, and textile spaces.

Techniques of textile spatiality in architecture are based on hands-on textile crafting knowledge, engineering lightweight spatial structures, and digital processes. Textile knowledge was part of architectural education only at Bauhaus from 1919 to 1933. However, the influence of designer knowledge that originates in the Bauhaus textile workshop, although essential for contemporary architectural research, is not accredited as such. Thanks to

4 For example, the Centre for Information Technology and Architecture (CITA) and ETH Zurich conduct intensive research into digital knitting, while the University of Stuttgart Institute for Computational Design and Construction focuses on robotic winding and Fibrous Architecture.

recent exhibitions and studies,[5] we have a better understanding of the commitment and impact the designers had on contemporary art and architecture. They paved the way for textiles beyond craft and for the relational mediality of textiles.[6] Using the vocabulary of architecture and art, it was possible to confront »a long-standing assumption in art history that craft is a manual or technical, but never an intellectual, art« (Smith 2014, XXI). Gunta Stölzl led the Bauhaus textile workshop before founding a textile company. Lilly Reich developed the concept of adaptive open spaces with mobile, wall-like curtains.[7]

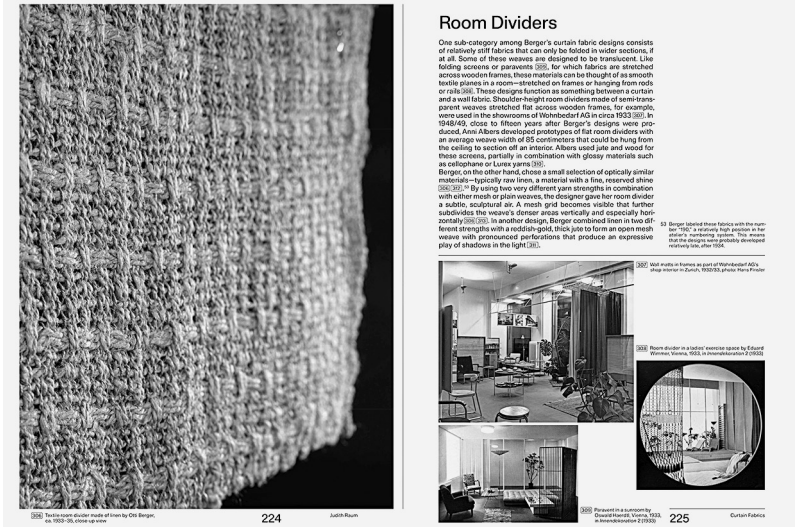


Fig. 4: Spread from *Otti Berger. Weaving for Modernist Architecture* by Judith Raum for the Bauhaus–Archiv/Museum für Gestaltung, Berlin, 2024

Otilija Berger, known for her novel research under the name of Otti, developed textile terminology still in use today, as shown in studies by Judith Raum and her team (Raum 2024). Working with materials like nylon, wood, cellophane, and ramie, they redefined textiles as assembled structures rather than mere materials, as defined recently (Vincent 2008), establishing their application in industry and architecture (fig. 4). The transition from naturalistic motifs to geometric designs in textiles influenced non-representational architectural forms.

With the outbreak of WWII, a number of artists moved to the US, including exiled scholars from Bauhaus. Thanks to Annie Albers, textiles became part of architectural education at Black Mountain college from 1933 and at the New Bauhaus in Chicago from 1937 onward, with Marli Ehrman leading the textile workshops. With actors around Buckminster Fuller, interdisciplinary synergetics research on dynamic structures that draws from natural sciences and lightweight architectures related to traditional textile architectures, such as the Mongolian yurt, came into contact with spatial textile logic. Kenneth Snelson's research into weaving defined tensegrity structures as using tensional integrity as their structuring principle. The lightweight structures have optimized dead load, the weight of a structure itself–thus, the structurally employed material reflects the gravity-defying forces of the active, live load. Membranes, tents, domes, pneumatic structures, spatial trusses, folds, and shells as well as optimized concrete structures all encompass lightweight structures. Initially they were not studied in the context of textile knowledge. They often reflect the anticipation of an emancipated, progressive society, and independence after colonialism gained momentum in post-war architecture also in South America with Felix Candela, Eladio Dieste, and in socialist countries with figures such as Ulrich Müther in the GDR. These optimized spatial structures can also be deployable and mobile, spanning areas in temporary infrastructures like stairs and bridges, shelters and housing, meteorology, aero- and astronautics, and prosthetics. They follow the forces of the material. Modeling these structures is an inspirational and empowering process–using a small amount of material to practice space-making, or better even, space-taking. Body spaces, and particularly collective body spaces, are essential for teaching in architecture.

The exhibition *Weaving Beyond Bauhaus* (Art Institute Chicago 2019) traces the network of influences that originate in Bauhaus textile research. The first textile artist and designer with a solo MoMA exhibition (1949), Anni Albers published *On Weaving* in 1964, which we still use for reference today. The emancipation of educational and exhibiting politics led artists to engage in challenging conventional spatial practices, among others, Lenore Tawney, Sheila Hicks, Else Regensteiner, Ethel Stein, Claire Zeisler, and Eva Hesse, who were studying with Bauhaus alumni in Chicago and Yale, Gego, an architect and engineer trained in Stuttgart, Lydia Pape, Lydia Clark, Hélio Oiticica from Brazil, and Magdalena Abakanowicz, Ritzy Jacobi, and Jagoda Buic from socialist Europe. With their experiential spatial interventions, investigations of relational forms, materials, and processes, their work can be examined as post-structuralist, or criticism of structuralism–

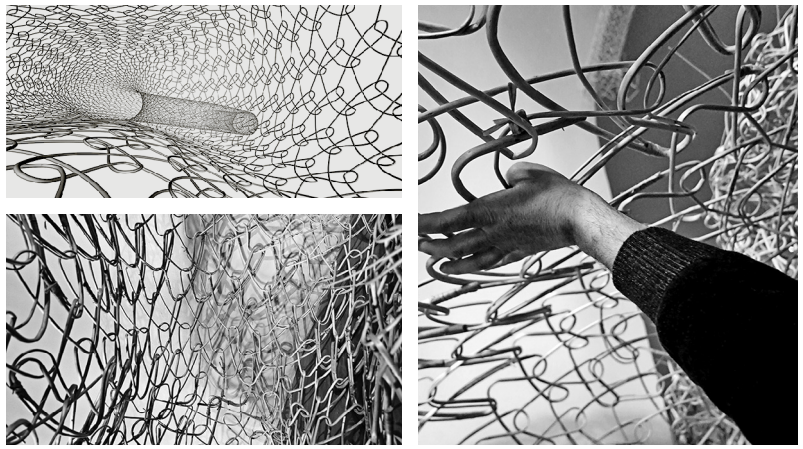
5 See the international research project and exhibition *bauhaus imaginista*, Haus der Kulturen der Welt Berlin, 20.9.2019–12.1.2020, the accompanying exhibition catalogue (von Osten & Watson 2019), and the online journal *www.bauhaus-imaginista.org/concept*, 2018–2020.

6 Joined by the Constructivists who defined art objects as laboratory experiments and the combination of faktura, material properties of an object, and tektonika, its spatial presence.

7 Velvet Silk Café in Berlin, which was designed in 1927 by Lilly Reich and her partner, Ludwig Mies van der Rohe, was part of an exhibition about women's fashion. The pioneering concept can be defined as temporal textile spatiality.

»supple structuralism« (fig. 5). → Stretching Virtuality, 83 Their work is essential for contemporary architectural research. Along with the Situationist International, they paved the way for an architectural practice undertaken as spatial agency, rather than merely the art of building and constructing.

8 Architecture exhibitions at the German Expo Pavilion (1967), Multihalle Mannheim (1974), and the Munich Olympic Stadium (1972) conceptualized architecture as an adaptive, evolving environment rather than a static form.



The Apollo program led to major breakthroughs in textile science and engineering, and the Blue Marble photograph of the Earth taken from the moon orbit in 1968 catalyzed interdisciplinary discourse, integrating ecology, anthropology, media theory, and architecture into a networked perspective: »Architects must be as networked as the spaces they produce.« (Wigley 2001, 88)

Textile logic shaped architectural education and research at the Institute for Lightweight Structures (IL) in Stuttgart, led by Frei Otto since 1964. Their studies, early examples of parametric design, used material behavior to drive architectural form-finding[8] and made IL a global center of lightweight and biomimetic construction. At the dawn of the twenty-first century, Frei Otto lamented in a lecture at DAM Frankfurt (2000), »we failed«—a reflection on architecture's struggle to integrate sustainable, material-driven design into mainstream construction. Yet, digital design and fabrication research have since revived these principles.

The most precise use of textile techniques for defining space and spatial relations in philosophy is offered by the distinction between the smooth and the striated in *Milles Plateaux* (Deleuze & Guattari 1987, 481)—felt and woven fabric describe the spaces of different intensities and their mixes, smooth and striated, nomadic and stationary, war and state apparatuses. Textiles are used in their paragraph on the *Technical Model of Space(s)*

Fig. 5: Inside textile space—an experiential spatial intervention for relational investigations applied in architectural research

alongside the musical, mathematical, physical, maritime, and aesthetic models. *The Smooth and the Striated* also touches on knitting, embroidery, and crocheting, elaborating on quilting as a practice of women's collectives and spatial appropriation. North American patchwork, shaped by migration and communal practices, not only bears the names of trajectories, it is inseparable from movement in an open space.

Bernard Cache used Semper's *Stoffwechsel* theory and Deleuze's notion of spaces of different intensities is defined through textile techniques as a tool for discrete architectural materials and structures during early digitalization in architecture. Hence, textiles today would be the abstract procedure emerging within the transposition process that leads us from primitive fabrics to contemporary modulation techniques (Cache 2000).

Written on the verge of digitalization,[9] such post-structuralist theories significantly influenced architectural and urban theory. Architecture started to disappear in glass reflections and deconstructed spaces. With digital tools it melted into constructed landscapes and complex geometries—merging spheres into meta-balls, multi-domes, and blobs—dissolving rigid structures and paving the way for textile logic and »supple solids.« In parallel, the terminology that draws from filamentous logic is used in theory for defining the relations with the environment—intertwining, meshwork, fold, network, entanglement, line, textility, foam, membrane, plasticity, supple solid, rhizomic, and tentacular (fig. 6). → Stretching Practices, 43

9 See Deleuze and Guattari's writings on the rhizome (the *Rhizome* chapter first published in 1976, then as introduction in Deuleuze & Guattari 1987) and *The Fold*, 1988

Fig. 6: Entangled and intertwined—inhabiting the meshwork, network, textility, plasticity, supple solid, rhizomic, and tentacular

Textile philosophy is written by means of engaging and making (Dormor 2020). This terminology stemming from textiles is used to address a shift towards processuality. Ingold (2002) positions weaving as the ontology of making to address the processuality of materials against a hylomorphic model of creation in which practitioners bind their own pathways or lines of becoming into the texture of material flows comprising the lifeworld. He also re-introduced Deleuze and Guattari's term entanglement used

by Ian Hodder (2012) to define the interdependent relationships between humans and things. Ingold proposes the notion of meshwork, the web as an extension of the spider, to give a better sense of rhizomic and flows of force and lived gatherings than does the term network. Actor Network Theory's »network« refers to the complexities of linkages that relates things beyond their supposed existence as stable regional entities. Catherine Malabou uses neuroscience, therm plasticity, and textile-like behaviors to address its adaptability and potentiality: »Plasticity is the power to receive form, but also the power to give form or to annihilate form. Habit embodies this double movement: it is a repetition that is never mechanical but always contains the potential for transformation.« (Malabou 2010, 12)

Textile Spatiality in (Natural) Sciences: Filamentation

Filamentous bacteria form biofilms in response to environmental stress, growing laterally rather than by dividing, ensuring survival in fluctuating conditions. ❑ Exhibition, fig. 23, 142 Filamentous structures (Østerlund, Persson & Nikoloski 2023, 452–462) pervade biological and physical systems, from cytoskeletal elements and leaf venation to vascular networks, solar filaments, and the cosmic web. Cytoskeletal filaments provide cellular support and transport; vascular systems distribute nutrients; solar filaments influence space weather; galactic filaments define the universe's large-scale structure. Across biology, filamentous forms unite eukaryotic kingdoms–Animalia, Plantae, Fungi, Chromista.

Prior to the *Stretching Materialities* exhibition, the online TA Tour enabled digital exploration of the TA T building through augmented reality, revealing spaces typically hidden from public view. → Stretching Practices, 27 The porosity of space–both digital and analog–was palpated with tentacular pixels: digital images of filamentous structures. Filamentation and semi-permeability in exhibiting and architecture were explored through scans of mycelium, cosmic web visualizations, and cosmic ray imaging. Rendered visible, cosmic rays transform even stone into semi-permeable material, something seemingly as porous as textile. This sparked new interdisciplinary dialogues and projects. Collaborations with polymer physicist Fardin Gholami led to novel insights into nano-scale textile, like molecular structures, extending into projects such as *The Sensing Knife* and *Haptic Hanbok*. → Stretching Senses, 299 ❑ Exhibition, fig. 25, 143

10 Project *Active Curtain*: Natalija Miodragović (project lead), Nelli Singer, Daniel Suárez, Christiane Sauer, Bastian Beyer, Iva Rešetar, Stefanie Eichler, Juni Neyenhuys, Regine Hengge, Skander Hathroubi, Cécile Bidan, Michaela Eder.

The research on formable wood and warp-knitting, foundational to *Structural Textiles*, began with *The Active Curtain Project* (*After Nature* exhibition, Humboldt Forum, Berlin 2020–2025) and continued through *Stretching Materialities*. Like an extracellular matrix in biofilm, the five by five-meter large fibrous scaffold–a structure that fosters growth, whether in biological tissues or construction–showcases interdisciplinary research on cellulose through its void-defined structure. By developing prototypes, cellulose and bacterial cellulose are studied in collaboration with the Weißensee School of Art and Design at the intersection of microbiology (Humboldt-Universität zu Berlin), materials science (Max Planck Institute of Colloids and Interface), and architectural design (MoA).[10]

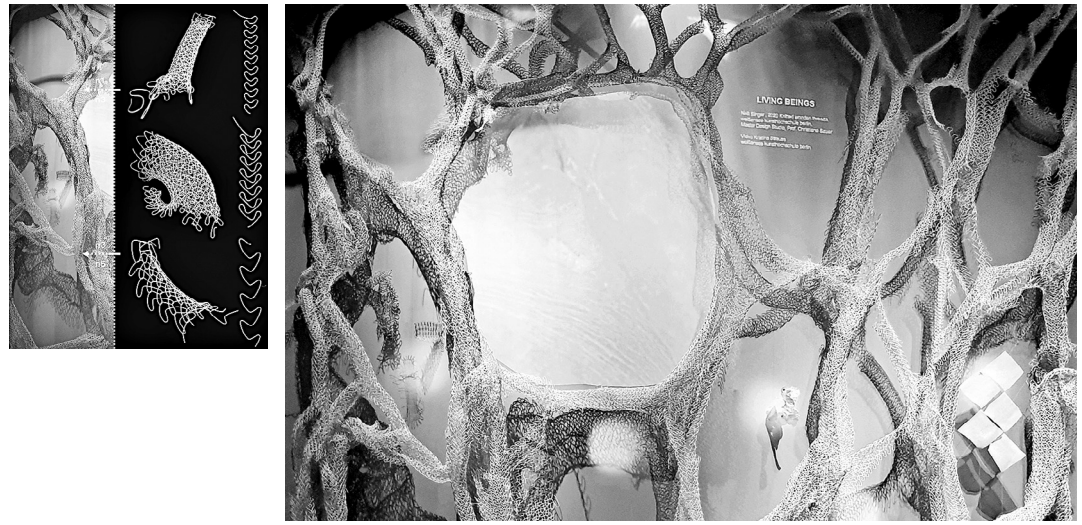


Fig. 7: The structured material: higher pattern densities or knit resolution in the upper area, and lower towards the bottom reinforces the large hanging structure, made using mainly median loop size (a). The overall structure explores the structures of biofilm by expanding it to human scale (b)

The *Active Curtain Project* is not a passive surface but an active spatial structure, echoing cell membranes and bacterial biofilms (fig. 7). With my background in lightweight structures and spatial textiles, Nelli Singer's focus on tacit knowledge and climate-sensitive textiles, and Daniel Suárez's interest in augmented knitting in architecture, we developed a warp-knitting-based material system.

> They are practically everywhere: huge colonies of mucus-secreting bacteria that build bacterial cities on a microscale. (Serra & Hengge 2019)

While biological tissues act as micro-environments of interacting forces, architecture introduces gravity. The material is structured:

a pattern with higher densities is used in the upper area in order to stabilize the large structure and to span the two-meter-wide gap for a video projection surface (fig. 7). Branching principles from trees, studied by material scientist Michaela Eder, with specific fiber orientation and higher fiber density in reaction wood, are translated into structured material—using the higher density knit for branching reinforcement (fig. 8). Microscopic images from the Department of Microbiology at HU Berlin and the Max Planck Institute visualized this research, revealing dimensions otherwise imperceptible. → Intermezzo 3, 202

The perceivable porosity of these enlarged textile methods allows us to imagine material on the microscale as part of our environment. In order to physically model MoA member and mathematician Myfanwy Evans's adaptive mathematical models of organic bulk tissues, bridging mathematics with biology, physics, and physiology, led to choosing rattan (and later willow) as material for modelling. These organic long fiber-based liane and branches are bendable yet stable, suitable for adaptive complex geometries involved. While engaging with research findings from the natural sciences I uncovered that digital and computational methodologies for tracing filamentous networks are applied across radically different scales and ontologies. From microscopic biofilms to cosmic filaments, these networks—sparse or dense, bent or straight—reveal a shared structural logic, bridging disciplines and dimensions.

Structural Textiles—Plektonik

The architectural research into self-supporting material systems and planetary resources, *Structural Textiles—Plektonik*, made from fast-growing woody plants like rattan and willow (rather than timber), became both exhibit and an apparatus for exploring the relations and processes during the exhibition. The research, presented at international textile,[11] engineering, and architectural conferences, as well in workshops with the public, also contributed to exhibiting as a research method.

The transdisciplinary project—collaborating with architects, textile designers, microbiologists, and material scientists—in the frame of *Stretching Materialities* explored how exhibiting can be employed as a research method in regenerative architectural design and cohabitation. *Structural Textiles—Plektonik* translates the textile techniques of warp knitting to an architectural scale and recognizes the loop as the »building block.« In warp knitting, unlike in weaving, where the weft thread interlocks between the warps, the warp »yarn« is pre-formed into a continuous looping element, allowing the loops of neighboring warps to interlock. In contrast to classical weft knitting with a single yarn forming consequent interlocked rows, this method has multiple warp yarns. Drawing from Deleuze's comparison of weaving and knitting, it enables the creation of an endless, smooth surface.

11 Aachen-Dresden-Denkendorf International Textile Conference (ADD-ITC) 2023; XI International Conference on Textile Composites and Inflatable Structures 2023—Structural Membranes; UIA World Congress of Architects, Copenhagen 2023

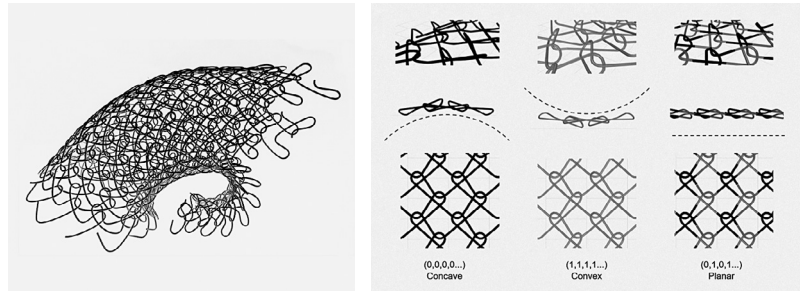


Fig. 8: Different loop sizes can reinforce the form (a). The direction in which one loop interlocks with its neighbor—either from above or below—determines concave, convex, or flat surface continuation (b)

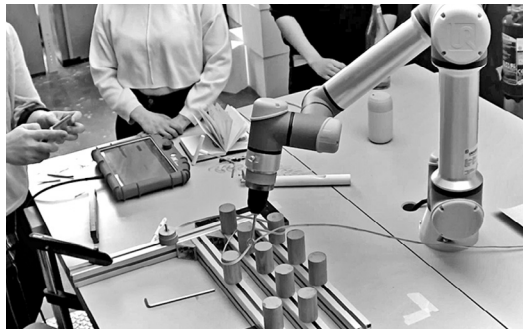
The direction in which one loop interlocks with its neighbor—either from above or below—determines the specific order of the loop, producing either a concave or convex surface (fig. 8b). This process can be efficiently coded using binary code, allowing for the programming of surfaces into particular forms. Combining this ability with different loop sizes enables the creation of complex surfaces (fig. 8a).

This research focused on *active yarns*—filaments and techniques that store elastic energy, such as willow, rattan, and even metal wires. Willow and rattan exhibit bendability and formability due to their filament structures. Unlike timber, plant fibers like willow twigs and rattan palms (liane) are elastic and hygromorphic, gaining plasticity after water absorption and maintaining their looped form after drying. These filament properties impart stability on the fabric itself. Active yarns are continuous strands that inherit the elastic properties of resilient, plant-based filaments of finite length. The continuity of plant-based yarn can be achieved by interlocking preformed filaments or binding them together. The filaments are entangled using a warp-knitting technique, with varying loop sizes determining the structure's strength and stability.

During the course of *Stretching Materialities*, we developed continuous active yarns by binding willow twigs with softer materials such as flax, wooden wool, and sheep wool using Kemafil® technology from the Saxonian Textile Research Institute STFI.

12 http://www.baukunster-finden.org/en/research/projects/tera-x-braided-wood

The self-similar model was used to create hybrid yarns as we replicated the geometry of the rattan and willow cross-sections and variated it for machine feeding. Different fittings were developed and used for producing continuous hybrid yarns. The continuity enabled the use of otherwise finite wooden twigs for the large coarse warp machines. Thus, the result can be recognized as a filament, defined as an elongated fiber, usually used for 3D print technology. Industrial yarn-making is also human filamentation of matter. The novel research introduced wood to the textile industry, and we see the research going in this direction.[12] This resulted in the creation of preformed textile elements up to one meter wide and twenty-five meter-long in size. The innovation to »build by looping« and (warp) knit hybrid active yarns, rather than stacking blocks (interlocking loops, or as Ingold proposes, knotting), opens new possibilities for architectural scales.



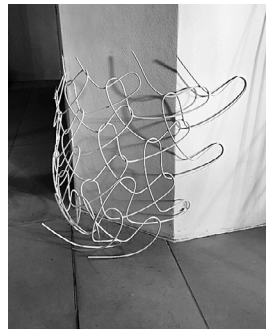


Fig. 9: Digital fabrication—preforming willow splints and rattan. Trial error studies at Weißensee School of Art and Design Berlin, Bauhaus 4.0 (a) contouring walls of TA T (b)

A digital twin was developed through various parametric models for local and global topology. To explore automation in robot-aided fabrication, a method that also serves analytical purposes, we created a script (fig. 9). The textile space became accessible in virtual reality in the interactive exhibition *Stretching Materialities* at TA T Berlin. → Stretching Virtuality

Willow exhibits mechanical and thermal properties ideal for reinforcement and is biodegradable, low-cost, and effective in remediating polluted water and soil. This knitted structure is envisioned as a potential fibrous scaffold for additive techniques, such as concrete or earth, where plant filaments are traditionally used. This scaffold facilitates growth and can support biofilms, such as bacteria or fungi mycelium. The varying porosity and densities achievable through knitting techniques allow the structure to function as a filtering and harvesting spatial membrane—for light, sound, and gaze, and, with the biofilm layer, also for water and air.

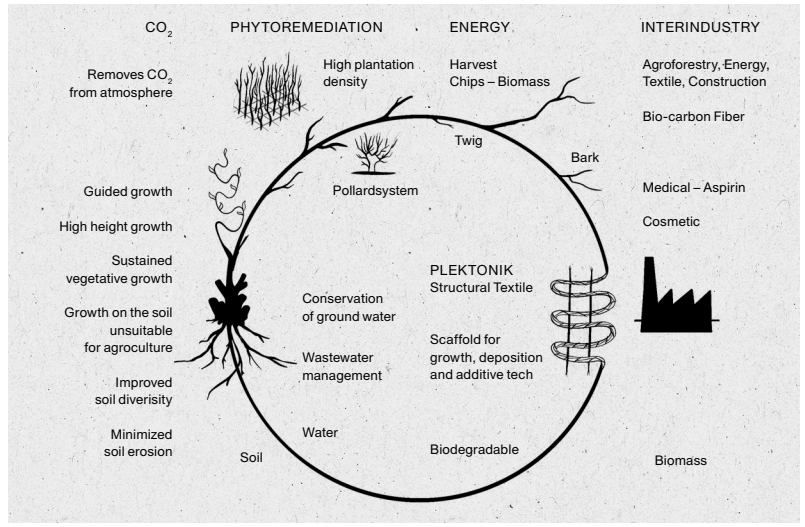


Fig. 10: Circular culture, looping economy—bio-materials connect industries and organisms with landscapes, waters, and soils

These materials are classified as Non-Timber Forest Products (NTFPs), and locally grown willow branches are residuals from the aspirin and cosmetic industries, which only use the bark (fig. 10). The project took a step towards a post-waste society, where not only timber but also small-diameter willow branches are considered valuable resources for architecture, while exploring how non-uniform agroforestry »residuals« and also »social residuals,« such as textiles and plastics, can be redefined and certified within the circular or looping economy and construction.

STRETCHING MATERIALITIES… AND SPATIALITIES

The initial concept for the *Stretching Materialities* exhibition was not to add exhibits. Instead, the goal was to create a mise-en-scène that reveals the exhibition space in the former veterinary anatomical theater and to exhibit processes as a »space-matter anatomy theater.« This shift from displaying objects to research as a staging process emphasizes the active, performative nature of matter and space. It is through a single filamentous hypha that symbiotic lichens penetrate both: stone and air, branching their existence, totaling and metabolizing between environments. The plaited prototypes are not envisioned as objects but as tools, apparatuses for drawing attention and investigating processual relations of matter and void, materiality and spatiality, bodies and spaces.

Besides clothing, transporting, and containing, textile techniques such as netting are used vastly for soil, surface, material, and structural reinforcement, like plaster and concrete, or lightweight elements from train parts to wind turbines. Like technology, architectural textiles are »present-at-hand« (*vorhanden*)– invisible to us in plain sight, an affordance taken for granted, much like the ground, sound, and air (McLuhan 1967, 165).

Once we entered the exhibition building, we would first notice human bodies: researchers, mediators, front desk employees–each engaged in the labor of the exhibition. Yet, as we engaged more deeply with the exhibition, we began to become aware of more-than-human actors. The space revealed the acting bodies of stones, plants, dust particles. The exhibition showed that these hidden processes–matter in motion, interacting materials–were always performing, even without an audience. Drawing on Rancière's *Emancipated Spectator* (2009), we asked: is there a theater without a spectator? The exhibition challenged passive spectatorship, separated from both action and knowledge; the spectator became an active participant through engagement with the processes on display. The exhibition needed the emancipated spectator to be complete, fostering the way of »how to pay attention,« as Isabelle Stengers (2013) proposes.

→ Intermezzo 3, 198

Where Do Architectures and Bodies End and the Exhibits Begin? Theater of Cytoskeletons, Exoskeletons, Biofilm Anatomy

Made from peeled willow and revealing a golden shimmer, the prototypes were in constant iteration during the exhibition, appearing as skeletons of strange »plant animals« exhibited in open showcases–sometimes crawling out. ❑ Exhibition, fig. 10, 132 Produced for architectural research, they were positioned to resemble an anatomical study collection. The shape of the of the loop, the way it bends is unique to the material and method, and it makes willow unrecognizable while still familiar. With their rhythmic repetitions, the prototypes were reminiscent of structures from the animal and insect world–spines and exoskeletons.

During my research on industrially bent wood I found that the measurement for elasticity, the young modulus essential for estimating how much a certain material will deform under a given load, and how much energy it will store or release, is the same for human tendons and willow trees, bones, and oak trees. To be processed in the warp and knitting machine, yarns need a certain elasticity, a young modulus threshold.

In the first showcase, industrial spacer textiles were translated into knitted willow samples at the scale of architectural elements–walls, floors, or ceilings (fig. 12). ❑ Process, fig. 19a, 280 Previous research on spacer textiles at Frankfurt University of Applied Science explored the void–the space between two interconnected textile layers–as a literal material layer and spatial affordance. *Spacer* fabrics are manufactured textiles in which two outer fabric layers are connected by a layer of pile threads that space them, hold them apart (fig. 2c). This textile space is the special feature of these structures. They are breathable, used for cushioning–negotiations between things and bodies–and as textile reinforcement for lightweight elements. In architecture, they have the potential to perform not only as thermo-regulative insulation membranes or formwork but also as filters and harvesters for air, heat, atmospheric water, and electromagnetic waves, as well as scaffolds for biological growth.

The use of different materials–flexible willow shives and stable willow branches–programs the elasticity and stability of a structure, ranging from flexible and responsive to structurally rigid and solid, and from comfortably smooth to sharp and striated. One can feel and compare the energy stored in these knitted spatial trusses.

These prototypes were models for the layered architectural membrane, fabricated with the warp knitting technique. They too were skeletons–reminiscent of enlarged fragments of layered plasma membrane and cytoskeleton. The structure of the cell membrane as a model of relational individuation and semi-permeability was found in a layered spacer textile.

❑ Process, fig. 19c, 280

Gilbert Simondon also recognizes the membrane as a border between temporalities, as Anne Sauvagnargues explains:

> The polarization of the membrane characterizes the living; it is not only topological and spatial, but chronogenetic, productive of time. The present emerges on the membrane's exterior; it catalyzes action and intervenes on the reality to come [à *venir*], however beneficent or detrimental this reality may be. The future [*avenir*] depends on action and is split between favorable and unfavorable, useful and harmful. (Sauvagnargues & Roffe 2012, 57–70)

Biologist Harold Morowitz developed a detailed scenario for the origin of life, a prebiotic evolution in which the formation of membrane-bounded vesicles in the primeval oceans created two distinct environments—an outside and an inside—in which compositional differences could develop. As membranes grew, they eventually split into smaller vesicles. Semi-permeable membranes allow energy and matter to flow through, including chromophores that absorb sunlight to generate electric potentials. This energy conversion process may have driven growth and replication, offering a model for life's origins (Morowitz 1968). The in-between space where the filtering process takes place evokes the spatiality of the border—a liminal space. Not a mere surface, it is a space that affords communication between regions of differing intensities and temporalities—interior and exterior, body and space, matter and environment.

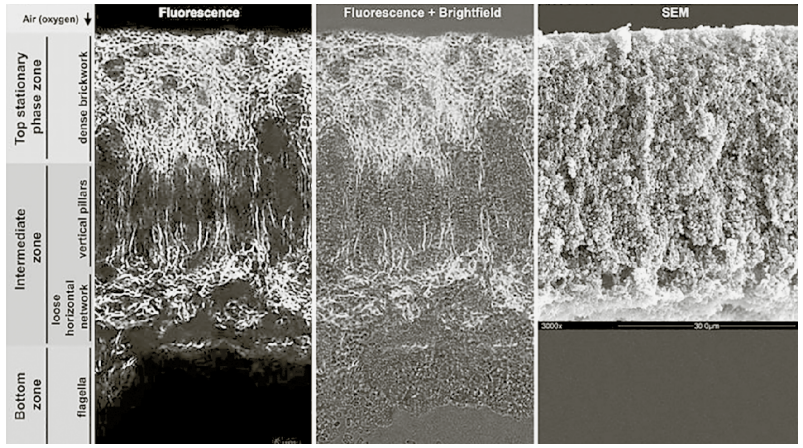


Fig. 11: The cross section of bacterial biofilm cellulose shows two interconnected layers and similarity to spacer textile (a), discussed with microbiologist Regine Hengge (b). On the macroscale, biofilm filters the light of the exhibiton showcase (c)

Moreover, the concept of tubular filaments and microfibrils derived from cell membrane structure is seen to show morphogenic potential. These semi-permeable spatial textiles open up the space for intertwining inside and outside, human and more-than-human habitat. The membrane—as defined by the cell membrane as a semi-permeable space of exchange and flow—is not merely a surface but a space and a state. → Intermezzo 4, 247

While engaging with the research on bacterial cellulose, the result of bacterial filamentation, I also recognized the layered membrane in the cross section of filamentous bacterial biofilm. What appears as a thin layer is actually interconnected twofold, bilayered fabric, a filamentous membrane on a microscopic scale (fig. 11). With support from Regine Hengge and Michaela Eder, these findings were shown at the Biomimetic conference. I placed the samples with bacterial biofilm growing on the lignin-cellulose rattan on the built-in light fittings of the exhibition showcase. With their specific materiality, they filter the exhibition lighting inside the showcase. During the course of the exhibition, further multilayered samples were produced with Skandar Hathroubi at the Microbiology department at Humboldt Universität zu Berlin. Considering that research into bacterial cellulose is engaging with a single surface, the multilayered samples presented us with a novel finding (fig. 11).

13 Travelling exhibition *Critical Zones. In Search of a Common Ground*, first exhibited at ZKM | Center for Art and Media Karlsruhe, Germany (2020–2022).

Fig. 12: Display cases with continuously developing willow yarns

Latour, for the exhibition *Critical Zones*,[13] defined the thin layer where most of planetary life occurs as a biofilm, borrowing terms from biology for the morphogenetic propagation of microorganisms: »It is no more than a varnish, a thin mat, a film, a bio-film.« (Latour 2020) Further, to address the interactivities of trans-scalar environments, he implies the human/animal scale of the membrane, the skin of planet Earth: »We have to imagine it as a skin, the skin of the Earth, sensitive, complex, ticklish, reactive. That's where we all live—cells, plants, bugs, beasts, and people.«

Wearing Baskets

The scale and the resolution of the knit made the samples suitable for wearing. The second display case in the exhibition space became a fundus, a wardrobe of all architectural samples that we were wearing during the research. ❑ Process, fig. 2, 266 The research examined clothing, architectures, and technology as homeostatic conservation layers, and the extended endothermic

14 등등거리 (Deung Deung Geo Ri)

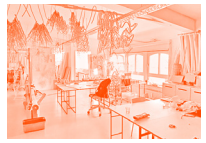
metabolism of the human body. The extension of the human body through woven, constructed, and networked materials signifies a profound shift in the biological definition of humans. To observe humans biologically as naked, textile-less beings appears as a fiction of science. The images of uncontacted peoples, indigenous tribes that do not want contact with capitalistic society, excite us, since they make us think that we, too, can exist as organisms without or with minimal extensions (fig. 13).

A key question arose in our pursuit of active architectures: how can our external membranes be designed as extensions of living systems? Variable permeability properties enable active mediation between internal and external environments. Textile knowledge lies in understanding how to contain matter in different states: regulating body climates, programming materials to alternate between solid and flexible, or adapting porosity. The structural textile prototypes evoked the intricacy and precision of anatomical samples. → Stretching Senses, 328

Fig. 13: Networks and membranes: a human–extended organism

Animal-built structures are properly considered organs of physiology, in principle not different from and just as much a part of the organisms that are more conventionally understood as organs. In their edited volume *Modell Hütte,* Karin Krauthausen and Rebekka Ladewig (2021) included a text by Turner about the *Extended Organism*, suggesting the hut is a human extension. In a chapter on filtering architecture in the same volume, Susanne Jany and Khashayar Razghandi make an argument for the biological approach to architectural and media practices, comparing the filtering organism of *Tunicata* to experimental projects from pneumatic lightweight architecture that explore the relation with the environment. »The notion of the *extended organism* situates such filtering architectures within a biological framework, arguing for a symbiotic view of spatial and material practices.« (Jany & Razghandi 2021, 456) On the one hand, we have a layered, semi-permeable membrane for individuation of processes, on the other, a membrane as filtering extended organism, which is how we define our relation to the environment.

Spending time in the same space with other disciplines in MoA's Experimental Lab was knowledge-productive. ❑ Process, fig. 6, 269 My models with double layered spatially crocheted rattan twigs (fig. 14a) reminded anthropologist and designer Yoonha Kim of traditional undergarments (Deung Deung Geo Ri).[14]



These have a solely climatic function—to secure space for separating and cooling the sweating body from the silk *hanbok*. It is made by splitting wisteria trunks into thin pieces and weaving them into a vest shape.

This is a ground-breaking revelation, since it confirms several arguments: wearing baskets—textile wooden »yarns«—stands in a human tradition, climate can be regulated on the scale of the body space, and the same techniques can be used for wearing and building. ❑ Process, fig. 3, 266 This important piece of traditional clothing together with the *tantoshi* (worn on the arm) is exhibited alongside the *hanbok* of the *Virtual Sensing Knife* project as an introduction to the research on architectural prototypes (fig. 14b). Today, this streetwear can be seen only in the museum. It is revived in the exhibition to enable a rethinking of the climatic negotiations between the body and the environment. → Stretching Senses, 318

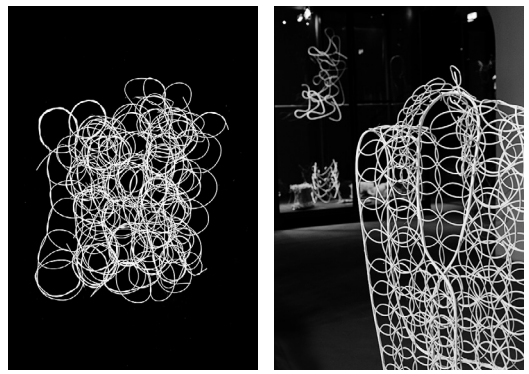


Fig. 14: Negotiating climates, bodies and architectures: spacer crochet model (a) and traditional climate regulating vest Deung Deung Geo Ri (b)

Film director and musician Leila Albayaty explored the space using her voice, preferring not to appear as human but to *become a tree*. Depriving herself of bodily appearance, she allowed her voice to resonate through the space, amplifying hidden material processes. By transforming sonic reflection into emotional and spatial affect, she explored layers of identity, subjectivity, and more-than-human polyphony. Singing along the curved walls of TA T, she activated a phenomenon where sound waves, through acoustic focusing, concentrated at focal points—allowing unexpected clarity and transmission across distance.

Metabolizing the Exhibition Space

With the developed loop-based technique, complex geometrical surfaces can be fitted. Like crochet, knitting can render complex forms and geometries. The adaptive objects

15 The essay was written for the Hella Jongerius exhibition *Space Loom #1* (2022).

were shaped and positioned to trace, the intricate forms of the exhibition space: along the edges of the arch, around the column, and smoothing the corners and contours. They served as an apparatus for tracking and tracing architectures and bodies. Much like symbiotic lichens growing on stones, metabolizing both the exhibition walls and space, knitted prototypes »stretched« the walls into open space, acting as extensions–as weathering.

In their essay *Event of the Fiber* (2022),[15] MoA members Regine Hengge and Karin Krauthausen describe textile spatiality as a possible human-made extended organism (also drawing on Turner):

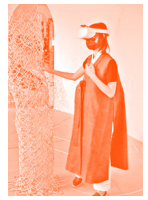
> Fibers are delicate lightweights with vast surfaces–in relation to their volume–that can simultaneously enter into multiple weak interactions. These interactions result in strong overall cohesion, while still allowing for local reconfiguration or loosening without the entire structure tearing or collapsing. This intricate, intertwined world of fibers forms soft, elastic, dynamically changeable, yet stable structures–the very kind needed by active, growing, living systems, not only inside their cells and tissues but also at their flexibly expandable interfaces and protective envelopes, where controlled communication with their environment occurs. (Hengge & Krauthausen 2022, 4)

Ultra-light yet stable, the adaptive objects were scattered throughout the exhibition space. The porous structures, changing the contours of the actual walls of TA T depending on the light, were at times barely visible. Some appeared as shed exoskeletons or skins of unknown insects or animals. Larger samples, placed in open showcases, were occasionally worn by visitors. These prototypes made visible the metabolic processes occurring between bodies, organisms, the exhibition space, and the mineral-based architectural wall. The wall, apparently built with large red limestone, is itself undergoing weathering–its surface deliberately arranged to appear as spalling, crumbling, and eroding–stripped of its representational role. ❑ Exhibition, fig. 1, 121

> It is not the boundary itself that makes an organism distinctive, but what that boundary does. In other words, the boundary is not a thing; it is a process, conferring upon the organism. (Turner 2002, 9)

An organism's persistence relies on the tangible boundary that separates it from its environment. Though it may seem solid, an organism's outermost boundary is, in fact, highly permeable, allowing a continuous flow of matter and energy. This new perspective on the living world helps us view animal-built structures that perform physiological work, capturing and channeling chemical and physical energy, as extensions of living bodies.

Through computation and digital modeling, different filamentous structures unify processes occurring at various scales into a shared realm. Bacterial filamentation–similar to the silk-spinning of spiders and moths–is a self-metabolizing process through which an extended organism creates its own environment. Human filamentation similarly engages with textile structures, networks, fibers, filaments, branches, beams, pipes, and cables. The exhibition *Stretching Materialities* explored the filamentous »extended organism« applied to architecture and human-made structures. Turner's argument of the extended organism, when applied to human »space-making« as thermodynamic continuity, helps us understand our inseparable connection to our environment. ❑ Exhibition, fig. 25, 143



At stake is the »notion of self,« where the self implies a symbiotic collective. This relationship between self and collective highlights how individual organisms are not isolated entities but part of a larger environment. It mirrors the symbiotic relationships in filamentous structures–interacting not only with other organisms but with materials, objects, and spaces.

Exhibiting, weaving, and architecture, then, can be seen as forms of »human filamentation«–an extension into the delicate, thin fabric, the biofilm of planetary life, as Latour calls it. The digitalization of filamentous processes contributes to remediation, care, and monitoring, thus redefining architecture and other spatial practices. Sensor-embedded textile systems, for instance, can monitor air quality or humidity levels in real-time, allowing adaptive responses to environmental changes and promoting sustainable building practices. ❑ Exhibition, fig. 2, 122 These sensitive wooden filaments react to humidity as shown in the project *Living Beings* by Nelli Singer, and act as analog sensors, revealing material activity. In an era where material resources and environmental conditions are changing too rapidly to rely solely on transgenerational knowledge, tracing and monitoring have become essential for learning. This insight blurred the

architectural »edge« of the exhibition space. The display of the object became a negotiation between the exhibit and the architecture itself. The prototypes or meta-types acted as tools for exploring spatial relationships between bodies, materials, and environments (fig. 15).

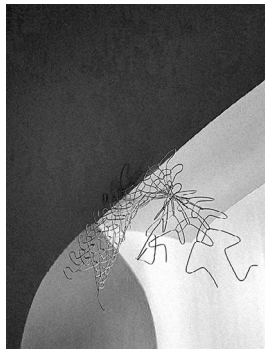
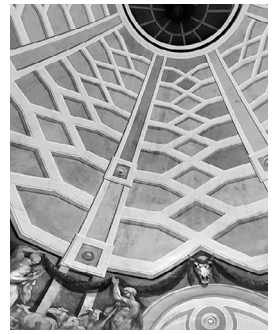


Fig. 15: Structured material is adaptable to the complex surfaces of the TA T building

The rough red stone at the base of the massive arches evokes the Rote Mainsandstein riverbanks. Sourced from the planet's core, this juxtaposition of materials reflects different temporalities—the two-million-year-old origin of the stone versus the building's mere 200-year history—provoking reflection on humanity's connection to the matter used in spatial production. Meeting the exhibition space halfway, the stone pile, designed to appear as eroding, introduced a sense of »strangeness« into the space. It stretched the stone collections of HU, showing the activity of stones and introducing human impact to matter-morphosis. → Stretching Time, 214 What makes a stone collectible, rather than viewing it as simply »material residue« or mere planetary matter? It is through what we discard that we define ourselves. (Calvino 1994) The *Leaking Stones* challenged traditional practices of collecting and conservation, juxtaposing human disruption—bioturbation, extractivism, tectonic altering, mining, and construction. ❑ Exhibition, fig. 1, 121 Interestingly, Berlin's highest elevation is a human-made hill called Arkenberg in Pankow, built by piling up construction debris and surpassing Teufelsberg, which was formed from WWII rubble. Urban tectonics and landscapes are also stretchable. In order to emphasize the finite nature of planetary resources, two meteorites from the Humboldt collection joined the stone exhibit. Shaped by their fall through the atmosphere, these meteorites yet contain the same minerals that are present on planet Earth, symbolizing universal continuity of matter. → Stretching Time, 214

WILLOW REALITY (WR)

The illusionary meshwork-like painting inside TA T's amphitheater dome depicting animal scenes is the historical example of making a collective augmented space for science. The force derived from animal sacrifice, distributed by vulnerable humans and plant garlands, is structural—it symbolically carries the load of the dome over the amphitheater (fig. 16a). Unlike virtual reality (VR), where everyone has their own VR set, this historically painted virtual space high up in the amphitheater is a technology for the collective—designed for a collective experience.



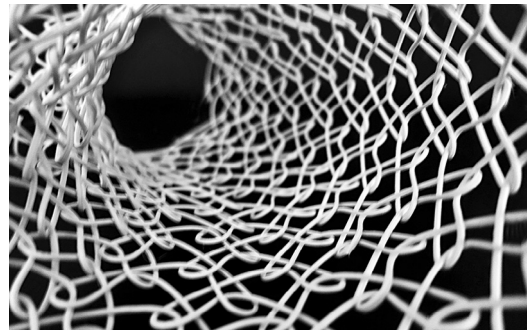


Fig. 16 The illusionary meshwork-like painting inside TA T's amphitheater dome with animal, plant, and human scenes (a) and model for the Haptic Nest (b)

The neoclassical edifice, with its anatomical theater, was an architectural innovation inspired by the veterinary anatomical amphitheaters in Paris and Lyon. Conceived on the verge of the French Revolution and the ideation of a future society, the amphitheater, wooden benches, and laced guards form the perfect globe, which was prominent in visionary architecture by Étienne-Louis Boullée and Claude-Nicolas Ledoux's Palais National. In a text accompanying the exhibition *Making Things Public* (Macdonald & Basu 2007, 105), the authors argue that the single sphere, the dome, the parliament of bodies, exemplified with visionary architectural drawings by Ledoux from the time of the French revolution, should be dissolved.

Space as a collective, as a collection, and as a public entity was examined simultaneously in the exhibition space and in VR. The shared experiences formed an informal collective—an instant community. The act of accessing the *Haptic Nest*, though highly personal, was at the same time public—you were crawling and moving—performing in the exhibition space. In VR, you were aware of other visitors in the VR environment and their movements. Unlike conventional architectural textiles that are in tension or hanging, the self-supporting structure and co-knitted *Haptic Nest* was conceived as an environment to re-enact the interplay of matter, energy, and space for collective imagination. This responsive willow installation, pleated both digitally and physically, formed a trans-digital responsive environment—a spatial, woven nest. Simultaneously accessible in VR, it explored the multi-scale of material porosity (fig. 1, 6–7). Its responsiveness revealed the material driven behavior and allowed us to examine bodily haptics, the notion of ground, and environmental density.

Porosity is measured in nothingness. In architecture, the 60% perforated metal panel or web is »60% nothing.« The void in textile is as essential to the woven structure as the material itself–this void is palpable: »…it's teeming with the full set of possibilities of what may come to be.« (Barad 2007, 354) Therefore, the textile as a technique becomes a tool for exploring spatiality. This duality of the material and the immaterial within a textile serves both as a starting point and a tool for investigation.

In VR, the geometry of the accessible structure appears perfect but rather featureless. The crackling sound of the willow, the force of the twig responding to body weight and pressure, and the texture of the reticulated structure guided the hand to explore. The hesitation in analog explorative movements is different from those in VR. The knitted column was a digital replica of the column in the exhibition space. While the actual structural column is rectangular, clad in wood, it appears rounded. The column exists in several realities: the original structure hidden from view, the representative wooden cladding that makes a hollow sound, the knitted column, and the columns in VR. ❑ Exhibition, fig. 25, 143

Apart from the existing architecture and the leaking stones, the knitted column and *Haptic Nest* were the only constructed spatial elements present in both VR and the exhibition space. → Stretching Virtuality, 83 The aim was a simultaneous experience, a sensorial juxtaposition of the textured objects with the smooth surfaces of the walls and columns. The developed warp knitting method using willow branches resulted in a novel, self-supporting textile structure. The willow structure *Haptic Nest* was designed on a human architectural scale; a fishing trap immersing the visitor, an embodiment apparatus: you could crawl inside or even walk in if you were small, either alone, or with someone else.

From the very beginning of the preparation phase for the exhibition, the space itself provided clues as to how to proceed. The goal was to make an accessible, experiential space and to establish a relationship with the exhibition space. The walls are so thick that their openings create a unique space. It is neither a room nor a wall; it is the space within the wall.

The woven, plaited space afforded by *Haptic Nest* represents an interplay between the material and the immaterial. The porosity became part of the exhibition space, creating a larger void, while the materiality of the plaited willow created a distinct spatiality. Visitors were invited to enter the tubular willow structure; the initial idea was that the feeling should resemble entering the old doorways, designed to bend down

on entry, making an entrance to a space of a different density and intensity readable through bodily movement. This transitional spatiality is reminiscent of biological processes, where the membrane serves as an actual phase, a process of mutual separation and connection.

The other important aspect was to alter the relation to the ground. The ground, like air, is often taken for granted. Altering the ground initiates in the mind-body the process of a reinvestigation of the surroundings. Initially, we envisioned that the whole space would be covered with stones, and the willow ground would be cushioned with structural textile prototypes.

Such cushioning prototypes, with different levels of adaptivity and interaction, from elastic to solid, were exhibited in the display case. ❑ Process, fig. 19, 280 The ground was activated, with one single »structural fold« between the fragile slow body of the visitor and the stone floor of the exhibition space. A soft, pressurized body that should not be punctured, the skin organ as an interface was always extended with wearable textiles, or, if not, aware of its vulnerability from the outside. The fold activates the body to negotiate with the structure. The nest is minimal habitat, a porous niche, an architecture of the in-between, a chronogenetic membrane. → Intermezzo 3, 191

It is a sensible inside-outside, like the experience of touch, a re-learning and sensing self that is perceptible in itself, where the self is extended:

> … the body sensed, and the body sentient is as the obverse and the reverse, or again, as two segments of one sole circular. … Why would the synergy not exist among different organisms, if it is possible within each? Their landscapes interweave, their actions, and their passions exactly fit together: this is possible as soon as we no longer make belongingness to one same »consciousness« the primordial definition of sensibility, and instead understand it as the return of the visible upon itself, a carnal adherence of the sentient to the sensed and of the sensed to the sentient.« (Merleau-Ponty 1968, 138, 142)

The accessible, large *Haptic Nest* engaged the visitor's hands to guide the body into the structure. ❑ Exhibition, fig. 11, 133 The digital model was not identical, addressing the imperfections of

reality—an analog glitch. The apparently infinite digital space allowed a journey through different scales: from the tubular installation, the fiber of the willow branch, to the filament of the lichen on the weathered rock. The experience had a »mise en abyme« or Droste effect—entering a yarn that is knitted.

As part of the exhibition, participants were given two meter long willow branches. ❑ Process, fig. 7, 270 Using the pointed tip to probe floors and walls while placing the broader base to their ears, they engaged in a low-tech yet highly immersive sensory practice. The hollow sap channels of the willow acted as natural acoustic waveguides, transmitting vibrations and amplifying sound—offering an immersive *Willow Reality* in parallel to the VR technology. → Intermezzo 3, 194 The exhibition unfolded as a progression—from vibration and sound to polyphony, and from filament or fiber to textile spatiality. The situated immersive practices—inhabiting textile spatiality, engaging with immersive VR and *Willow Reality*, and participating in collective embodied experience—examined the polyphony of spaces, materials, bodies, and scales, entangling conservation, degrowth, and decay.

Structural Textiles with Nelli Singer and Daniel Suárez

Nelli Singer, Daniel Suárez, and myself reflected on the process of developing the *Structural Textiles* project, a novel post-waste material system that is employed in exhibitions as an architectural research method, bridging microbiology, materials science, design, textiles, and architecture. Textile designer Nelli Singer's *Living Beings* is a thread made of wood that deforms independently and partially in different ways depending on humidity. Only a closer look at the »hydrophobic« properties of these materials made it possible to specifically develop a wooden thread with comparable properties. When entangled, dynamic surfaces or objects can be produced that react interactively to their environment and can perform different movements. The perplexing effect comes from the fact that the created surfaces can move on their own, as if by magic, like animations. Knitted fabrics, which obviously have no central body or control mechanism, seem to temporarily transform into living beings. As an architect and interdisciplinary researcher, Daniel Suárez explores experimental design methods and fabrication processes in architecture. His work bridges human craftsmanship, vernacular design, and digital fabrication through computational tools. Focusing on the interplay of craft, fiber materials, and digital technology, his research examines how digital instructions, geometry, and fabric formation principles inform innovative structural designs.

In order to develop *Structural Textiles*, we also had to consider the aforementioned *Active Curtain* project, where the idea emerged to showcase bacterial and plant cellulose research to represent the interdisciplinary cluster (fig. 7). Petra Blaise's *Inside Outside Studio* was selected with the concept of open, free space by suspending all the exhibits: as dynamic curtains, or mechanized showcases that can be lifted up. The findings from *Active Curtain* were further developed for and during the *Stretching Materialities* exhibition. Transdisciplinary exhibition-making means engaging with research from colleagues across disciplines and their perspectives, forming a thought collective. → Stretching Virtuality, 80 The publicity of exhibiting makes these collectives permeable. Moreover, through reflecting on the process, we diffract (Haraway & Goodeve 1999, 102): embodied social knitting, more-than-human subjectivity, adaptive growth, and reassembling change the notion of materials and spaces, positioning the experiential level as essential to material system research.

Over time, Nelli, Daniel, and I experimented with rattan for larger structures, merging techniques across disciplines—loops, looms, and materials—and eventually created a five by five-meter structure. By scaling up bacterial cellulose architectures and enlarging traditionally small stitches, we opened up new dimensions and perspectives. We integrated findings from Nelli's *Living Beings* project, Daniel's knitting fabrication research, and my warp knitting work from Frankfurt University of Applied Sciences with Claudia Lüling. This integrative approach shaped the branching structure and allowed us to explore bacterial design and the materiality of bendable rattan. The project evolved organically, with each team member contributing complementary skills. While we didn't always know the final outcome, the project grew, showcasing large-scale design and structure.

The shift from small-scale stitches to larger loops significantly changed the structural dynamics. When scaled up, they created a unique architectural impact. This change required us to alter how we connected the tubular yarn structures, resulting in new terminology for the production process. Each structurally

and topologically relevant assembly received a nickname—such as »the elephant« for a directional change in the warp knit. In branching, similar to a tree, the knit resolution was denser, thanks to Michaela Eder's materials science expertise. This not only facilitated communication during decision-making but, in the case of Nelli's project, gave the material system subjectivity, making it »more than human.«

Nelli's *Living Beings* project was also part of the *Stretching Materialities* exhibition. Initially, we hoped to let visitors interact with the cellulose by spraying water to observe its activity, which was instead showcased in a video with images in different scales. Microscopic analysis from researchers at the Max Planck Institute of Colloids and Interfaces allowed viewers to explore the exhibited structures in motion, revealing the swelling behavior of

16 Scaffolding is also the extracellular structure of bacterial biofilm.

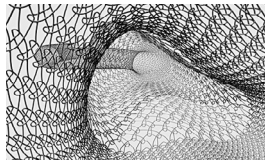


Fig. 17: Like Urban Knitting activism, the large structures call for social knitting (a), Nelli Singer's spatial forming of the *Haptic Nest* (b) in parallel with the digital (c)

the material at a micro level. This connected the larger physical installation to its underlying cellular structure, bridging the material's macroscopic appearance with its microscopic reality. An important aspect of the project was »social knitting,« drawing from bacterial quorum sensing (fig. 17a). The team worked together on a large project, which is typically a machine-driven or individual task. This collaborative effort was especially unique during the pandemic when the team worked in isolation while others stayed home. The large-scale knitting project and hanging structure, a fibrous scaffolding,[16] is denser at the top with intricate branching details to distribute forces. An interesting challenge was how gravity impacted on the structure, requiring adjustments like knitting upside down to prevent breakage. The directionality of warp knitting was crucial for ensuring stability.

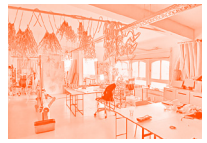
Flexibility, adaptability, and reversibility are key features of the system. We designed the system to be adaptable, allowing us to pivot it and introduce new structures or fields. It's amazing that we can potentially re-conform (a modular structure has the proportion of optimal conformity) the structure without cutting or destroying it. The ability to reconfigure is an important feature (fig. 17b). By unlocking connections

between the loops and redirecting them, we were able to create entirely different forms. Even after five years, the structures remain in good shape without the need for maintenance, meeting the necessary period for material approval. In addition, we can now also see that the strained part »took form« and can hardly be reassembled without soaking and drying again.

The method of exhibition as research became central to our process. It allowed us to not only exhibit outcomes but also the journey of research itself. Through the *Stretching Materialities* exhibition, we were able to continue developing our material system, and the exhibition context provided an opportunity to scale up and explore new structures. Not all textile designers are open to stepping beyond machine-scaled, independently produced textiles, but Nelli was enthusiastic about engaging with this broader perspective.

Choosing willow was a natural decision, reflecting our holistic approach to materials. Elena Eulitz, who works with elasticity structurally introduced us to the material, and I conducted extensive research on rattan sourcing. Despite my efforts, including contacting suppliers, I was never able to fully determine the origins of the materials. Michaela Eder suggested I would need to live where the materials grow in order to truly understand them.

While working in MoA's Experimental Zone, an open work space where the designers with practice-based research also conducted experiments and produced prototypes, surrounded by these structures, we developed a sense of what it meant to inhabit them. ❑ Process, fig. 6, 269 The exhibitions at Humboldt Forum and TA T provided a context to expand our research in ways we might not have considered otherwise. Daniel summed it up:



> Considering the entire production sequence we achieved for the exhibition, it's impressive. We developed this system in just a few months, while our own research might have taken two to three years. Each exhibition gave us the opportunity to explore different aspects. Usually, research has deadlines, but the exhibition really pushed our limits. Preparing for the TA T exhibition in six months was a challenge, but it sparked productivity. We didn't rush things just because the opening was approaching. Ultimately, we created something meaningful under pressure.

I remember early models of what we called »active« prototypes, created with wool and flax materials I found at a local market. Initially, I thought we'd just need to produce samples for industrial prototyping in Chemnitz, but the pandemic changed everything. Most of our work was done manually, offering a new experience. Nelli added:

> With every material and scale, the knowledge expands. Shifting to willow was a completely new challenge. While working with laser-cut wood and rattan was easier, willow has a character of its own—it tries to return to its original shape, which makes it tricky to work with. The sound of the material was also different. Rattan is silent, but willow cracks, revealing the tension within, adding a whole new sensory layer. It was almost as though the willow was speaking to us!

We also discovered the special properties of water after soaking the willow, which helps plant rooting—adding another dimension to how we interacted with the material. In TA T's special eighteenth century vaults, we were able to negotiate the architecture of the exhibition space with our material systems. We produced prototypes that reflected the space's geometry beautifully. → Stretching Practices, 29

The installation felt immersive compared to the previous exhibit, *Active Curtain Project* at Humboldt Forum, which had a more contemplative atmosphere. Visitors interacted with the structure differently; it felt more alive. Although the earlier project focused on living organisms and movement, it didn't have the same dynamic presence. We managed to create structures that were both accessible and resilient. Nelli took the challenge of ceiling loads seriously—the structure can hold up to 300 kilos.

Meanwhile, Nelli's experience in the automotive industry revealed that advancements have been made in textile machinery, highlighting the potential and limitations of weft flat knitting, circular knitting, and weaving for architectural applications. While weft and warp knitting have shown flexibility, particularly in spacer textiles, warp knitting machines have lagged behind in innovation. Spacer textiles, reliant on stable materials, show promise in adapting warp knitting processes to thicker materials like willow, aligning with architectural scales. The challenge is overcoming existing machinery constraints to unlock new material and process possibilities. Exhibition as an architectural research method in cohabitation, *Structural Textiles* examined the very structure of architecture and the construction industry, resources, materials, spaces, and practices. Exhibition making, creating a continuous *warped space* for different actors, made the holistic approach possible, which is needed to address the very structure of the discipline. Beginning during the exhibition runtime, the project *Myko-Plektonik* with Vera Meyer and Bertram Schmidt from the department of Applied and Molecular Microbiology at Technische Universität Berlin, and architect Dimitra Almpani-Lekka explores *Structural Textiles* as scaffold for growth of filamentous fungi, *Fomes fomentarius*, sourced locally.

Fig. 18: *Myko–Plektonik* explores the filamentous fungal growth on *Structural Textiles*

Expanding the influence of the Bauhaus textile researchers as well as artists engaged in filamentous architectures, digital fabrication, and lightweight structures further opened up the possible capacity of these structures toward a new transdisciplinary (post-)structuralism that Wolfgang Schäffner (2016) calls »supple structuralism.« The textile logics encompassing digital ecologies and textuality contribute to relational and processual materiality.

Returning to Rancière and the question if there is a theater without a spectator, the proposed exhibition concept of »doing nothing« comes from a rejection of extractivist architecture and a call for degrowth in the economy and thus in architecture and construction. More precisely, it derives from the architects Lacaton & Vassal's concept for renovating a large exhibition space, the Palais des Tokyo in Paris, for which they won an architectural competition by leaving the building as it was, without doing anything. Yet, »doing nothing,« according to Lacaton, is a very complex and elaborate project.[17] Passivity, in line with *The Limits to Growth* (Club of Rome 1972), is in itself a lot of work:

17 https://untappedjournal.com/stories/edwin-heathcote-architecture-of-doing-nothing

the capacity to imagine the future we want is our main task. In theory, these processes take place even if they are not observed.

This shift from displaying objects to research as a staging process emphasizes the active, performative nature of matter and space. The exhibition, however, intended to shift the visitor's role from a distant observer to an active participant, out of the desire to create communities, through collectives, through shared experiences. The word drama originates from the Greek word *drama*, meaning action. Active matter can be read as a kind of »matter drama.« Rather than a passive experience, the exhibition invited action in front of living bodies, offering visitors the chance to become part of the performative processes. We can see here the social role of exhibiting and its potential as an empowering practice. → Intermezzo 4, 257

The activation of participants took place in two stages: first, through the strangeness and enigma of the exhibited processes, which prompted visitors to become amateur scientists, searching for clues and understanding. Second, they were drawn into action by the performative energy of the exhibition. This created an exchange of energy–vital, metabolic: the exhibition needed the participants in order to complete the hidden theater of matter.

As a research method, exhibiting situated broader inquiries into »active matter« by examining processes across multiple temporal and spatial scales through the lens of »place« or »zone.« It engaged with collections, data, locations, networks, climate, and more by including different places that are inherently connected to exhibition making–from the Max Planck Institute for Colloids and Interfaces, the fields where willow is grown, to the cables on the bottom of the ocean, and computing servers where exhibition data are scattered and stored. These places radiated and filamented into zones, fields, and clouds and interacted with other zones into networks and climates. Polyphony, much like Timothy Morton's (2013) concept of hyperobjects, → Stretching Practices, 25 → Stretching Senses, 309 offers a conceptual framework to address the complexity of changes in material and spatial resources that impact biological diversity and human life. Architecture today operates not only at visible scales of spectacle but also within metabolic, nano, and hyper scales–such as weathering, digital ecologies, economy, and climate.

As an interdisciplinary practice, the exhibition brought together scientists, designers, and humanities scholars, encouraging them to expand their research questions and foster clear communication across disciplines and with the public. This approach emerged from a critique of institutional museums, shifting the focus from presenting static knowledge to questioning: how do we come to know something? Engagement with social and scientific practices is addressing the quest by Isabelle Stengers for a better science. Remediation–in the media studies sense of re-mediation with new media technologies–is combined with remediation in the sense of healing soil and landscapes used in ecological studies. Both terms met in the framework of the exhibition. Thus curating, or healing, received another meaning in the context of regenerative design.

The accessibility of exhibition spaces and collaboration with curators shaped the scope of research conducted during the exhibition period. Less accessible spaces for experimentation resulted in limited spatial interventions, with research primarily conducted during the preparation phase (e.g., the *Active Curtain Project*), encouraging more contemplative interactions with the research material. More accessible spaces enabled ongoing research throughout the exhibition period, allowing for iterative changes and developments (e.g., *Stretching Materialities*). Concrete physical engagement with objects and spaces, combined with spatial interventions, fostered bodily engagement and immersion, creating opportunities for embodied knowledge. Audience interaction was essential for completing the exhibition, as public engagement could not be avoided or ignored, and instead contributed to the exhibition. These shared experiences built an informal community and contributed to a collective knowledge and »critical mass« towards new cultures of material through publicity.

Curated public engagement provided valuable feedback, enriching the research process. Prolonged or repetitive engagement with an exhibition, or »inhabiting,« was able to transform passive observation into active participation. Exhibitions hold the potential to generate a »research surplus;« through their creation, »this research surplus does not only concern how much we know, but also involves different ways of knowing« (Bjerregaard 2020). This method remains open and adaptable, embracing unpredictability as part of its process–*exhibiting in the making*. By collaborating with artists, traditional craftspeople, and industry, and by showcasing processes, this approach incorporated diverse ways of knowing, interconnecting various ecologies of knowledge.

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BODY MATTER LABS

Natalija Miodragović in conversation with Lara Ladik

Intermezzo 3

• Natalia Miodragović: Your Master thesis, *Tapping into the matter edge. Cultivating bodily attentiveness with the non-human as part of Stretching Materialities* at the Institute for European Ethnology at Humboldt University in 2023 is tied to the exhibition *Stretching Materialities*. The objects on display in the exhibition invited visitors to actively engage, encouraging them to explore and train their perception by observing how they might alter along with their environment throughout the interaction. Could you elaborate on the role of the body and bodily awareness in this context?

• Lara Ladik: As a movement researcher, body practitioner, and cultural anthropologist-in-becoming at the time, my Master's thesis evolved around the question how body awareness in the exhibition space could foster our perception of our shared interdependence with materials, exploring them as living entities. Are we able to trace their aliveness within ourselves, beyond habitual visual observation and intellectual understanding of (the biological and physical laws governing) how materials interact with their surroundings? What kinds of ontologies are being shaped? To pursue these questions and ultimately develop a mediation proposal with scores for visitors, I first engaged in my own movement explorations. An example of this auto-ethnographic endeavor is the dive into the »willow nest.«[1]

Through such auto-ethnographic explorations, and later also extensive ethnographic material gathered from participants of workshops called »Body matter labs«[2]—which I co-facilitated with professional dancers Jozefien Beckers and David Kummer, and where body perception was placed center stage—I investigated how negotiating with material can align with the notion of sympathy.

• NM What is sympathy?

• LL While growing up and navigating life, we learn—hopefully—to behave empathetically towards one another and the living world at large. However, empathy, as philosopher of science Vinciane Despret understands it, has its limitations. It risks being only one-directional: I can be empathetic towards another being, but in doing so, I position it as something different and outside of myself. Like an object, the other can be seen empathically, but my empathy does not enable the other to return to me as a subject (Despret 2004, 128).

I find the experience of sympathy when I allow myself to explore my body as a plane of potentiality, as I had experimented inside the willow nest: when I perceive myself as matter *relating* to other matter seemingly outside of my body, and *respond* (with movement or feelings, for example) instantaneously when *perceiving* that relation. Just as in the willow nest, where I had no goal or intended direction in sight, I simply followed, vertebra by vertebra, the points of contact with the willow branches. I not only learn to *feel* within myself what initially seems outside of myself, but I also—and this is where it seems to become an art of perception—learn and train myself to sense the quality of the matter (dense, hard, bendable, with soft air chambers in-between) and myself in responding to those qualities at the same time.

As philosopher Mark Eli Kalderon suggests, »Sympathy is what makes the extra-somatic present in haptic experience. Thanks to the operation of sympathy, we experience from within what the extra-somatic is like.« (Kalderon 2018, 51)

Experiencing not only the extra-somatic, but also the immediate response gives me an understanding of overcoming my preconceived duality between myself and the material world. Could this approach help us grasp the aliveness of our surroundings and our inter-beingness with it on an embodied level? To feel this in *responding*, are we becoming reciprocal extensions to our material surroundings, becoming-with-another?

Fig. 1: Inside the willow nest

Integrating body and movement awareness into a mediation proposal that invites visitors to engage through playful exercises has proven, once more, not only to be beneficial in preventing the phenomenon of »museum fatigue« within exhibitions. An approach like this keeps visitors engaged with the topic and may spark conversations arising from their focused and intimate experiences with the exhibition (Løppenthin et al. 2022).

Those who were open to exploring the various objects in *Stretching Materialities* while tuning into body sensations reported feeling engaged, awake, curious, and inspired, with sharpened senses. They became more considerate of themselves and their actions, understanding that perception builds upon participation. Ultimately, it also fostered a sense of connection among visitors who were initially strangers to one another, and to the »living material« itself.

Negotiating. Auto-Ethnography
Lara Ladik (Excerpt)

Timid at first, curiously listening, I slowly crawl inside and through the willow nest. This tunnel-like space, composed of large meshes, feels stable yet bendable under my weight. I am the larger, undeniably noticeable particle, dense and clumsy. The material composition of my body—water, bones, cells, breath—meets the surface of the willow branches. The bends in the mesh press into my flesh and resist my bones. It resists me—or do I resist? I move and soften around points of contact. The empty spaces of the mesh become tangible. They are my refuge where I can hook in a finger or a foot. Resting, intertwining, softening.

The web as a whole yields under my weight. »Natalija! What if it breaks?!« I exclaim, worried about damaging this beautiful sculpture that has grown over months with the work of many hands. »If it breaks, it breaks! It's about negotiating,« she reassures me. I try and synchronize my movement with my breath, extending into the structure. I release movement into the willow, receiving it back as I withdraw. Breathing with willow—I'd never thought about it. I learn to move forward through the meshed space with ease, finding tiny, precise movements within my body, adjusting vertebra after vertebra along the willow structure, seeking only the next point of contact, not thinking about my final destination.

Like invertebrate creatures such as worms, I test my immediate environment, then move along. A new sensation arises: I mold into my material environment, accurately, moment by moment. My movement originates from the matter that I meet—not from a visual destination that my body follows with a biomechanic response.

Imagining the fluids inside my body dropping down, as if they were pouring around the bends of the willow gives me a sensation of density within me. It's a fluid density contained only by the breathing barrier of my skin. What probably seems like an absolute still point from the outside is full of shared micro-movements, full of shared life, between me and the willow. My eyes are the last to follow—enjoying the new perspective they've been moved into. Suddenly, gravity feels different: the denser the structure on which I rest my leg, the more it supports me, the lighter my leg feels. I feel light-bodied—in parts, at least. My micro-movements matter.

1 See *Negotiating* excerpt below.
2 »I can only come into my own in community with other living matter,« cited from Andreas Weber, biologist and philosopher.

ANTENNAE—WILLOWALK

Natalija Miodragović

Intermezzo 3

The group »Antennae,« formed by Chloé Lee, Samuel Perea-Díaz, and VanTa during an art residency at the *stretching senses school*, chose to bodily expand—»stretch«—experiences by interacting with willow branches. The three multimedia artists initiated this artistic research encouraged by myself, architect and researcher, and anthropologist Yoonha Kim. We were interested in unfolding the willow's sonic dimension that we discovered during the preparation of the exhibition *Stretching Materialities*. The artist group created two artworks that explore sensing in motion and sensing walks in Extended Reality (ER), an emergent field employing Virtual Reality (VR), Augmented Reality (AR), and Mixed Reality (XR) technologies.

In conversations with artist and architect Samuel Perea-Díaz, he describes *Willowalk* as a listening journey, a process of weaving sonic terrain. For Samuel, listening opens up the in-between, the intersecting spaces of being with others, both human and more-than-human. He posits that listening requires sonic participation and engagement with our surroundings, which implies understanding the epistemologies and pluralities that constitute the built environment.

Fig. 1: *Willowalk*. Listening Workshop at Charité Campus

Willowalk is a form of extended listening that involves grasping a willow branch with the hand, extending it next to the thumb, and gently inserting it into the outer ear. This allows one to hear the sound transmitted through the willow's material from the outside world to the inner ear. It introduces audiences to a unique method of sensing spaces by using a temporary sonic antenna as a prosthesis to extend the senses on their bodies.

Two coupled artworks produced by the Antennae group negotiate how immersive technologies engage with virtual and/or actual walks for the senses. *Antennae* is a VR artwork that brings audiences close to hearing bone conduction by amplifying sound via two willow branches attached to a VR headset (Meta Quest 2) and playing it back in rendered delayed light impulses and capturing sounds.

Fig. 2: *Willowalk*. Listening Workshop at Charité Campus

Willowalk is a listening workshop, a guided journey weaving sonic terrain with listening walkers exploring the surroundings of the building of Tieranatomisches Theater (TA T) on the Charité campus in Berlin. We began with a sound walk, using the architecture as a score to follow, and walked as a group from the exhibition space to the outdoors. Shortly after getting outside of the building, we focused on the surrounding sounds while working in pairs—one with closed eyes and prioritizing the oral, while the other concentrated on other senses. During a collective walk while listening through the willow branches, we gently scratched surfaces, followed later by the *Antennae* experience in the amphitheater. The listening workshop concluded with a group discussion. Walking shapes listening as a collective experience through our sharing of individual sensations and impressions that disclose different sonic materialities in the actual and virtual spaces. The transformative potential of this artistic intervention into sensing spaces is evident in the feedback received from participants who expressed a newfound appreciation for the sonic aspects of the environment they perceived:

> With worlding in mind—the sound walk makes you »hear« the sun, the dry grass, and soil on the Charité Campus. The ecologies of birds, humans, machines (air conditioning), material perturbation (sealing the soil with bitumen), and flow.
>
> I feel more connected to my oral senses.
>
> Today I had the chance to have branches instead of arms and listen to the rocks on the floor. I trusted a complete stranger to be my eyes. The words in my brain took a short vacation. When they came back all tamed and smiley, they told me I should let them go away more frequently. Gracias por la transmisión.
>
> The soundwalk was really ear-opening.
>
> Humans are so soft to touch and hearing. They come across as a pretty large organically shaped jelly mass with pressurized membrane (skin) as an interface.

(Quotes from different participants' feedback on the listening workshop *Willowalk*)

THE SPATIAL OBSERVATION OF THOUGHT

Natalija Miodragović in conversation with Jean-Daniel Berclaz

Intermezzo 3

• Natalija Miodragović: For the finissage of *Stretching Materialities*, you conducted a one hour artistic performance in the amphitheater of Tieranatomisches Theater (TA T), entitled *L'Attente* (The Awaiting/Anticipation). Why did you choose the space of the amphitheater?

• Jean-Daniel Berclaz: There were already many ideas in the exhibition space. I wondered what else could I do here? I'm not someone who looks for or brings a lot of materials. I'm more interested in another language. And my own material is also perhaps a kind of silence of solid materials. I found that this theater is already an installation in itself, it's already a work, it's already a structure. It's already there.

When I was told about the history of this place, the main story was that of the elevator going up and down. In fact, we were gathered in the space of the dissecting room, where animal corpses used to be placed on a big plate for dissection. The animal is a mirror, a reflection of ourselves—because an animal does what we do, it walks and eats. There's not much difference between them and us, we are animals, and when you open the inside, there's a liver, the kidneys, we all have the same system. It's like a car engine, you need all its parts, and the system needs fuel. When we talk about the power of an engine, we talk about horses—horsepower.

• NM The horses, the animals, were the essence of the transport and war industry—an animal machine, an enhancement of the human body. The TA T building, one of the first Veterinary Anatomical Theaters, was built during the horse pest pandemic. Until then, anatomical theaters were built for the knowledge of the human body. I am interested in your process of conceptualizing this performance. In French, the title *Attente* translates into waiting but also into anticipation: attentive waiting.

• JDB When one is downstairs, in the rotunda, one is in the very structure of this theater. Basements are always laboratories. In a family setting, if there are children who want to make music, we put them in the cellar in order not to wake everyone up. Somehow, all this music down there is like a laboratory, in search of something. The floor above is the explanatory aspect of the laboratory. As an artist, I cannot explain anything scientifically, but I can consider the meaning of a place—that is my science. The amphitheater reminds me of my time in art school, where I loved to visit life classes, drawing living models—people instead of animal corpses. It was also a kind of amphitheater, with an almost religious feeling. Everyone has a sketch pad, and they draw. You hear only the sound of the pencils and other than that—there is silence. And that is the image I have of the moment when the professor would come to give a lesson and was waiting for the animal. The elevator with the animal would rise and everyone would be there, waiting for the professor to speak. I wanted to recreate that scene.

• NM The very moment is essential. What role does time play in your work?

• JDB I've been thinking about anticipation, waiting for a result, waiting for an action. When you take the train for an hour, you are no longer in the city. In general, when you look out of the window, you're out of the city, you've crossed the forest, and you're somewhere else. You haven't done anything, and you're waiting an hour to arrive. I did an internet search for horses, and I found the sound of a horse galloping. If you loop the sound of a running horse, you loop, loop, loop—it becomes techno. At some point, you run with this expression; it provides a rhythm, and you follow it. It's like an engine, or a train. I edited the whole thing into a one-hour

loop. My timing for the performance was the music. I knew that when it stopped, the hour was up. And then I do what the audience does: wait for one hour. The act of waiting is that moment. I am in the same situation as the audience, I don't know how long we've been there, or if there are ten minutes or half an hour left.

• NM The amphitheater has a voluminous dome—a large space built specifically for thoughts, for learning and teaching. My logic as an architect is: if there is a space, there is materiality to be accommodated—the materiality of thoughts. You said that what matters to you is the spatial observation of thoughts: are these the audience's thoughts?

• JDB It is also the audience's thoughts because what I found interesting is playing on symbols. Like this silly sculptural object with the horse I installed. There was »symphony« there. In the center of the round elevator surface, I placed a round mirror that reflected the ceiling, on which I placed the small sculpture of a horse (fig. 1). The horse sculpture turned around and around, much like the horses on those tables used to, and the ceiling then turned with it.

• NM Alongside the VR technology experience we featured in the exhibition, this seems to be the ultimate analog experience, an action by an artist experienced in person. You had your mirror, your thoughts—your tech.

• JDB I also found a child's horse toy with small bells that I glued to the end of a broomstick. It has a wizard-like quality to it. The professors are in the field of magic because they explain things from another world. I think it's important to create a space of detachment between the person, the public persona, and the professor's persona. It's there, like a crystal ball within a crystal ball. You can even predict a bit of the future, anticipate. There are plenty of little cues like these that are small symbols but sufficient to shift your attention. Otherwise, you wouldn't stay captive. I'd say that's similar to music, much like the galloping horse becoming techno. And all of this is part of the broader picture. It's important to think of it as the window of a train. It's the window that makes you look outside. If there's no window, you won't look outside.

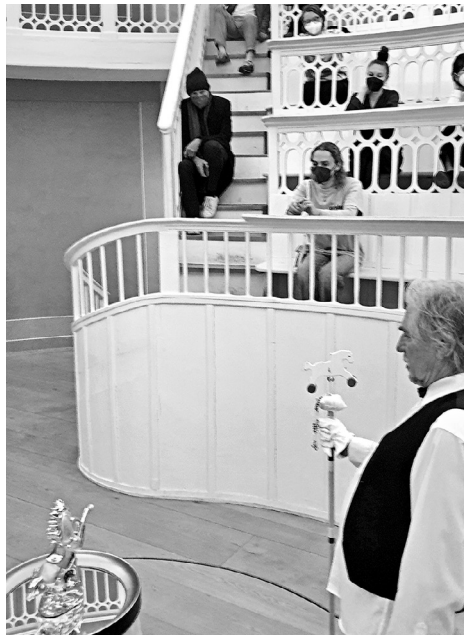


Fig. 1: Jean-Daniel Berclaz, *L'Attente*. Artistic performance in the amphitheater of TA T

• NM You have already said that you need tools to captivate the audience and bring them into the professor's reality. Were you captivated by the exhibition?

• JDB You made all these experimental objects out of willow. What I liked was the idea of it being based on resonance. You could hear sounds with objects, actual long willow branches, if you put them in your ear. I like that you could listen as if they were mobile phones, you could telephone to different spaces. And when you talk on the phone with spaces, a space responds to you by vibrating in another object. We were able to move around with something, a twig, and that is also a sort of management of space. The woven willow structures that you make from these same twigs are somehow solid; they are trivially transparent and solid at the same time. It is a solidity that both limits and delimits space—you can see through it, but it is also a boundary because you can see through it.

• NM Your ongoing project is *Le Musée du Point de Vue*, a museum solely within the personal realm; it is art without artwork. In this work, there are no objects at all. Is there a connection to *L'Attente*?

• JDB My *Point of View Vernissages* are more about the expectation we have of artworks. After all this expectation of the artwork at a vernissage, you leave immediately afterward. In the *Point of View Vernissages*, I consider that the exhibition space is always where you are. Everything you can see around you is the exhibition. So, the exhibition walls are the limits of your gaze. The walls lead to the museum hall. If the site is outside, your gaze goes much further. And then you have to find a place where things speak to you. First, you need a place with a political story, an issue, or something specific. The interest is also to point out something that people have never paid attention to; they always pass by it but never notice it. For me, it is a bit like easel painting. The artist goes with their easel, sets up outside, and paints. Similarly, the *Point of View Vernissages* are like an easel painting, and the audience creates the painting. I don't present myself as an artist. I have an artist's project, but I am just the museum director and curator because I chose the place where I put the museum. In absence of an artist, the audience does the artist's work. I have done a hundred of these events worldwide. It is really interesting because the audience initially wonders if there will be fire-breathing, acrobatics, or if someone will undress. But I do absolutely nothing. I simply dress properly because I respect the museum, so I am well-dressed. Everything is professional, and people suddenly forget everything. They are there, and they completely forget any questions they may have had. They leave enthusiastically, and they say, »Oh, it was fabulous.« You know, when you go to a vernissage, everyone hangs around the table with food and drinks. After all, why look at the art? They will say, »Merde, it is closing in ten minutes! I will come back to see the art another time,« and that's it.

IMMERSION
INTO THE MICROSCALE

Natalija Miodragović in conversation with Michaela Eder

Intermezzo 3

• Natalija Miodragović: Michaela, as a material scientist, the time you spent with us designers and exhibition-makers examining the materials we are working with was crucial for the project. Your knowledge of trees and fiber architectures in biology provided us with additional insights, particularly when it came to observing material properties at a microscopic level. You taught us where to look, how to observe, and introduced us to the practices and experiences of the natural sciences, such as using a microscope or preparing samples. This experience gave me a different sense of scale (such as the microscale) but also of time or pace. I found observation through the microscope to be quite a calming experience, offering a different awareness of time. This was my introduction to working in the lab. I have learned to appreciate working with matter in a focused manner at what one might call a microscale of events, and I found the collaboration between science and design to be very useful. I wonder, how useful—or useless—does it strike you as a material scientist?

• Michaela Eder: The useful- or uselessness depends on the viewpoint of both disciplines. The benefit for a designer can be the information about the microstructure of the raw material; at the same time, this information does not necessarily influence the process of »Gestaltung.« However, this is exactly what is useful to us: we obtain the information of what can (and cannot) be done with a given material. This helps sharpen our research questions related to material properties. The designers' experiments are particularly helpful for plant materials because of the huge diversity in material structure and properties, even within the same species or the same individual, since design experiments are typically much faster than studies at very small scales. In our research, materials science, we often focus on a very specific question. Yet, there is such a vast diversity of knowledge, and with each designer, architect, or humanities scholar who comes into the lab and wants to investigate their material, my knowledge of the diversity of structures and properties increases. Even though I do not use this knowledge directly, in the end, it contributes to my own research.

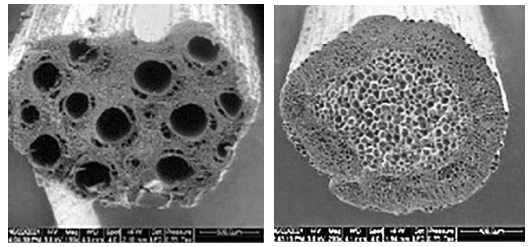


Fig. 1: Microscopic images showing the fiber structures of rattan (left) and willow (right)

• NM You were teaching us how to cut samples and observe them in order to understand the forces and practice of bending a willow twig, for example—the differences between its lower part, which is closer to the roots and soil, and its tip. As part of the same twig, these structures are both similar to each other and also radically different. As designers working with the material, we felt this in particular when bending the twigs. It was insightful to understand what had already been experienced or concluded while negotiating the forces in the twigs.

• ME What I found particularly interesting about this project was that you brought both willow and rattan into the lab, which have completely different growth patterns. When examining different sections, you can see where the differences lie—and this is essential knowledge (fig. 1).
❑ Process, fig. 23, 284

• NM Yes, they are completely different. Willow is a tree, and rattan is a palm, but they both possess properties of elasticity

and formability. This is more of a user-oriented description. When I mentioned that willow could be described as a local (European) bamboo, you disagreed, saying that bamboo belongs to the monocotyledoneous plants, as do the grasses, and that bamboos are not trees. However, both can be bent and formed. The elasticity of the material makes the local winds visible. Wind itself is invisible, but it becomes visible through its interaction with the environment. This kind of remote or delegated sensing is needed to understand complex processes like climate and urban dynamics. Wind can be seen—or rather felt—in the material because when you bend it, it reminds you of the wind bending the trees outside. This property comes from these bendable species and the landscapes they inhabit. You also mentioned that the majority of the material is actually dead tissue.

• ME The property and effects of this flexibility are due to the fact that your twigs of willow and bamboo were thin and had a high aspect ratio. On the living plant, they also needed to be flexible because, otherwise, they would just break in heavy wind, since the cross-sections weren't large enough. By contrast, if you look at the stem of a large willow—it's not flexible. In addition to the larger diameter of the stem, the material formed at the periphery is much stiffer and supports the crown. Flexibility of large stems doesn't make sense in this case since it would simply bend and fall over.

• NM Your reaction motivated me to learn more about the tree itself. After reading scientific papers on the subject, I now understand that the tissue that was once transporting sap eventually changes. As the tree grows, it becomes dead tissue and adopts a more structural function, whereas initially, its role was more infrastructural—transporting sap.

• ME Do you know how a tree grows? A stem grows both in height and diameter. The so-called apical growth takes place at the tip of both stems and branches. The cambium—a ring of meristematic cells, located between the wood and the bark—forms wood cells (xylem) toward the inside and bark cells (phloem) toward the outside.

As a tree grows, its diameter increases and so does the circumference of the cambium, ensured by cell division in tangential direction. Concerning the functions of the tissues, the xylem transports water from the roots to the shoots. Nutrient transport from the crown downwards takes place in the phloem. Additionally, the radial connection between cells is ensured by wood rays, also formed by the cambium. While the axially elongated xylem and phloem cells are derived from so-called fusiform initials of the cambium, the more isodiametric ray cells derive from ray initials.

After cell division, cell differentiation and thickening take place. Cells that need to be water-conducting must get rid of their cell content in order to be able to transport water quickly. This means that they die a few days or weeks after they are formed to become fully functional. The ray cells, responsible for nutrient storage and transport processes, remain alive. As the tree grows and gets older, not all of its cross-section is needed for water and nutrient transport. Transport only takes place in the outer part, the so-called sapwood, while the inner part, the so-called heartwood, is dead. The ray cells have died and in many cases this process of heartwood formation leads to a higher resistance against microbial degradation.

• NM Many designers in the Cluster actually conduct research on and with cellulose-based materials. Welcoming more designers into material scientific labs seems essential. Would you say that for these collaborations to work, it is crucial to understand that everybody is trying to contribute and tolerate what might be considered stupid questions?

• ME I would say it's not about tolerating, it is really about openness and the willingness to explore how this collaboration can lead to fruitful discussions. I believe it's not sufficient just to put scientists and designers together. They also need to connect with each other, which requires trust and respect. This trust is necessary in order to feel comfortable with asking any questions.

Fig. 2: Immersion into the hybrid willow yarn at Max Planck Institute of Colloids and Interfaces, Golm

• NM As an architect, this project is also about all the remote spaces connected to the research project at hand. You work at the Max Planck Institute of Colloids and Interfaces in Golm. The building in which the lab is situated is an important node in the network. I think that this building is unique in the sense that it houses microscopes, connecting you to other scales.

• ME It is unique because of the people who work there, because of what they think and what they do. Maybe coming back again to the benefits of working with designers, especially given the work you and Nelli Singer did, it was extremely inspiring to see that the knitting and entangling of your twigs with certain geometries allowed movement in different directions while restricting others by the presence of neighboring elements. My guess is that a materials scientist would not have come up with such an idea and would certainly not be able to realize it in such an aesthetic way. Structures and prototypes such as yours trigger our thoughts about what the interesting research questions are. What do we need to know to advance structures like that? With each of these experiments, we are also learning more about the material, and this is something we should not underestimate. I think this is one of the really important aspects for us. It triggers critical thinking in different directions. Also, we need the designers' speed of working! You are so quick compared to us. It's quite useful. But I guess designers also need to get used to our slow pace; we need to get used to each other. In the end, we benefit from collaboration. Seemingly useless interactions are, in fact, essentially useful.

Stretching Time

Researching Collections. Temporal Morphologies and Transformation of Matter

Nina Samuel

1. INTRO: COLLECTION OBJECTS AS EMBODIMENT OF TIME

Far from being static relics, objects in collections are constantly evolving, shaped by a variety of influences—from historical and cultural contexts and changing academic perspectives to wider socio-political and technological shifts. Their material decay reveals the enduring effects of time, environment, and human interaction, while archival and exhibition practices such as handling, conservation, and curation further transform them. Together, these processes continually redefine their meaning and function.

How these objects function as generators of knowledge is closely linked to these different constellations of time and matter. As Eilean Hooper-Greenhill explores in *Museums and the Shaping of Knowledge* (2003), objects in collections contribute to the ongoing construction and redefinition of knowledge through their interactions within cultural, disciplinary, and educational contexts. In this sense, as carriers of time and memory, their meaning is continually reconstituted through these processes and practices.[1]

At the same time, conservation efforts strive to suspend the natural flow of time by concealing decay and degradation to create an illusion of timelessness. This approach has been described as »stripping things of their relationship to time,« a strategy that ultimately proves to be unsustainable given the dynamic nature of materiality (Burström 2011, 125).

Building on these ideas and my own personal research interest, the exhibition section *Stretching Time* at Tieranatomisches Theater (TA T) emerged from collaborative practices → Stretching Practices, 55 as part of a shared research effort to explore how collection objects embody and reveal the passage of time and the dynamics of material transformation. The exhibition space became a veritable laboratory where interdisciplinary collaboration was not only presented but actively practiced. Researchers, curators, and artists from fields as diverse as art history, design, computer science, geology, anthropology, architecture, dance, and materials science came together to push the boundaries of their respective disciplines. They explored how to make the interplay of objects, space, material, and time tangible, and how to engage with the active matter of our environment in ways that transcend traditional disciplinary silos.

1 Objects circulate and accrue meaning through their interactions within cultural, disciplinary, social, and educational contexts, see Appadurai 2007. For how the practice of exhibitions is involved in the construction of knowledge, see Lehmann-Brauns, Sichau & Trischler 2010.

During the exploratory phase of the exhibition-in-the-making, university collections became a key focus—not only because they were more accessible during the COVID period but because they offered a unique conceptual perspective. Unlike static museum displays, these collections are not passive archives but active sites of knowledge production.[2] They transform abstract notions of time, activity, and passivity into tangible learning experiences. Used in teaching and research, they serve as dynamic resources rather than historical artifacts, bridging past and future while continuously shaping knowledge in real time—a characteristic that can be called »presentness« (Hennig 2015, 120–122). They embody a hybrid of temporal concepts, with the balance between these temporal layers to be determined for each collection.

This perspective shaped our fieldwork as we explored university collections firsthand. In multiple visits, both individually and as a research group, we engaged with the Späth Arboretum, the Geological-Geomorphological Collection, → Intermezzo 4, 235 and the Zoological Teaching Collection. We also examined the dust collection at the Museum für Naturkunde Berlin as part of our joint research. → Stretching Practices, 210 This fieldwork ultimately informed the subsequent investigations in the exhibition space.

2. EXPLORING THE COLLECTIONS: LAYERS OF TIME IN THE SPÄTH ARBORETUM

My journey into the temporality of collections began with a research visit to Humboldt University's Späth Arboretum. To explore how university collections embody different temporal structures, I had several in-depth conversations with Thomas Janßen, head of the collection. His insights shed light on the delicate balance between activity and passivity in botanical collections, revealing how they navigate the interplay between preservation, dormancy, and reactivation.

At the Arboretum, collections are divided into dynamic living specimens and carefully preserved materials. As Janßen explained, »the living collections are constantly changing and need constant care, so time is an ever-present factor.«[3] Every tree, flower, and seasonal change in the garden bears witness

2 Cf. te Heesen 2008, 489. Also see Brüning & Raulff 2021.

3 Interview with Thomas Janßen, conducted 21 February, 2024. All following quotes from Dr Thomas Janßen are taken from this interview.

to nature's ongoing cycles of growth and decay. In contrast, the preserved collection—including resin-embedded specimens, herbarium sheets, and seed archives—appears more stable. Yet, as Janßen explained, even the most apparently static specimens are inscribed with time. Resin-embedded specimens, for example, designed to preserve plant material in a permanent state, are themselves subject to the passage of time as the preservative resin cracks, air bubbles form within, and the material may become yellow, darker, or brittle over time (fig. 1).

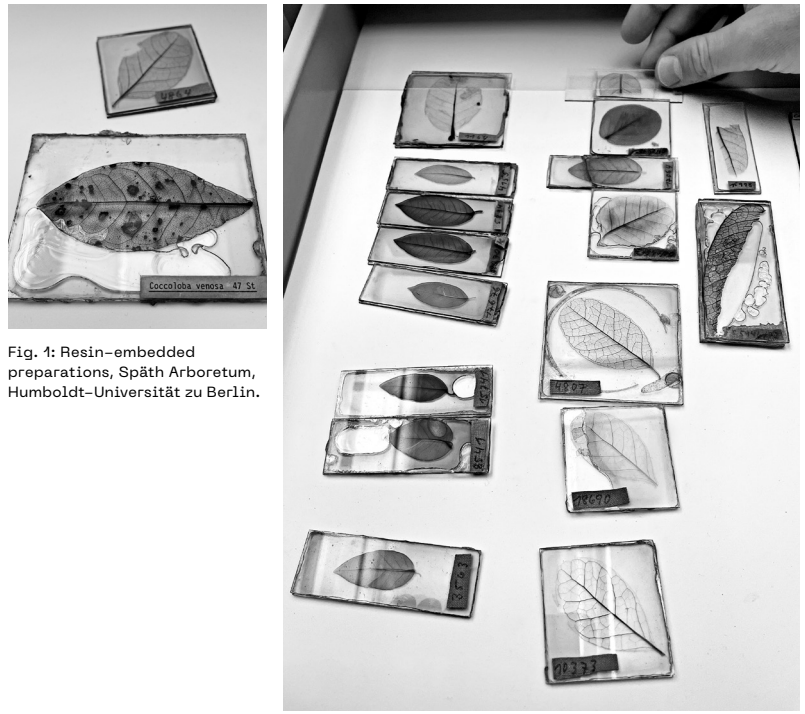


Fig. 1: Resin-embedded preparations, Späth Arboretum, Humboldt-Universität zu Berlin.

The chosen conservation technique, designed to arrest decay and to meticulously preserve its historical and scientific value, ultimately reveals the impossibility of truly freezing time.[4] The subtle changes in the resin are not just signs of decay; they are active records of time that encapsulate the interplay between forces of nature and human methods of preservation.

The herbarium sheets extend this narrative of temporality. On the one hand, they slowly change over time: colors fade, textures dry out, and the delicate structures of flowers and leaves deteriorate. On the other hand, they record time in two ways: each sheet shows not only a dried specimen but also a detailed label with critical data—who collected the plant, where, and when, preserving the moment it was collected. This

4 This is a common problem in collections. Another example is animal hides and skins, where certain chemicals, originally designed to stabilize their structure, can cause them to decompose more rapidly over the years.

information creates a timeline that helps researchers track long-term shifts in phenology and flowering patterns—key indicators of environmental changes such as global warming—and serves as a bridge between past conditions and scientific inquiry into our future as Earth's inhabitants (Primack et al. 2021).

Freezing as Conservation: Passivating Biological Activity

A key method for archiving these morphological and temporal details for future study is cryopreservation. As Janßen emphasized, »herbarium specimens must be periodically frozen to stop biological activity, especially to prevent infestation by pests such as insects.« This preventive practice—temporarily »passivating« the material to preserve its scientific value—illustrates the paradox of conservation: objects are preserved by interrupting natural processes, but this intervention is itself cyclical and must be repeated over time (fig. 2).

Fig. 2: Refrigerating of herbarium sheets, Späth Arboretum

Cooling and drying have long served as fundamental cultural techniques for preserving organic and inorganic materials alike. Across historical periods and scientific disciplines, these processes have been used to halt decay, stabilize matter, and extend the longevity of objects, whether in food storage, archival preservation, or museum collections. Rather than stopping change altogether, which would imply total passivity, these techniques slow down and regulate natural processes such as decay, degradation, or transformation. One could call it a controlled form of activity—managing the passage of time rather than eliminating it. By intervening into the ways in which materials age or remain stable, these techniques make time tangible and manipulable, transforming it into something that can be actively shaped through conservation practices.

At TA T, refrigeration as a method of slowing down natural time is one of the defining historical layers, and it shaped my approach to the site. In the past, horse carcasses were stored there and their preservation was prolonged by refrigeration. As a result, preservation techniques and the slowing of time played a central role in my study of the university's collections. Although refrigeration was not directly present in the exhibition space, and only conceptually through the slowing down and stretching of time, it remained a core idea throughout my curatorial work.[5]

5 This resurfaced for instance in workshops like *The Power of Water* with curators in 2023.

Dormant Time: The Potential Energy of Seeds

Another layer of temporal complexity is found in the seed collection, which Janßen described as »incredible time capsules.« Seeds represent a unique state of *passive activity*: Although dormant, seeds are imbued with the potential for life. They contain all the necessary genetic information, waiting for the right conditions—moisture, temperature, or chemical signals—to awaken them. Moreover, the shape of each seed, despite its passive state, embodies an ingenious strategy for active dispersal—whether by wind, animal fur, or digestion (fig. 3). As Janßen noted, this duality makes seeds a powerful symbol of both the past and the future. Moreover, this duality is emblematic of the collection as a whole—a mixture of latent potential and ongoing activity that unfolds over time.

Fig. 3: Examples from seed collection, Späth Arboretum

Seeds hold the memory of past ecological conditions while carrying the potential for renewal, linking preservation with cycles of reactivation. As Janßen noted, some seeds in the Arboretum's collection are stored for future research or exchanged with other botanical institutions, forming a global network. This oscillation between dormancy and activation parallels the shifting relevance of many collections in the academic world, where value and attention fluctuate with research priorities and scholarly trends. For example, some parts of the Arboretum, such as a cabinet with a GDR-era wood collection, remain undocumented and unresearched but are preserved for their potential future importance.

The Späth Arboretum is a space of constant transformation, where objects shift between states of activity and passivity, preservation, decay, and renewal. The interplay between natural growth and controlled conservation in this environment has deeply influenced my understanding of temporality within university collections and laid the conceptual groundwork for *Stretching Time*.

3. MORPHOLOGIES OF TIME: EXPLORING THE GEOLOGICAL COLLECTION

This tension between conservation and transformation took on an entirely different scale in the Geological-Geomorphological Collection. Here, time was no longer measured in seasons or decades but in millennia, recorded in the very structure of the rocks. As Jeffrey Cohen (2015, 2) observed, »stone is primal matter, inhuman in its duration.« The shift from botanical to geological collections also meant a shift from the controlled interventions of conservation science to the broader planetary forces that shape materials over deep time, such as plate tectonics, glacial movement, and erosion. How do rocks, like seeds, store time? How does weathering reveal the hidden activity of matter? And what role does human intervention play in accelerating or disrupting these cycles, especially in the Anthropocene?

Research conducted through numerous visits and conversations with geologist Mohsen Makki, head of the collection, revealed that stones are—despite their apparent immobility—far from inert. → Intermezzo 4, 235–243 Instead, they are incredibly active materials that are fundamental to life on Earth. In vast temporal cycles imperceptible on human time scales, they are in constant motion, forming, eroding, and reforming.

In discussions with the Object Space Agency (OSA) group about the temporal dimensions embedded in the Geological Collection, it quickly became clear that a selection of stones should form the centerpiece of the TA T display case, seamlessly connecting with other parts of the exhibition. This choice resonated with Natalija Miodragović's concept of »Leaking Stones.« → Stretching Spaces, 174 Moreover, the collaboration opened up the possibility of integrating meteorites from the Geological Collection, thus expanding the view of the finiteness of matter on Earth in our curatorial concept. Clemens Winkler's exploration of atmospheres and gaseous matter revealed further intersections: his understanding of the exhibition space as an interwoven, experimental ecosystem—where his cloud responds to visitors' vapors—corresponds to the slow weathering of stones, a process driven by moisture but unfolding imperceptibly slower than aerial transformations. → Stretching Practices In addition, we sought to engage more holistically and corporeally with the materiality and temporality of the stones. This led to a close collaboration with Studio Above & Below, who created a geological VR environment for Christian Stein's exhibition section. → Stretching Virtuality Developed in collaboration between Mohsen Makki and myself, this immersive environment deepened the sensory experience of geological time and transformation.

Fig. 4: Installation view

The selection of stones for the exhibition was made following numerous visits to Mohsen Makki and in close collaboration with him. We were guided by the question how to make the passage of time tangible—allowing visitors to trace the marks of wind, water, and geological pressure across their surfaces.

Sediments of Time: Weathering as a Conceptual Nucleus

Weathering emerged as the central conceptual thread in the exhibition segment, shaping both the selection of objects in the display cases and the broader investigation into time's material manifestations (fig. 4). The exhibition explored how weathering acts as a sculptor of geologic form, shaping rocks through interactions with atmospheric forces, climate, and biological processes. Over millennia, wind, rain, snow, and plant life have inscribed time on the surfaces of rocks, leaving distinct patterns, textures, and colors that reveal their history of transformation.

Fig. 5: From left to right: (a) Display case shelf »Morphologies of Time« showing different forms of weathering, such as (b) solution weathering by wind and rain, specimen found in Langenburg am Rhein, collected by Albrecht Penck, 1893

It is an active process that gradually transforms matter, producing distinct morphologies that reveal the passage of time.

Many of these morphologies were displayed in the display case, illustrating how different weathering processes create unique geologic forms (fig. 5a). One rock bore the marks of wind abrasion, its smooth surfaces and sharp edges shaped by the direction and intensity of airborne sand particles (fig. 6c). Another showed the dual effects of rain and wind, with an initially rough texture formed by prolonged exposure to water, only to be polished later by sustained dry, sandy winds—a process spanning thousands of years and reflecting changes in climate. → Intermezzo 4, 242

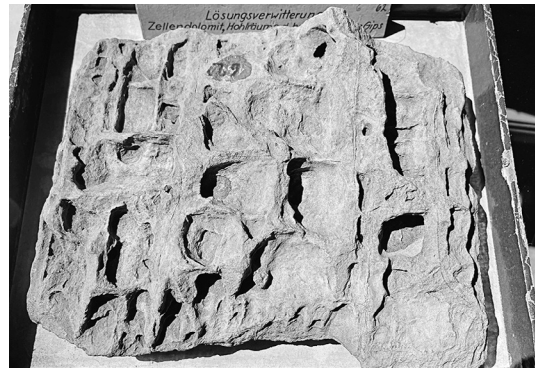
Other specimens in the collection showed evidence of chemical-biological weathering, where traces of plant roots and ancient worms from the Jurassic period remained imprinted in the stone long after the organic material had disappeared (fig. 6b). Another sample showed the effects of freeze-thaw cycles, where snow and meltwater had etched deep grooves into the rock (fig. 6a).

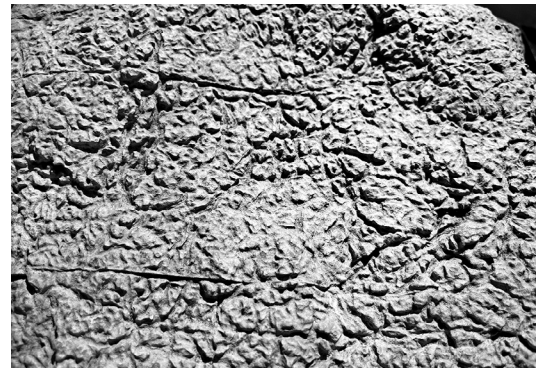
Weathering also alters a stone's color, leaving mineral signatures that chronicle environmental changes. ❑ Exhibition, fig. 8, 128 Depending on climatic conditions and a rock's chemical composition, its surface may take on deep reds from iron oxidation, pale yellows from water exposure, or dark patinas from prolonged organic interaction. Time is painting itself onto the geologic record, creating a colorful visual archive of environmental history.

By showcasing these morphologies of time, the exhibition emphasized weathering as a central force in geology—one that not only breaks down matter but also actively reshapes it. This perspective underscores why weathered rocks are key elements in geological collections, not only for their scientific value but also for the narratives they reveal about Earth's deep time and ongoing transformations. Weathering plays such a crucial role in geology that it directly influences collection strategies, shaping acquisition decisions in the Humboldt collections.

Weathering challenges conventional notions of temporality. It is not only a geophysical phenomenon but also an ecological, political, and cultural process that reflects the passage of time in ways shaped by human intervention.[6] As Holzhey and Wedemeyer (2020, XIII) argue, the effects of environmental catastrophes are already being registered, making weathering not just a slow geological transformation but an active marker of planetary change. In this sense, weathering is not just about erosion—it is also about persistence, a way of experiencing time that leaves traces in both natural and cultural landscapes.

6 For an extended discussion of the concept of »weathering« see Holzhey & Wedemeyer 2020





By presenting and incorporating these processes, the exhibition invites visitors to see weathering as more than just decay—it is a dynamic inscription of time onto material form. The display case thus presents not just geological specimens but sediments of time itself, embodying the slow rhythms of global transformation.

Fig. 6: More forms of weathering: (a) solution weathering by ice, snow, and meltwater, (b) chemical–biological weathering, etched by plant roots, and (c) weathering through wind abrasion

Anthropogenic Rocks: Entangled Temporalities of Humans and Stones

Stone time and human time are increasingly intertwined, as human activity has significantly altered the Earth's surface. Through industrialization and urbanization, humans have created anthropogenic soils and rocks, transforming landscapes on an unprecedented scale. These man-made geological formations—some of them highly toxic—serve as unintended archives of human influence.

Berlin's soils and those of other cities act as repositories of urban development and industrial history (fig. 7). New soils are created by overlaying the natural soil with substrates of anthropogenic or technogenic origin. These soils have new and unique chemical and physical properties and are classified differently than natural soils.[7]

7 These human-altered soils, such as those displayed in the exhibition, are currently being studied as part of an ongoing research project by Mohsen Makki.

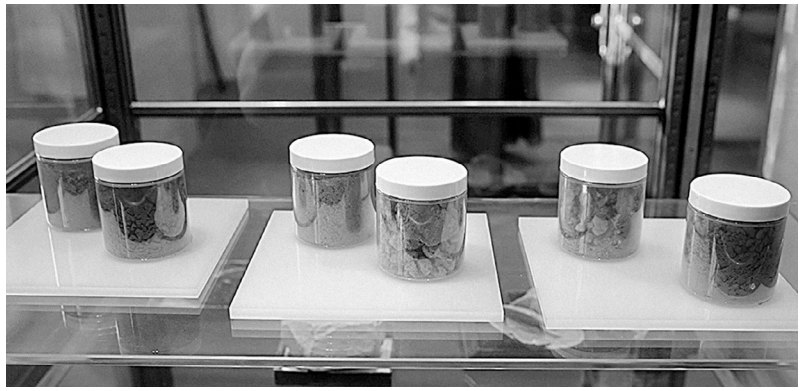


Fig. 7: Soils of Berlin

A historical perspective on anthropogenic soils is provided by a selection of different medieval slags (fig. 8). Since the Bronze Age, over 6000 years ago, humans have inadvertently created new types of solid rock as waste products of metal, iron, ceramics, and glass production. While these materials resemble naturally occurring rocks, their chemical composition often contains hazardous substances, such as arsenic and cadmium, that can leak into the environment when in contact with water. As part of these anthropogenic formations, the exhibition featured a volcanic rock from Iceland that–though visually indistinguishable from industrial slag–was formed naturally and contains no toxic compounds.

These materials emphasize the deep entanglement of natural and human-made geological processes. Just as wind, rain, and tectonic forces shape the landscape, industrial activity and urbanization have introduced new layers of geological

Fig. 8: Slags from Medieval Ages

transformation. By including anthropogenic rocks in the exhibition, we expanded the concept of weathering to include the material legacies of human intervention. This connection between humans and stones becomes even more apparent when their temporal markings serve as a lens through which we can explore the future.

Matter-Morphosis: The Potentiality of Cracks and Growth from Decay

Stones exist in a perpetual state of transformation, undergoing slow but continuous cycles of formation, erosion, and regeneration–what might be called »matter-morphosis.« During these processes, time marks stones with cracks caused by geological movement or climate change.

When stones crack, water is allowed to seep in and widen the fractures. Changes of climate, rainfall, and warmth gradually seal the cracks over time. This process reveals the stone's potential for self-healing, as geochemical or mechanical processes eventually close the cracks over millions of years (fig. 10).

Fig. 9–10: Samples from the shelf »No Decay without Growth.« Left: Calcite; right: Alpine limestone with wrinkled folds

Conversely, cracks in the inner layers of the Earth can become a protected space for the growth of new stones. Within rock cavities or deep underground in crevices, minerals such as crystal desert roses or calcite emerge, demonstrating that in the world of stones, there is no decay without growth (fig. 9). More than an act of erosion, weathering is also an act of creation, highlighting nature's continuous cycle of transformation.

Cracks do not only promote growth and repair but also allow interactivity with and adaptation to environmental changes, as the example of lichens shows. Their filamentous hyphae metabolize fissures, penetrate the rock, and intricately weave biochemical compounds between the solid base and the airy atmosphere. This ability of lichens to capture ephemeral matter represents a potential for forging new relationships with resources and initiating new material cycles.

Cracks were central to the conceptual framework of our exhibition, acting as a magnifying glass that revealed many aspects of the interplay between matter and time. Every crack in an object, every fine line that crosses an object's surface tells a story, carrying the weight of history and marking its journey through time. Cracks in objects evoke memories and invite us to imagine the moments that led to their creation: accidental drops, natural aging, the forces of nature that shape fractures, and practices of conservation, storage, and display.

Cracks do not only signify the passage of time but also manifest a sense of openness and potentiality.[8] They suggest that the object's story is far from complete, like a branching tree with divergent paths. Each crack invites us to consider alternative trajectories, encouraging our imagination to speculate about what the object might have witnessed or experienced. As we project ourselves into its narratives through our own memories and experiences, we weave stories and associations that intertwine with the textured surface created by those cracks.

Formed over millions of years, each rock holds interstellar memories. The cracks on the surfaces of these geological objects act as windows into the past, revealing the transformative forces that have shaped the stone, our planet—and our galaxy. These silent witnesses embody planetary forces, geological activity, and tectonic shifts. Geologists decipher these cracks, for example on an erratic boulder, carried by glaciers during the Ice Ages, to understand its long journey through changing climatic conditions.

Cracks hint at future transformations and hold an epistemic potential, offering untapped information and hidden narratives. They also remind us of impermanence, emphasizing our fleeting presence in the face of geological time. Cracks open irreversible spaces of possibility that are unique and unrepeatable. They encourage reflection on our relationship with Earth, especially in times of crisis, and our potential impact on its future.

Cracks not only trigger interventions such as repairs, they also embody their own agency within the dynamic interplay between the object and surrounding activities and practices. Consequently, cracks can be seen as disruptive elements, disturbances in the dialogue between objects and humans—or perhaps they are better understood as a language through which the object communicates with us as we study potential futures of objects and spaces and their agencies.

By considering the cycles of renewal in stone and its inherent potentiality, we can gain deeper insights into the broader implications of conservation techniques. Material objects, whether natural or man-made, exist in a continuous cycle of change, decay, and renewal. The act of conservation, however, interrupts this cycle by stabilizing and immobilizing materials, thereby limiting their potential for transformation and constraining possible future developments. The degree to which conservation regulates these possibilities depends on the material itself. Restoration, on the other hand, seeks to reconstruct a lost state, to preserve a specific narrative – not only for individual objects but also for the architecture of public spaces such as museums. The choices we make regarding restoration, renovation, and reconstruction reflect our interpretation of what should be preserved and how memory is formed.

In essence, restoration limits the possibilities of different pasts, while conservation limits the possibilities of different futures. Both practices extend beyond the material object and influence how we understand history, culture, and identity.

The self-healing capacity of geological materials challenges traditional conservation narratives that seek to halt change. Conversely, *Stretching Materialities* highlighted how matter is never static. Cracks, often associated with fragility, can also be sites of renewal, demonstrating that preservation and transformation are intertwined.

By making these slow processes visible, the exhibition encouraged visitors to rethink stones as active materials—dynamic participants in Earth's evolution rather than passive relics of the past. This perspective raises broader questions for conservation: instead of striving for absolute stability, could we learn from geological processes, embrace change and transformation rather than simply resist them, and more closely align ourselves with the dynamic processes found in nature?[9]

The Power of Water: Rethinking Temporality and Conservation

Inspired by observations in the Arboretum and the Geological Collection, water emerged as a powerful metaphor and material agent for understanding temporality in my research for and during the exhibition. Beyond its role in geological self-repair of cracks, it became a central focus within the broader exhibition framework, particularly in the exploration of conservation techniques.

8 The transformative potential of cracks is also reflected in discussions on their performativity within theater studies; see for example Hartung 2023.

9 For this approach in conservation see DeSilvey 2017.

10 For more details, especially in relation with university collections, see Samuel 2024.

The Power of Water, a workshop originally planned to accompany the exhibition but postponed due to the impact of COVID-19, was rescheduled for June 2023. ❑ Process, fig. 15, 276 This workshop explored the transformative power of water—not only as a natural force shaping landscapes and weathering rocks but also as a conceptual lens for understanding processes of temporal immobilization and material transformation. The »Objektlabor« at TA T was an ideal setting for the workshop, as it had previously hosted Anna Kubelík's installation → Intermezzo 1, 61 —a performative sound artwork that responded to the fluctuating humidity levels in the space. ❑ Exhibition, fig. 9, 130

The interplay between water and conservation has long been a subject of inquiry, particularly within the field of conservation science. Since the eighteenth century, scholars have debated the relationship between water and material stability over time, recognizing its paradoxical role as both a destructive and regenerative agent.[10] Seemingly so ordinary and ubiquitous, water is the only element that exists simultaneously in all states of matter on Earth, its properties remaining central to both natural and human interventions into material conservation. Research continues to explore how water can be used to stabilize, restore, or modify materials in a controlled manner.

Fig. 11–12: Experimentation during the workshop *Power of Water* at Objektlabor of TA T, June 14, 2023

Throughout the exhibition research for *Stretching Time*, conservation science played a crucial role in uncovering hidden material transformations. While the study of material activity draws from a variety of disciplines, the field of conservation itself is often conspicuously absent from these discussions, despite its core mission of slowing or halting material change. Conservators accumulate invaluable tacit knowledge about how to slow down natural processes, effectively »freezing« time in collection objects, and how materials respond to time and environmental forces, knowledge that was made tangible through this hands-on workshop. Designed as a physical engagement with conservation practices, the session introduced participants to the practical applications of water in conservation treatments, with interactive demonstrations and experiments that allowed visitors to explore water's role in shaping, preserving, and even transforming matter (fig. 11–12).

The water workshop extended the exhibition's exploration of the dynamic interplay between time, matter, and conservation, ensuring that its themes kept resonating long after the exhibition closed. It underscored the crucial role of fluidity in shaping our perceptions of temporality within collections and for cultural techniques.

4. THE DISPLAY CASE AS EXPLORATORY RESEARCH APPARATUS

Upon entering TA T, visitors were greeted by large metal display cases—historical objects in themselves, dating back to the nineteenth century, when museum practice sought to protect objects from visitors. Then, as now, display cases were conceived as safeguards, quarantining fragile specimens from human breath, touch, body heat, and airborne particles. This strategy, rooted in the idea that visitors posed a threat to objects, has persisted as a museum standard, reinforcing the separation between viewer and exhibit.

Since one of our central research questions was how to make the dynamic processes of materiality—such as the weathering and transformation of stone—tangible in the exhibition space, it was a logical step to explore how the display case itself could be reimagined as a tool for this exploration. Due to restrictions concerning those geological objects on loan for the exhibition, it was not possible to open all display cases completely. However, we chose to leave them partially open, transforming the cases into an interactive starting point—one that encourages dialog and inquiry rather than mere observation (fig. 4).

The Haptic Box and Hands-On-Station

To challenge and expand the concept of the display case, a Haptic Box was inserted into it, turning it into an exploratory

research apparatus—a dynamic interface between objects, curatorial research, and visitor interaction rather than presenting a passive display case.

The idea for the Haptic Box grew out of research in the University's collections, where both the Späth Arboretum and the Geological Collection highlighted the essential role of tactile knowledge in scientific inquiry. In the Arboretum, touch, smell, and even taste enhance learning—whether handling seeds or feeling the textures of herbarium specimens. Similarly, in geology, tactile engagement is fundamental; as Mohsen Makki pointed out, specimens are meant to be held, traced by hand, and sometimes even tasted to identify mineral compositions. → Intermezzo 4, 238 This shared reliance on sensory perception in both fields reinforced the importance of hands-on engagement for making material transformations and temporal layers tangible.

Fig. 13: Haptic Box explored by a visitor. Design of the box: Colin Marc

By reaching into the Haptic Box, visitors engaged directly with the materials on display without seeing them first, shifting the focus from visual perception to tactile exploration. The box invited them to »touch time«—to experience the effects of time on matter through the textures of sediment grains in eight different sizes, mirroring the tactile methods geologists use to analyze rock formations. This sensory approach challenged the primacy of vision and offered a haptic encounter with the processes of weathering and material transformation (fig. 13).

The Hands-On Table, installed next to the display case, provided an experimental space for visitors to actively explore weathering processes (fig. 14–15). By handling dolomite and limestone, visitors could explore the different textures that natural processes have created over time. Applying a 10% hydrochloric acid solution to the stone surfaces then triggered a reaction that simulated the effects of rainfall, condensing centuries of weathering into seconds. This interactive station encouraged hands-on experimentation, allowing visitors to experience geological transformations firsthand, whether using the provided specimens or their own stones brought in for testing.

Fig. 14–15: Hands-on-station

By opening the display case—physically and conceptually—we disrupted the traditional boundaries between conservation and interaction, between passive display and active experimentation. However, it was equally in the act of closing the case that a transformation occurred: by enabling visitors to experience touch before sight, the display case became a »feel case,« shifting from a barrier of separation to a space of sensory exploration. This dual gesture of opening and closing reinforces the exhibition's core question: how can material objects embody and reveal the passage of time?

As a site of material storytelling, the conceptually expanded showcase also played a central role in our mediation program, fostering engagement with the deep connections between materiality, time, and human experience, such as Kaaren Beckhof's engagement with stones in her performance using rock flour. → Intermezzo 5, 357 Visitors engaged with themes such as the vastness of geologic time in contrast to human temporality, and the ways in which stones—often perceived as inert—carry narratives and personal memories through their formation and transformation. Small enough to fit in a pocket, stones are among the most common souvenirs, collected from places of significance and imbued with personal meaning.

Virtual Encounters with the Active Materiality of Stone

In addition to the physical and haptic explorations, the exhibition extended this sensory engagement into the virtual realm. The »entrance« to this world could also be found on the Hands-on Table via a small plate with a stone and the inscription »You can enter this stone in the basement of our Virtual Elevator.« → Stretching Virtuality Through the Virtual Elevator, visitors were able to experience the sensation of »stepping into« the dense mass of a stone—the same stone that was physically present and available to touch at the Hands-on Table. This immersive experience allowed them to move through the interior of the stone's structure, encountering its layers, fractures, and densities from an impossible, greatly magnified perspective. By digitally expanding the stone's microcosm into a walkable environment, the Virtual Elevator transformed a seemingly solid, passive object into an active landscape, revealing the intricate materiality hidden beneath its surface.[11]

11 The design of the visual representation of the inner materiality of the stone was created in collaboration with the Max Planck Institute of Colloids and Interfaces, Department of Biomaterials, in Potsdam.

Fig. 16: Still from *Geological Performers*, VR experience by Studio Above & Below, 2021

Through the Virtual Elevator, visitors also entered *Geological Performers*, a VR experience by Studio Above & Below they designed based on insights into weathering processes and stone surfaces that I gathered from Makki during the research phase of the exhibition (fig. 16). ❑ Process, fig. 12, 274 Functioning as an immersive time capsule, it allowed visitors to experience the dynamic changes of weathering on stone surfaces and offered an alternative perspective on geologic time—to witness the slow, imperceptible transformations that typically unfold over millennia, compressed into an interactive, dynamic

experience. Walking around the VR space, the generative forms and changes of the digital materials of the virtual stones were constantly evolving, inspired by Berlin's weather. → Stretching Virtuality, 92 External real-time weather data entered the virtual indoor space and transformed into parameters such as movement, speed, forms of computer graphics, and cracks in the digital stones.

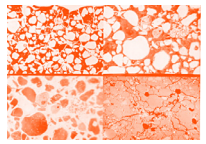
Crucially, because touch is fundamental to geological knowledge, this virtual experience also required haptic engagement. To activate the interaction, visitors picked up a stone tracker—a 3D-printed replica of the desert rose displayed in the case. ❑ Exhibition, fig. 20, 140 Holding this print, they navigated the VR space, approaching digital stones whose textures, structures, and patterns constantly evolved according to wind, humidity, and temperature fluctuations outside the exhibition space. By merging tactile engagement with real-time environmental dynamics, this experience highlighted the active materiality of stone and offered an intuitive way to feel and interact with the passage of time, making the invisible forces of planetary change tangible and perceptible.

5. EXHIBITION AS PROCESS AND RESEARCH

From the moment visitors entered the exhibition, it was clear that this was not a static display but an evolving process. As researchers and curators, we deliberately abandoned the conventional position of presenting finished results or settled theories. Instead, we exposed not only our research but ourselves—embracing a state of openness that made us vulnerable to critique, dialogue, and transformation.

This approach shaped the way visitors engaged with the exhibition. Rather than passively consuming information, they often came with questions, insights, and even their own expertise. The exhibition became a space of exchange, where visitors actively contributed to discussions, suggested new perspectives, and even suggested ways to expand the project. These interactions influenced the exhibition itself, reinforcing its experimental nature and its role as an ongoing research process. Some of these visitor-driven impulses led to concrete additions

during the course of the exhibition, including the integration of two key contributions: Rochus Blaschke's scanning electron micrographs of weathered stones and Lena Dues's installation. → Intermezzo 2, 107 → Intermezzo 4, 247



Rochus Blaschke's scanning electron micrographs, some of the first detailed enlargements of weathered stones made in Europe in the 1980s, revealed microscopic landscapes of erosion and transformation. ❑ Process, fig. 20, 281 These images provided a striking visual record of how stones are dynamic sites of interaction between biological and mineral processes.

A key discovery in these images was the presence of biofilms—dense microbial colonies that form on stone surfaces. These microorganisms do not simply settle on the stone; they actively interact with it, secreting acids and enzymes that break down mineral structures. Over time, these biological interactions contribute to surface pitting and degradation, demonstrating that weathering is not just a mechanical or chemical process but also a biological one. Beneath the biofilm, the crystalline structure of the stone remains visible but altered—showing that the stone surface itself is in a constant dialogue with its environment.

Blaschke's work also highlighted the concept of stones as breathing entities. Metabolic processes of these microorganisms produce CO_2, which reacts with water to form a weak acid that further etches the stone. This symbiotic relationship between biological life and geological materiality transforms stone surfaces into living, responsive systems—challenging the perception of stone as static or lifeless. The micrographs capture weathering as both a destructive and generative force, where decay and growth occur simultaneously: as minerals dissolve, new crystalline formations can emerge, reshaping the stone's surface over time. Blaschke's images offer a rare glimpse into the hidden life of stones, where microscopic processes shape geological materials as profoundly as wind, water, and tectonic forces.

Dues's installation *Auturgy of Carbamide* expanded the discourse on self-organizing material systems and the fluid boundary between organic and inorganic matter. → Intermezzo 2, 108 Two glass cylinders and a Petri dish filled with a saturated carbamide solution formed a laboratory-like composition. Over time, carbamide crystals grew independently, formed by the climatic conditions of the exhibition and the shape of the glass container, rendering material transformation tangible. The material became an active participant, a subject rather than an object of the exhibition, raising questions of agency, authorship, and creation: Who or what is active or passive?

12 See Döring 2021 and Bjerregaard 2020.

This perspective on material agency was explored in the event *About Microbes, Stones, and Orbits* where Dues engaged the audience in a conversation about crystallization as a fundamental geological process, linking it to both the desert rose and the calcite in the display case, revealing surprising parallels between mineral growth and microbial activity. By incorporating urea, commonly known as carbamide, *Auturgy of Carbamide* underscored that the supposed divide between animate and inanimate nature is not fixed but fluid. This exchange challenged fixed distinctions between life and matter, revealing their dynamic interplay, showing how stone, crystal, and microbes are in constant flux, actively shaping and being shaped by their environment.

CONCLUDING REMARKS

Despite the growing trend among major institutions to present science in a »laboratory« setting and to emphasize process,[12] exhibition spaces are still rarely conceived and used as active sites of research and collaborative inquiry. Our exhibition attempted to do just that.

Stretching Materialities was not merely a display of artifacts but a dynamic research process—a collective exploration in which each collection object, experiment, and interaction probed into the deeper, often hidden activities within objects and spaces. By bridging disciplinary boundaries, the exhibition challenged conventional notions of how we perceive and interact with matter, time, and the complex histories embedded in objects.

Our concept of a research exhibition aligned to a certain extent with Simon Sheikh's (2013, 40) idea of an exhibition as a »place for enacted research«—being not just a »vehicle for the presentation of research results (…) but a site for ongoing research around formats and thematic concerns of the exhibition,« emphasizing the exhibition space as an activated site of inquiry rather than a passivized display.

The *Stretching Materialities* exhibition was conceived as a living, evolving space that embraced the uncertainties and complexities inherent in the research process. Inspired by the concept of »doubt« as a critical force in scientific inquiry—an approach advocated by Marjan Doom (2020) in *Museum of Doubt*

and exemplified by Ghent University Museum—our exhibition was rooted in the often hidden processes that drive both scientific and artistic practices. Doom (2020, 13–28) suggests that exhibitions of university collections should cultivate an atmosphere of doubt, embracing vulnerability and prioritizing the asking of questions over providing definitive answers, with a focus on process rather than final outcomes. Rather than offering a linear narrative, the exhibition invited visitors to engage with the research process itself—to witness experiments unfolding in space and how the act of exhibiting becomes an active, participatory process.

However, if one looks into the history of exhibitions for conceptual antecedents, models, or inspiration for our exhibition, the 1970s offer productive insights. The late 1960s and 70s present a transformative period in exhibition making, marked by a shift away from traditional, didactic displays to more experimental and participatory approaches. Exhibitions during this period began to challenge the passive role of the viewer, inviting them to participate in the creation of meaning. This era saw the rise of interdisciplinary and multimedia exhibitions that blurred the boundaries between art, science, and technology and encouraged visitors to engage with the material world in new and imaginative ways.

A pivotal but often overlooked exhibition from this period is *Welt aus Sprache* (1972) at the Akademie der Künste in Berlin, which exemplified this shift. Integrating semiotic theories into its design, the exhibition transformed signs and symbols into physical and sensory experiences. Far from being passive observers, visitors engaged actively with the materiality of language through various media. This emphasis on sensory interaction created a dynamic space where knowledge was not simply transmitted but co-created through experience.

The exhibition intertwined sensory exploration with analytical reflection, particularly through the »Pentagon of the Senses,« where touch, smell, taste, hearing, and sight were treated as distinct sign systems. Interactive stations such as wine tasting, spice boxes, and tactile experiments allowed visitors to engage with non-audiovisual perceptions, which they then translated back into language. Our Haptic Box closely parallels the design and conceptual approach of the »Tastkasten« in *Welt aus Sprache*, both reinforcing a feedback loop between individual sensory experience and collective interpretation.

This interplay between embodied experience and critical reflection was at the heart of *Stretching Materialities*. Like *Welt aus Sprache*, the exhibition invited engagement, making visitors co-creators in the process of knowledge production. Both exhibitions challenged conventional distinctions between observer and object, revealing that materiality—whether language's, matter's, or the body's—is something to be experienced firsthand. By integrating multi-sensory engagement, these »feel-hear-shows«—structured around tactile, auditory, and visual experiences—redefined the exhibition space as an evolving site of interaction, transformation, and reflection.

The central goal of *Stretching Time* was to reconceptualize materiality as inherently active—constantly in flux and inseparable from time. As a collective, research-driven project, the exhibition functioned as an experiment in knowledge exchange, challenging both curators and visitors to rethink the interplay between time, material, and space. It invited them to explore not only how we engage with and shape materialities but also how these materialities in turn shape our understanding of time, space, and change.

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THE TEXTURE OF TIME:
A Journey Through Stones, Touch, and Active Matter

Nina Samuel in conversation with Mohsen Makki

Intermezzo 4

The exhibition section Stretching Time—Researching Collections is based on the premise that different concepts of time, activity, and passivity of materials—questions about the relationship between time and matter—are embodied in collection objects. In order to explore and discuss these ideas, we conducted field studies in several of Humboldt University's collections. Among these, the Geological-Geomorphological Collection was particularly fruitful for exploring the relationship between time and matter.

Through numerous visits and conversations with Mohsen Makki, the director of the collection, weathering emerged as the conceptual core of this section of the exhibition and began to influence other parts of the show. Working closely with Makki, we discovered that stones are far from inert. Instead, they are incredibly active materials fundamental to life on Earth. The continuous cycle of rock formation and transformation, driven by plate tectonics, underscores their vitality. Despite the vast timescales involved, which are beyond human comprehension, rocks demonstrate an ongoing process of change that is essential to the life-sustaining mechanisms of the planet.

During this conceptual phase, a broader question emerged: how can weathered stones enhance our understanding of contemporary museums and their role in visualizing the passage of time? In addition, we explored how stones relate to the politics of time and whether museum objects share a similar time and memory structure with ruins, addressing key questions of ruin archaeology. We raised these and other questions during inspiring conversations with Makki and countless hours we spent in his collection, opening shelves and cabinets, touching a variety of rough and textured surfaces, and experimenting with our own hands.

Makki's research covers a wide range of topics, including the genesis and distribution of urban soils in Berlin, soil-based vertical farming in metropolitan areas, the interaction between soil and society, and geo-ecological solutions for rapidly growing cities. Geographically, his geo-archaeological investigations span regions such as Iran, Tajikistan, Uzbekistan, and Italy. His extensive expertise has provided invaluable insights for our exploration of the temporal dimensions embedded in museum collections and the living history they represent.

This preparatory interview, conducted three months before the exhibition's opening, not only inspired the selection of stones for the display case but also formed the conceptual basis for the design of the interactive and exploratory elements, as well as the VR environment planned in collaboration with Studio Above & Below. It also highlights the profound implications of understanding stones as active participants in the Earth's history and future.

Fig. 1: Drawer cabinets from the Geological-Geomorphological Collection of Humboldt-Universität zu Berlin

● Nina Samuel: One of the most exciting insights for me from our meetings in your collection was the importance of haptic knowledge in geography. Knowledge is always created by touching stones, by feeling surfaces. To me, this aspect seems to be central both to the selection of objects in the Geomorphological-Geological Collection and to geological knowledge in general. It could perhaps also be described as »implicit knowledge,« acquired over time and through connoisseurship, which cannot always be written down. It seems that the materiality of the stones also allows us to sense invisible processes that are inscribed in their materiality. What role does the sense of touch or the feeling of rock surfaces play in geological knowledge and collecting?

● Mohsen Makki: Geoscientists, particularly geomorphologists and geologists, believe that when we pick something up and physically engage with it, we connect with it and facilitate learning. This physical connection sets in motion several components of learning. Learning involves not only hearing and seeing but also feeling and smelling, and in geology, even tasting. You wouldn't lick the hand specimens in the collection today because they've been used by students since 1890. But a fresh rock is licked to test the salt content, for example,

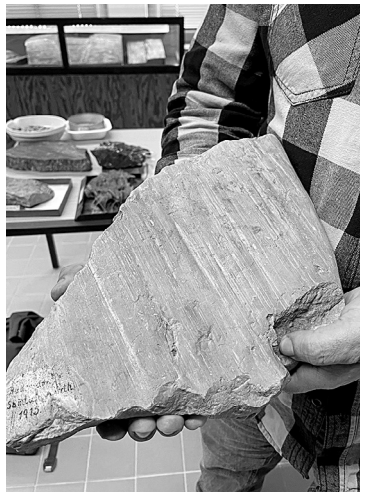


Fig. 2: Glacier cut from Rüdersdorf

or to reveal certain structures (e.g., microstructure or texture) that would not be visible in a dry state. So touch is the name of the game in geoscience. When you hold rocks in your hand, you can rotate them or look at them from a different angle with better light. Our objects are meant to be touched. This is reflected in the size in which most of them came into the collection—small enough to be kept in drawers from which they can be taken out at any time (fig. 1–2).

The Geomorphological-Geological Collection was founded in 1906 as a teaching collection. When Albrecht Penck (1858–1945) took over the management of the Geographical Institute in 1906, the history of today's teaching collection began. The aim was to use the material for didactic purposes and rather than collecting particularly valuable stones, it was about collecting as many ordinary stones as possible from the most diverse regions, specially cut into small hand pieces so that they could be easily stacked and as many as possible could be accommodated.

• NiS During my visit, I was also fascinated by Albrecht Penck's limestone with glacial striations (fig. 2). What role did the sense of touch play with this stone?

• MM Our students learn in the first semester that glaciers always have a direction in which they erode rock. A glacier grinds the rock in a distinctive way. By feeling, you can find out exactly which direction this is and how it combines with the traces of other stones that the glacier has taken with it, such as grooves and scratches. This stone comes from Rüdersdorf, near Berlin, and is made of limestone. At that time, glaciers were known from the Alps but not from northern Germany. Penck recognized from the »glacier scars« on this rock that there must have been glaciation in northern Europe as well. It was a groundbreaking discovery.

Fig. 3: Touch the object from the collection! You can feel the abrasive effect of the flowing water. The water has only smoothed the surface of the rock in one direction. You can feel that the surface is rough in the opposite direction

• NiS In this context, I would like to return to a second hand piece collected by Albrecht Penck in 1893 (fig. 3). Could we also speak of a special significance of haptic knowledge and the senses in this context?

• MM The sense of touch plays a central role in geology and geomorphology in general. In this example, the rock has undergone two processes, first solution weathering, where contact with water created a rough surface. Then it was placed in a relatively dry area where the wind blew mainly in one direction for about a thousand years. The surfaces touched by the wind were polished smooth. But the leeward surfaces remained hard. So you can brush in two directions, one is completely smooth—that's the direction of the wind. The other direction is very rough—that is the lee. So the sense of touch plays a very important role here.

Another example are ventifacts. They occur mainly in regions with little or no vegetation, such as deserts. Depending on the environment, the climatic conditions can be dry or cold deserts. Due to later climate changes, such as warming at the end of the Ice Age, ventifacts can also occur in areas where they would not occur today. For example, they are found in the moraine landscapes of northern Germany, which were cold deserts or steppes during the last ice age, the Weichselian periglacial. They therefore reveal a great deal about global climate history.

• NiS Our exhibition is about materials and their hidden activities. From a geological point of view, stones can also be described as active material, except that their activity is beyond the direct reach of humans or human perception. What do you consider to be the activity of stones?

• MM From an anthropocentric perspective, it may seem that rocks are passive, especially when only considering our short lives. However, geology and geomorphology show a cycle of rocks. A rock can originate from magma and reach the Earth's surface through plate tectonics. There it is weathered by exogenous forces and becomes sediment, which through diagenesis becomes solid rock. This solid rock moves back underground through plate tectonics. If it sinks deeper, it can be melted again by the melting process, anatexis. In short, rocks are always moving. Unfortunately, these movements are so slow for human understanding that people perceive them as solid, immovable, and unchangeable.

• NiS For the exhibit, we display a collection of eight different examples of stone weathering results (fig. 4–5). This display is curated not only to illustrate the perpetual cycle of stones transitioning from gravel to silt but also to provide a tactile experience for visitors. Thanks to our Haptic Box placed in the display case, visitors are able to physically explore and feel the textures of these weathered stones, making the natural process both visible and tangible. → Stretching Time, 224

Fig. 4–5: Different grain sizes of weathered rock: gravel, coarse sand

• MM Gravel has rounded edges and a certain minimum diameter. In addition to gravel, there is coarse sand, fine sand, silt, and clay, which vary in grain size. The determination of these sand types is based on grain size, which is determined using special equipment and tables.

These substrates show different weathering conditions. For example, when a mountain disintegrates due to exogenous forces, coarser pieces, such as rocks, are formed first, which fall from the mountain and break. Over time, the pieces become smaller, depending on erosion factors such as wind, water, and frost.

Some erosion processes in nature create a natural sorting process. In fast-flowing waters, it's more likely to find stones and gravel, while in slow-flowing waters, such as the River Spree, grains of clay and silt are more likely to be found. In calm waters, clay particles can be deposited when the water is still. Over geological time, various substrates, such as sand washed in by rivers, can compress already deposited clay layers and squeeze water and solutions out of the clay (diagenesis). This pressure can lead to the formation of new clay, completing the endless cycle of new rock being formed from weathered rock.

• NiS What time periods are we talking about?

• MM How long this cycle takes depends on the climate. For example, chemical weathering is very slow in the desert and much faster in central Europe. In areas such as Central Asia, however, a layer of sediment such as loess can become several meters thick within a thousand years. In the ocean, it generally takes several hundred thousand years for a meter-thick layer of clay to form.

• NiS The sand shown in the exhibition also has a very current political dimension, especially when we think about how we deal with our resources.

• MM Sand may be a scarcer resource today than oil or natural gas. Modern society is experiencing a construction boom that requires large quantities of a special type of sand. This sand must consist of angular, non-rounded grains because these have better mechanical properties in cement. This special sand is usually found on beaches or in sand pits. However, the quantities available are insufficient. Some Arab countries and small island states need large quantities of sand to expand their territory by reclaiming land from the sea, as in the case of the Palm Islands in Dubai. Desert sand, with its round grains, is not suitable for this purpose as it does not offer sufficient stability. These circumstances have led to a global shortage of sand on the market, making it increasingly difficult to obtain large quantities. This in turn has led to the emergence of numerous criminal structures. In some cases, sand is mined in India or Morocco by digging large holes in sandy beaches. This sand is then illegally transported to Asia or Europe.

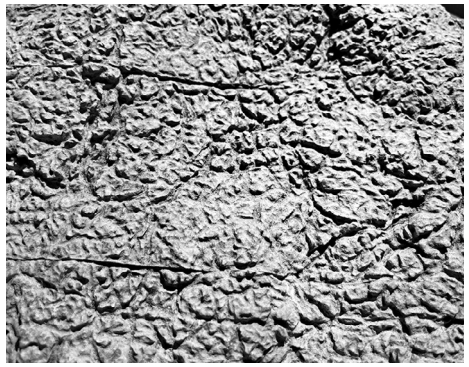


Fig. 6: Malm limestone, chemical-biological weathering, etched by plant roots; detailed view

• NiS Sand is ultimately formed by very long weathering processes. In this sense, sand can also be described as »pulverized (or ground) time.« Weathering processes are very present in the Geological Collection. To what extent can weathering be described as a driving force behind the collection strategy or as a collection criterion?

• MM Geography, especially geomorphology, is the study of the Earth's surface. As soon as a rock is placed on the Earth, it begins to weather. The dominant weathering factors vary from place to place in the world. We are therefore interested in changes on the surface at the macro, micro, and meso scales. Weathering is the basis for landscape design. In a discourse about a changing planet, weathering is one of the most important processes. Without weathering, there would be no diversity of color in the landscape. Anything exposed to the environment is subject to weathering—not only rocks but also all objects in your home.

• NiS Weathering not only varies in intensity but there are also very different types of weathering. In the exhibit, for example, we have chemical-biological weathering (fig. 6). Here we have a dominant pattern: a kind of network of sinuous lines. How did this pattern form on the rock?

• MM The irregular patterns you see are imprints of roots and traces of organisms from the Malm/Jurassic period. The Jurassic period was characterized by abundant plant life and the rock was a layer of mud. The pattern therefore comes from both plant growth and the tracks of worms, especially earthworms. Despite the decomposition of the organic parts, these imprints have been preserved to this day through specific processes and layering.

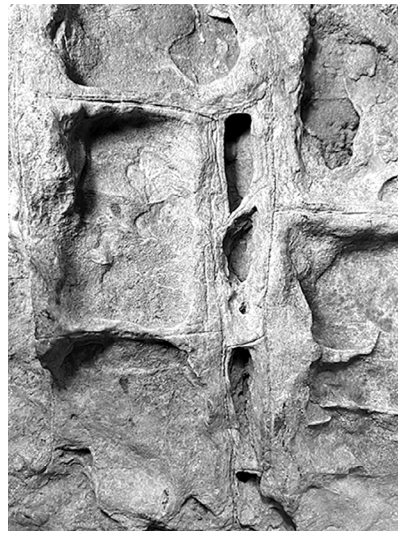


Fig. 7: Zellendolomit, solution weathering by ice and snow; detailed view

• NiS In addition to chemical-biological weathering, physicochemical weathering, also known as solution weathering, plays an important role in your collection (fig. 7). Can you explain these processes in more detail?

• MM The surface clearly shows the long-term effects of wind, water, and snow. Snow, in particular, has a major effect on the structure of the cavities. The meltwater is acidic and reacts with the rock, creating a flour-like weathering material that accumulates in the holes. In dry periods, such as summer, the wind intensifies this effect by blowing away the fine material and enlarging the hole. As the snow continues to fall, more snow collects in these holes, intensifying the process. Once weathering has begun, it is accelerated by the cavities because water can stay longer in the holes. Such forms often occur when the rock's surface is in the shade, as snow and water have more time to settle in the cavities.

• NiS There is another structure in the stone that I find interesting, these vertical, very fine lines (fig. 7). How did they form?

• MM These structures that can still be seen in the rock today, these straight vertical lines, were there before solution weathering. They are old cracks that have closed again. The rock was once broken and then »welded back together,« so to speak. And then it came to the surface and that is where the carbonic weathering began.

• NiS There are many examples in the collection of rocks that have been newly formed and grown through weathering processes. Take calcite (fig. 8), for example, how was it formed?

• MM The vast limestone landscapes of the Alps have been exposed to the constant action of rainwater for millions of years. This process, known as carbonic weathering, occurs when water, a weak acid, reacts with the limestone. Some of the limestone is dissolved. The dissolved material is transported by the flowing water. Carbonic acid weathering creates cracks in the rock that widen over time. Water flows along

these cracks, transporting the dissolved material and widening the cracks further. If the water enters an underground cavity, it can cause precipitation or the formation of lime (calcite minerals) under altered conditions, creating new forms underground. A long and slow weathering process eventually leads to the formation of such forms that look like flowers.

Fig. 8: Calcite

• NiS This reminds me of the processes that form the so-called desert roses (fig. 9).

❑ Exhibition Views, fig. 21, 140

• MM Calcite and desert rose are both formed from an aqueous solution. The difference is that calcite is formed in cavities in solid rock, while desert rose is formed in cracks in the soil, i.e., in loose material. High temperatures cause the soil material to shrink, creating cracks. Groundwater infiltrates these cracks and forms crystals (gypsum or barite) over time. The climatic conditions of the desert, especially the power of osmosis, are ideal for these processes. Desert roses (also known as sand roses) only become visible when the soil erodes. Calcite, on the other hand, is discovered when rocks are fractured or quarried, as in karst caves.

• NiS So while desert roses are formed by cracks in the loose soil, there is another type of cracks that also plays an important role in our exhibition. You can see them clearly here on the weathered limestone (fig. 10). How do these cracks form and how do they close again?

• MM These cracks, usually perpendicular to one another, are caused by tectonic movements of the Earth, such as great pressure or the rising of magma. They serve to equalize pressure. Perpendicular cracks are particularly common in limestone. As water seeps in, these fine cracks grow larger over time. This rock shows that a change to a warmer climate took place. The climate became warmer with more rainfall. The upper layers of the rock were heavily weathered, while a solution of bicarbonate accumulated in the cracks. Such solutions that accumulate on the rock can precipitate new minerals and thus close the cracks. In this way, a kind of coating forms on the rock and the cracks are closed by secondary materials.

Fig. 9: Desert rose

Fig. 10: Weathered limestone

• NiS Another particularly fascinating case of cracks in rocks is that of folded alpine limestone (fig. 11). Again, the focus is on cracks and their closure. In what way?

• MM Imagine the rock is like an accordion. When tectonic forces pull it apart, the white zigzag lines you see here become straight. These lines were originally cracks in the rock filled with secondary minerals such as calcite (white). Then pressure was applied from both sides and the accordions or layers of rock were squeezed together. Vertical shears formed in response to this tectonic pressure. Minerals and rocks were reshaped and new structures (folds) were created in the rock. All the white lines were once cracks running parallel to each other. This whole process may have taken millions of years.

• NiS Finally, we come to the subject of slag (fig. 12). This is also one of the moments when the Anthropocene theme appears in the exhibition.

• MM Humans have changed seventy percent of the Earth's surface. We see farmland and settlements everywhere. Even in the high mountains, humans are building houses and spreading civilization. But the foundations of the Anthropocene were laid much earlier. As early as the Bronze Age, 6000 years ago (4000 BC), humans began to produce new materials, such as ceramics. Take a medieval hand piece from the region of Harz. They tried to extract different metals or glass. Ultimately, it is a waste product of man. The production process of stone is involuntarily similar to that of volcanic rock. First everything is melted at a high temperature, then it cools down quickly and this creates these degassing holes in the rock. These rocks are called anthropogenic rocks or anthropogenic formations. They are dangerous to the environment because they can also contain pollutants such as heavy metals (e.g., arsenic and cadmium) that can be released when in contact with water. These stones can also weather badly due to an oxidation process and rust formation (see yellowish spots on the stone).

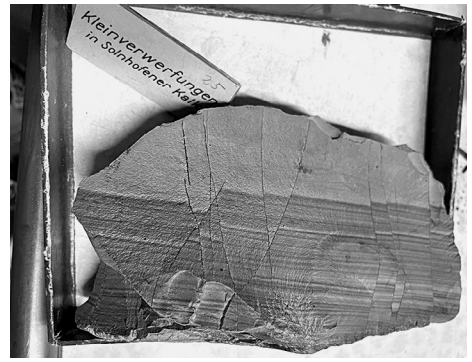


Fig. 11: Minute fractures in Sollnhofen limestone: cracks are immortalized in the rock as line drawings

• NiS From the perspective of your discipline, how would you classify the concept of the Anthropocene?

• MM The term is interesting and worth discussing, especially between geologists and geographers. Geographers such as Eckart Ehlers argue that humans have had a significant impact on the Earth, for example through changes in climate and water systems. Some geologists, however, insist that we are still in the Holocene, and see the Anthropocene more as an epoch within the Holocene. Some propose the atomic bomb tests of the 1950s as a marker

for the Anthropocene. It is also debated whether human influences from the Bronze Age, such as extensive deforestation for the production of ceramics and metals, could serve as a marker. The question of whether the Anthropocene is a new chronostratigraphic series or a new climatic stage within the Holocene remains open and is the subject of interdisciplinary debate.

Fig. 12: Slag from metal production

Fig. 13: Mohsen Makki with the collection of anthropogenic soils of Berlin

• NiS And the Anthropocene also plays an important role in the collection.

• MM Yes, we have set up a new collection area for anthropogenic stones and are also training people outside the university (fig. 13). This is especially interesting for Berlin as a former industrial city. All the big companies/industries, such as the metal industry, produced a lot of material, and the waste materials were also distributed in the soil. As soil scientists, we have to find out what materials are present in the soil and what effects they have on the environment. To this end, a table has been compiled for Germany that lists about 130 different anthropogenic formations that can also be found in the soil of Berlin and the surrounding area.

• NiS Dear Dr Makki, thank you very much for this inspiring interview.

BREATHING STONES: Exploring the Intersection of Microbiology, Geology, and Conservation

Nina Samuel in conversation with Anna Gorbushina

Intermezzo 4

This interview explores Rochus Blaschke's scientific photographs, which have been incorporated into *Stretching Materialities* over the course of the exhibition to reveal the hidden biological and geological processes that shape stone surfaces. In conversation with Anna Gorbushina, an expert in microbiology and geology, we explore how Blaschke's images reveal the often invisible interplay between microorganisms and stones. This discussion highlights the ways in which these interactions contribute to the transformation and life cycles of stone, deepening our understanding of materiality and its often hidden, dynamic, living aspects.

• Nina Samuel: You mentioned that in your research there are interesting points of intersection with Rochus Blaschke's work, particularly in relation to organisms and damaged stone surfaces. Could you elaborate how your research overlaps with his and what initially led you to study the relationship between biological organisms and stone surfaces?

• Anna Gorbushina: It's fascinating when you come across unexpected overlaps between different research fields. My interest in stone surfaces began during my PhD, which focused on the colonization and destruction of marble monuments in the Crimea. This research, funded by the Volkswagen Foundation in the early 1990s, looked at microbial colonization of stone surfaces, particularly marble. At the time, many projects were being funded in Germany to study stone degradation, particularly of monuments, in collaboration between different disciplines such as geology, materials science, conservation, and biology.

Initially, stone research focused mainly on the physical and chemical properties of materials, but the biological element began to appear in the early 1990s—the idea that microorganisms living on the surface of stones play a critical role in their degradation. Specifically, I looked at how organisms colonize these surfaces, what conditions encourage this growth, and how it affects the stone over time. For example, the marble surfaces of monuments such as those in the Mediterranean, the Acropolis, and the Crimea were colonized by microorganisms such as fungi and lichens. These organisms were actively altering the stone, causing significant changes such as pitting. These biological factors were largely ignored until we (a group of collaborating PhD students in the lab of Wolfgang Krumbein) brought them into the discussion.

• NiS It's interesting that you bring up the biological aspect of stone degradation, because the idea of a »defect« on a stone surface could be interpreted in many ways. Are these microorganisms seen as defects of the stone, or are they simply a natural part of the stone's evolution?

• AG That's an important question, and it touches on a shift in the way we look at these processes. Traditionally, people have seen these organisms as harmful—defects that need to be removed. But from a biological perspective, we now realize that microorganisms are a natural part of life on Earth. Wherever there are suitable environmental conditions—temperature, moisture, sunlight—microorganisms will thrive, and this includes stone surfaces. So while they may appear to be a »flaw« from a conservation perspective, they are actually an integral part of the stone's life cycle. They are part of its natural transformation process.

In the past, especially in the early twentieth century, the immediate reaction to the discovery of microbes was to eliminate them. But today we recognize that microorganisms are vital to many processes. In fact, they're often necessary to maintain the health and stability of ecosystems. The same is true for stone surfaces. Microbes can contribute to patination—a natural aging process that may not significantly alter the structural integrity of the stone but still adds to its aesthetic and historical value. So rather than seeing these organisms as purely destructive, we can see them as part of the stone's ongoing narrative.

So, the question of whether these organisms are »defects« depends on the perspective. From a biological perspective, they're a natural part of the environment. From a conservation perspective, they may be seen as something that needs to be managed to preserve the appearance or structural integrity of the stone. It's important to recognize that these organisms are part of the natural history of the material, and sometimes we need to work with that reality rather than against it.

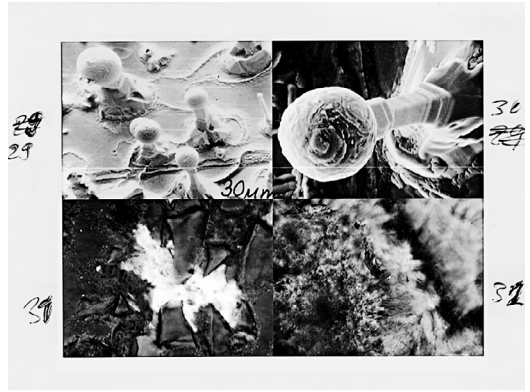


Fig. 1: Rochus Blaschke: Microscopic investigations on surfaces. Images from his lectures. Not dated

• NiS You've done a lot of work in the conservation field as well, particularly with restorers. How have biological insights shaped the way we approach the preservation of stone monuments today?

• AG This interdisciplinary approach has been crucial. When I taught microbiology to conservators between 1997 and 2007, a large part of my work was to raise awareness about biological growth on stone surfaces. Many restorers at that time were not trained to recognize microbial colonization. They might have noticed discoloration or surface changes but didn't realize these were often caused by biological activity. My goal was to help them develop the ability to identify these structures so they could differentiate between harmful microbial growth and normal patination. This was part of shifting the vocabulary and the mindset in conservation.

For instance, in museums, we can manage the environment to prevent microbial growth on stone surfaces. By controlling factors like temperature, humidity, and light, we can prevent the development of damaging biofilms without resorting to chemical treatments. This approach helps

preserve the stone in its natural state, whereas chemical treatments—like those commonly used in the 1990s—can sometimes cause more harm than good. They might kill the existing organisms, but they can also create conditions that encourage more aggressive microbial colonization in the future or lead to the formation of resistant strains.

• NiS Let's now talk about the photographs in the exhibition. They are electron microscope images from the 1980s, and they seem to offer a very detailed view of stone surfaces. ❑ Process, fig. 21, 282 Could you tell us what you, as a scientist, see in these images? What can they tell us about the interaction between stone surfaces and biological growth?

• AG These electron microscope images are incredibly valuable for understanding the microscopic interactions between biological organisms and stone surfaces. What immediately strikes me is the presence of biofilms on the stone. A biofilm is essentially a layer of microorganisms that forms on a surface, and in these images, you can see how the stone surface is covered by these biological colonies. These organisms form a matrix—a kind of slimy layer—that helps them adhere to the stone and interact with its mineral structure.

Fig. 2: Rochus Blaschke: Bacterial colonization on stone surfaces. Not dated

In one of the images, you can see individual microbial cells, which appear as small, rounded structures. What's interesting is that although these cells are relatively small individually, over time and while accumulating, they can have a significant impact on the stone. They secrete enzymes and acids that break down the minerals in the stone, leading to surface pitting and other forms of degradation. Beneath the biofilm, you can still see the crystalline structure of the stone, but it's clear that the biological layer is actively altering the surface.

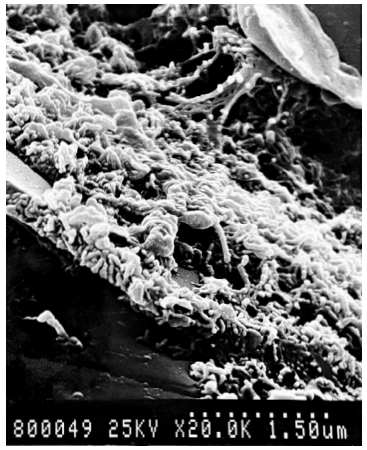


Fig. 3: Rochus Blaschke: Bacterial colonization on stone surfaces. Not dated

• NiS You mentioned that microorganisms on stone surfaces »breathe« in a way similar to our own metabolism. How does this process affect the stone?

• AG Yes, these organisms breathe and produce CO_2, which reacts with water to form a weak acid. This acid can etch stone surfaces such as marble, contributing to their deterioration over time. Respiration, like combustion, releases energy but in controlled steps. In these organisms, this process can take place inside or on the surface of the cell, affecting the stone.

• NiS So, in a sense, the stone surface itself »breathes« as long as it's colonized by living organisms?

• AG Exactly. These microorganisms allow the stone to interact with the atmosphere, essentially making the surface a living, dynamic system. The images reveal how deeply integrated the biofilm is—it's not just a layer on top of the stone but something that is directly linked to the mineral composition. The biofilm creates its own microenvironment, distinct from the surrounding air, which can accelerate chemical reactions such as mineral dissolution and further alter the stone's surface.

• NiS Does the process of preparing these samples for electron microscopy—like chemical treatments—affect what we see in the images? Would the stone look different without these preparations?

• AG Yes, the preparation process definitely affects the appearance of the samples to some extent. In the 1980s, when these images were taken, electron microscopy required the samples to be chemically fixed. This means that the biological material had to be stabilized with substances such as glutaraldehyde, which essentially »freezes« the biofilm in place. After fixation, the samples were dehydrated and then dried using critical point drying, which helps to preserve the structure of the biofilm while removing water.

These chemical treatments can slightly alter the appearance of the biofilm, but they were necessary to obtain such detailed images. Without them, the biological structures could collapse or disintegrate during the imaging process. So while the images aren't a perfect representation of what the biofilm would look like in its natural state, they still provide a very accurate view of the relationship between the biofilm and the stone.

Today, we use this traditional method along with more advanced techniques such as cryo-electron microscopy, which allows us to image biological structures without chemical fixation. In cryo-microscopy, the sample is rapidly frozen, preserving its natural state without the need for chemicals. However, this method has its own limitations, such as the fact that the samples can't be preserved for future study.

• NiS It sounds as if these microorganisms are deeply integrated with the stone surface, almost symbiotic. Is it possible to separate the biofilm from the stone, or are they too interconnected?

• AG It's difficult to separate them, especially if the biofilm has been on the stone for a long time. The organisms penetrate the surface of the stone and become part of its structure. In some cases, we can use weak acids to dissolve the stone without damaging the biological material, allowing us to study the organisms in isolation. For example, when studying coral reef organisms that have burrowed into the carbonate matrix, we can dissolve the carbonate to reveal the organisms' structures.

But in most cases, the relationship between the biofilm and the stone is so intertwined that it's hard to separate them naturally. The organisms don't just sit on the surface—they interact with the stone, changing its properties and contributing to processes such as weathering. The stone provides nutrients and physical structure for the organisms, while the biofilm changes the stone's surface in return. It's a symbiotic relationship in many ways.

• NiS You've mentioned weathering several times, and I'd like to delve deeper into that concept. Can you explain what weathering is and why it's important for both ecosystems and stone surfaces?

• AG Traditionally, weathering has been viewed primarily as a chemical or physical process. For example, rocks can break down as a result of exposure to water,

wind, or changes in temperature. Over time, the minerals in the rock dissolve or fracture, leading to the formation of smaller particles that eventually become soil.

However, we now know that biological organisms, particularly microbes, also play an important role in weathering. These organisms produce acids, acidic poly-saccharides, and enzymes that help break down the minerals in rocks, accelerating the weathering process. This biological weathering has been a critical component in the development of life on Earth, helping to create the soils that support plant life.

In terms of stone surfaces, weathering can lead to both degradation and transformation. For example, on monuments or building facades, weathering can cause the surface to erode, which can be seen as damage. However, weathering also contributes to the natural aging process of stone, creating patinas, mineral deposits, or a combination of the two that add to the character of the material. In this sense, weathering is both a destructive and a creative force—it breaks down existing structures but also creates new ones.

• NiS This idea of weathering as being both destructive and creative is really interesting. It reminds me of a discussion we had about the relationship between decay and growth. How do you see this relationship, especially in the context of stone surfaces?

• AG There's definitely a close relationship between decay and growth, especially when it comes to biological interactions with stone surfaces. On the one hand, microorganisms contribute to the decay of stone by breaking down its mineral structure. They produce acids and other compounds that dissolve the minerals, leading to pitting, erosion, and other forms of surface degradation.

Fig. 4: Rochus Blaschke: Microscopic investigations on surfaces. Images from his lectures. Not dated

At the same time, however, these organisms can also contribute to growth. For example, certain microorganisms can precipitate minerals, leading to the formation of new crystalline structures on the surface of the stone. This can happen in environments where minerals are dissolved in water and then precipitate as new layers on the stone. So while the organisms are causing decay, they're also creating new growth through biomass or in the form of mineral deposits.

This process is most evident in the formation of patinas on stone surfaces. A patina is a thin layer that forms on the surface of stone as a result of weathering, and it can be both a biological and a chemical process. Microorganisms contribute to the formation of the patina by interacting with the minerals in the stone, while environmental factors such as moisture and temperature help to shape its development.

In many ways, decay and growth are two sides of the same coin. The decomposition of the stone creates the conditions for new growth, and this cycle is a natural part of the stone's life. It's also an important aspect of the aesthetic and historic value of stone monuments. A well-weathered stone surface can tell a story about the passage of time, the environmental conditions it's been exposed to, and the organisms that have lived on it.

• NiS I'm also interested in the idea of »self-healing« stone that you mentioned earlier. Could you elaborate on this concept and how it relates to both natural and human-made materials?

• AG The concept of self-healing stone is a fascinating one, and it's something we see in both natural materials like stone and human-made materials like concrete. In natural stone, self-healing can occur through the process of mineral precipitation. For example, when cracks form in a stone surface, water can seep into the cracks and dissolve minerals from the surrounding stone. As the water evaporates, these minerals precipitate out and fill the cracks (e.g., with very fine micritic calcite), effectively »healing« the stone. This process is slow, but it demonstrates that stone is not a passive material—it can respond to environmental changes and repair itself over time.

In human-made materials such as concrete, the concept of self-healing has been applied more deliberately. Self-healing concrete is designed to repair itself when cracks form. This is achieved by adding bacteria to the concrete mix. These bacteria remain dormant until cracks form and water penetrates. When exposed to water, the bacteria are activated to produce calcium carbonate, which fills the cracks and restores the integrity of the concrete. This technology is particularly useful in the construction industry, reducing the need for repairs and extending the life of buildings and infrastructure.

The idea of self-healing materials, particularly those enriched with functional biofilms, is part of a wider trend in materials science to create materials that can adapt to their environment and repair themselves. This has important implications not only for construction but also for conservation, offering new ways of preserving stone monuments and other materials without the need for constant intervention.

• NiS Talking about human-made materials: You've also touched on the idea of anthropogenic stones—stones that have been altered or created by human activity. Could you explain what you mean by this and how it fits into your research?

• AG Artificial stones are stones that have been significantly altered by human activity, either through direct intervention or through processes such as pollution and industrial activity. One of the most common examples is concrete, which is essentially an anthropogenic stone. Concrete is made from natural materials such as limestone, sand, and gravel, but it's mixed and shaped by humans for use in construction. In cities like Berlin, anthropogenic stone is everywhere—on building facades, streets, and monuments.

The term Anthropocene has been used to describe the current geological epoch in which human activity is one of the dominant forces shaping the Earth's surface. While the term is still debated in some circles, geologists have identified specific markers—such as the presence of certain isotopes in sedimentary layers—that reflect the impact of human activity on the planet. This concept is linked to the idea of anthropogenic rocks, because they are a physical manifestation of our impact on the Earth. These stones are not just altered by humans—they are created by humans and play a significant role in shaping our environment.

In my research I'm particularly interested in how these anthropogenic stones interact with biological organisms. Just like natural stone, man-made materials such as concrete are subject to biological colonization. Microorganisms can colonize the surface of concrete, leading to the same kinds of weathering processes that we see in natural stone. In fact, some researchers are exploring ways to harness these biological processes to improve the durability of

concrete and other materials. For example, by encouraging certain types of microbial growth, we can promote the formation of protective biofilms that protect concrete from environmental damage.

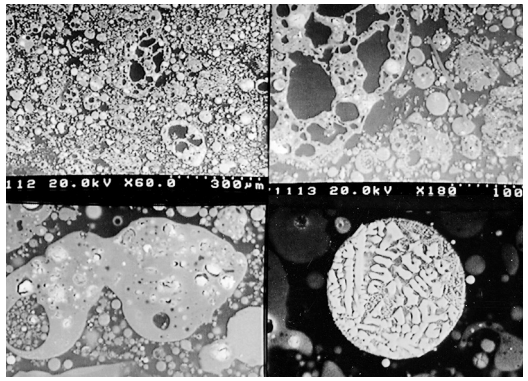


Fig. 5: Rochus Blaschke: Investigations on microscopy. Images from his lectures. Not dated

• NiS With growing awareness of environmental issues such as climate change, do you see a role for stones and minerals in addressing these global challenges? Are there ways in which stone can contribute to environmental sustainability?

• AG Absolutely. Rocks and minerals play a crucial role in regulating the Earth's climate, particularly when it comes to carbon sequestration. One of the most exciting areas of research at the moment is the concept of »enhanced weathering,« where certain minerals, particularly silicates, are used to capture and store carbon dioxide (CO_2) from the atmosphere. Silicate minerals naturally react with CO_2 to form stable carbonate compounds that effectively sequester the carbon and prevent it from contributing to climate change.

The challenge is that these processes are slow. In nature, the weathering of silicate minerals takes place over geological timescales, so it's not a quick solution to the problem of rising CO_2 levels. That's why researchers are looking at ways to speed up these processes, for example by grinding silicate rocks into a fine powder and spreading it over large areas of land or sea. This increases the surface area available for chemical reactions, speeding up the process of carbon sequestration.

In addition to enhanced weathering, there's also potential for using biological processes to capture carbon. Certain microorganisms, particularly cyanobacteria, are able to fix carbon from the atmosphere and convert it into organic matter. These organisms can grow on stone surfaces where they contribute both to the weathering of the stone and to the capture of CO_2. While this is a promising area of research, it's important to note that these processes alone will not be enough to solve the climate crisis. They need to be part of a wider strategy that includes reducing emissions and switching to renewable energy sources.

• NiS That's a crucial point. While stones and minerals have immense potential for environmental sustainability, they can't do it alone. We need to form an active partnership with them, a symbiotic relationship. Thank you for sharing your expertise—this conversation was truly inspiring.

• AG It's been a pleasure to discuss these topics with you. There's so much to explore in the interactions between biology, geology, and conservation, and I'm glad we had the opportunity to discuss these together.

ABOUT CLOUDS, ROBOTS, AND THE SEA
Thoughts on the Aesthetics of Metabolic Formations, Biodiversity, and New Ecologies in Art and Design

Panel discussion with
Babette Werner, Anne Duk Hee Jordan, and Clemens Winkler

Intermezzo 4

Following Claudia Blümle's invitation to contribute to the exhibition project at TA T led by Object Space Agency (OSA) in 2022, art and visual historian and curator Babette Werner addressed the exhibition's overarching topic from a practice-based and theoretical perspective. In her research and practice, Werner explores process-based and inter-media art and design practices at the intersection of technology and ecology, dealing with time, space, and transformation. Her lecture »About Clouds, Robots, and the Sea – Thoughts on the Aesthetics of Metabolic Formations, Biodiversity, and New Ecologies in Art and Design« discussed the notion of an ecological aesthetic by specifically analyzing links between visual representations of metabolic formations, biodiversity, and new ecologies in the shape of clouds, robots, and sea ecologies within the realm of art and design practice and theory.

The selected case studies within the context of the early 1950s until today were analyzed through the lens of transience and material relations. The discussed artworks were mainly entangled with or stem from art and science research collaborations such as Otto Piene's *Sky Art* and *Weather Project* (1973) at MIT, *E.A.T. — Experiments in Art and Technology's Pepsi Pavilion* (1970), as well as Hans Haacke's *Weather Box Series* (1963/64), Fujiko Nakaya's atmospheric cloud and fog sculptures, projects by the New Mineral Collective[1], founded in 2012 by Emilija Skarnulyte and Tanya Busse, and more-than-human contributions by Andreas Greiner[2] and Hicham Berrada,[3] as well as immersive sea ecology installations and robotic works by Anne Duk Hee Jordan and Clemens Winkler's cloud apparatuses, to name just a few. The lecture was followed by a performative talk to which Werner invited visual artist Anne Duk Hee Jordan as guest speaker and design researcher Clemens Winkler.

1 New Mineral Collective, Emilija Skarnulyte and Tanya Busse. https://www.newmineralcollective.com.
2 Andreas Greiner, TOCCATA FOR PYROCYSTIS FUSIFORMIS, A PIANO PIECE INITIATES NATURAL LIGHT, grand piano, dark room, Pyrocystis fusiformis, seawater, developed in cooperation with Sunlay Almeida Rodriguez, 2014. https://www.andreasgreiner.com/works/toccata-for-pyrocystis-fusiformis/?/=chronological.
3 Hicham Berrada, Presage, Tranche, 2007–ongoing, chemical landscape evolving in a glass tank, light. https://www.hichamberrada.com/portfolio/presage-tranche.

• Babette Werner: My first question to both of you is: What aspects are especially challenging in your artistic research practices working with non-human agents, specifically diverse species, robots, and environmental conditions such as clouds and sea ecologies, with which you engage in your work? And secondly, I would like to know which new areas you would like to explore by means of opening up to sense otherwise.

• Anne Duk Hee Jordan: As a visual artist, I find myself engaged in solitary research, delving extensively into the realm of insect and beetle sexuality and the intricate auditory processes governing their sound production. Unlike the auditory structures familiar to us, some of these insects exhibit unconventional placements, with ears situated inside the mouth or protruding as external tentacles. These unique adaptations dictate both their auditory reception and sound emission methods, forming a key focus of my research. It requires a profound understanding of how insects, beetles, and other beings operate, extending beyond the confines of our human perspective. Embracing a holistic approach, I seek to absorb insights from various entities within the realm of entomology, fostering a reciprocal learning experience that transcends our anthropocentric standpoint.

• Clemens Winkler: Yes, reciprocal learning, which might give us new aesthetic experiences of abstract societal questions today, such as how to deal with complex climatic phenomena, is also at the core of my practice. My interest in acting with clouds as non-human agents extends over several years and involves collaborative efforts, including the ongoing teamwork evident throughout the *Stretching Materialities* exhibition. Here, I'd like to zoom in and draw a connection to the concept of embodying non-human actors in the microcosmos, like in Duk Hee's description of insects, especially in my interest in microbes composing today's atmosphere, capable of sensing weather, and also living and thriving in clouds. When asked about my favorite cloud-dwelling bacteria, I often think of Pseudomonas syringae, a plant pathogen that resides in clouds and influences the phase transition of water. This bacterial activity, especially its role in transcontinental rain patterns, captivated me early on and allowed me to collaborate with the field of aerobiology, environmental sciences, and climate engineering for the cloud installation here.

• BW One aspect that stands out when discussing your work is the seamless transition from the macroscopic to the microscopic worlds—and back again. This thematic thread is evident in many of your pieces, Duk Hee, in mixed-media environments like *Making Kin* and your edible landscape project *Into the Wild*. It was also highlighted in the exhibition *Der Wurm. Terrestrisch, Fantastisch und Nass* at Urania in 2021 (fig. 1), which showcased a multimedia installation with a substantial entrance to a diverse world. This entrance provided an immersive experience, creating a zoom-like immersive sensation as viewers could enter and engage with the artwork.

Fig. 1: Anne Duk Hee Jordan, *The Worm: Terrestrial, Fantastic, and Wet*. Site-specific room installation, mixed media. Urania Berlin e.V., 2021

• ADHJ The creation process involved crafting an entrance resembling a door, signifying a worm's beginning and end, and maintaining a consistent design. Advancing towards the bottom of the worm led visitors to a darkened space, illuminated to highlight various worm species existing on a microscopic scale. Central to the installation was a notably giant worm, approximately fifteen meters in length, suspended from the ceiling, alongside the Olavius (a minuscule deep-sea worm measuring only nine millimeters in circumference). The Olavius, known for its sulfur symbiosis, provided valuable insights into the dynamics of symbiotic relationships in our daily lives. In addition to the immersive experience, we infused it with an element of playfulness, acknowledging the challenges posed by the COVID-19 era, where material exchange and collaborative work faced stark constraints. This consideration was manifested in the design, inviting interaction with a torch and facilitating encounters with various worm species. Collectively, these elements allowed participants to delve deeply into the microscopic world of these organisms, enhancing the overall engagement with the installation.

• BW You've probably already observed that a cloud above our heads is forming as we speak. Collaboration is intrinsic in artistic research installations and artwork, wouldn't you agree, Clemens? The collaborative nature of artistic research installations requires an exchange with diverse sources, including engineers and natural scientists. How does this dynamic unfold in your cloud project, especially through your diverse collections of the cloud findings on the wall, like these microscopic images of dust particles and contributions from microbiology, meteorology, geology, and educational sources? With the experiential nature of the cloud, could you elaborate on your primary objective in navigating its complexities and grappling with the concept of ephemerality and shapelessness?

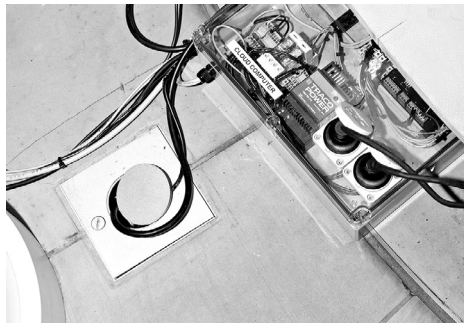


Fig. 2: Clemens Winkler, *Cloud Computer*, TA T, 2021/22

• CW Observing atmospheric, meteorological, and biological processes, the effects humans have on them, and the challenges for microbial life in for-humans extreme environmental conditions inform my practice in art, research, and design. It might start at a lower level, tracing life on minerals in the dust from a desert here in the exhibition space, up to untraceable climatic conditions around this exhibition space. Therefore, this cloud as part of a collaborative practice involves discussions with associated researchers in the field of Climate and Environmental Sciences but also with students here in the space about recreating structures seen in water vapor, or the sky, and in front of our bodies on cold winter days, and how this might be transformed into new experiences. In dealing with indeterminacy and shapelessness, I have collected scaled-up material models hanging from the ceiling, grown samples by airborne microbes, video installations on climate fiction, interactive VR work, up-to-event-scores and re-enactments on these protocol sheets, up to the chance of taking a direct breath from the visible cloud. This collection acted like an immersive track, but it also inserted a technique of irreversibility into the continuous process of cloud formations. It allowed me to orientate myself and led to consistency in my practice of sculpting clouds.

• BW I would love to delve deeper into knowledge sharing and how this sharing works for you. What do you do with your data about the climate, microbiomes, or the visitors? And who can participate in all the data you collect? (Clemens stands up and takes a sample with an air-biome collector from inside the cloud.) What are you doing right now, Clemens? Could you explain the underlying concept of this performative process to the audience?

• CW Certainly, I can perform the action as we continue discussing. This performance involves capturing reactions akin to fingerprints left in the air. If we removed our breathing masks right now, each person in the room would contribute a unique fingerprint to the air in this space. The accumulation of these imprints, particularly in a controlled environment like this conservatory, raises questions about the interplay of humidity, bacteria, and the decay of objects. It delves beyond the visible, encompassing residual body particles, body moisture, and heat, released—whether intentionally or not. Beyond the immediate focus on COVID-related sensitivities to air, this device I hold here in my hands, typically used in clean room laboratories for measurements, provides a unique perspective on the intricate activities transpiring in our environment, offering a glimpse into the potentially rich tapestry of narratives and dynamics in how we aestheticize air at present. Used in new, creative ways, it also shows me another way of dealing with practices of formless and ephemeral media—to dive into its consistencies and compositions through sympathizing with a microorganism. This might shed light on the whole history of the system by empathizing with it and exploring how it has developed its characteristics.

Fig. 3: Clemens Winkler, *Enveloping Atmosphere*, TA T, 2021/22

• BW Could you let us know more about your experience with more-than-human co-creation by »liberating the material« in the sense of »empowering« and »capturing« it?

• CW The focal point of my work, as showcased here, involves filtrating water collected during the recent stormy rain a week ago. The rain becomes a dynamic element, allowing us to revisit—indoors—the moment of its occurrence through this vapor. The data emanating from the droplets reveal the vapor's will and inherent dynamics, shaping my perspective as if I were sculpting the vapor. It's an appreciation of the freedom inherent in materials, a moment where I step back and observe, similar to how I approach clouds. Water is still one of the most unclassifiable materials we have on Earth. This reflective stance prompts consideration of how to intervene or depart from the conventional methods of contemporary design, especially in Western traditions, fostering a more sustainable and open-ended approach.

• BW Both of you appreciate the nuanced environment surrounding our

installation. The cloud is integral to the exhibition, interacting with everything within its purview. By allowing it to be unleashed and freely manifest itself here, the cloud becomes an interactive element in the exhibition space, engaging visitors who then saturate it with their own breath. Could you elaborate on the specific question or delve into the laboratory process involved in the design?

• CW The investigative process at TA T has led us to the development of a microclimate in the center of this podium, which we observe in its current state. The circular nature of the rotunda, capturing circulating elements in the wind (museum objects, visitors, and former residues), has resulted in the accumulation of dust particles. As we sit here, we find ourselves within an agglomeration of these particles, prompting ongoing reflections on navigating and understanding this distinctive microclimate. Here, if we read the installation as an atmospheric lab-in-the-making, observations of this cloud come through aerobiological and intra-machinic perspectives—Earth Learning and Machine Learning, I could call it. Intra-machinic is a term from art historian Ina Bloom drawing on Karen Barad's notion of intra-action. Above this cloud layer, you can experience up to 50° Celsius and 10% humidity right now, which prompts considerations of novel climate experiences here.

• BW Specifically concerning themes I explored in the lecture, I am curious about your perspectives on ecological aesthetics, sustainability inquiries, and the artistic production process. Additionally, I am interested in understanding your stance on collaboration, the reuse of materials and objects, as well as the repetition and documentation of a medium or idea in the context of art making.

• ADHJ Certainly, in my work, as you introduced in *Making Kin 1 and 2*,[4] there's an emphasis on incorporating clusters and sculptures into various pieces. Rather than creating entirely new elements, I focus on making models and strategically placing them in different environmental installations, considering how they can complement, and integrate into, existing compositions. Notably, the robotics I construct predominantly employ old materials, underscoring my commitment to repurposing rather than relying on new resources. The core concept is innovative, but the materials carry a history. In this approach, I draw inspiration from the work of Hans Haacke and Andreas Greiner, who you both mentioned in your talk, Babette. Haacke is a pioneering artist whose contributions from the 1960s and 70s remain relevant today. Haacke skillfully engaged with aesthetics and artistic terms, influencing how his artworks unfolded. Another artist who resonates with my practice is Andreas Greiner, a friend and former classmate. While our focus aligns on similar topics, we diverge in our expressions and material choices.

Fig. 4: Anne Duk Hee Jordan, *Making Kin*, installation view (detail), Kunsthaus Hamburg, 2020

• CW Working with leaking and weathering objects, surfaces, and materials made me focus on environmental factors rather than internal functions, making us subject-objects. I think that often, countering environmental changes in conventional ways leads to the challenges of the Anthropocene. We cannot avoid exhaustion from co-forming a cloud — including the pre-installed heating system here and the approach of redirecting river and rainwater into the building, nucleating on historical dust particles as well as the residues that we brought to this room. While these elements are exhaustive infrastructural residues, to me, they are, simultaneously, wondrous formations of clouds—signs of contemplation and hope. This contemplation extends to the observations of external elements, such as pollen and dust, infiltrating the space we discussed earlier. You mention repetition, which is crucial, and it prompts us to delve into the evolving nature of our practice, offering space for introspection and the development of openness and an attitude. When the entire exhibit relocates, a new phase of testing and results emerges for me, possibly initiating a fresh cycle of research. Each perspective in different places contributes to the rich tapestry of our collective understanding.

• BW Let's now open the floor for audience participation. We welcome your questions, comments, or ideas, aligning with the overarching theme of knowledge sharing prevalent in this exhibition. Feel free to share your thoughts or pose questions, and let's make this a collaborative and enriching conversation.

• Claudia Blümle: The focal point of the question seems to revolve, for example, around rendering the invisible visible (Paul Klee) and exploring how it integrates into our consciousness. I invite both of you to delve into the concept of ghosts—those emergent agents or remnants that transform into tangible entities. This notion introduces the idea of ghosts not merely as observable or perceptible but as living objects. Considering the historical context, ghosts resonate not only in the media, which inherently captures the echoes of the past, but also in transforming robots into entities that embody the essence of ghosts. This intriguing connection may align with the captivating climatic sculptures present in our surroundings. I encourage your insights on this fascinating interplay between visibility, history, and the living essence of objects.

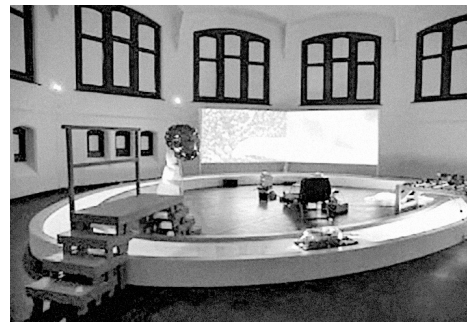


Fig. 5: Anne Duk Hee Jordan, *Making Kin 3.0*, site-specific installation, KIOSK, Ghent, Belgium, 2021

• CW Reflecting on the concept of ghosts evokes a sense of sudden manifestation as a correspondent to me, almost like in a theater play, when dust clouds tell us something about historical events, while influencing the future. Your question might link to Walter Benjamin's idea of the »angel,« not seeing history as a linear progression but as a series of ruptures, discontinuities, and unresolved tensions which continue to haunt our presence and future through »ghosts.« In sculpting and staging atmospheric events, I explore the cloud not only as a metaphor or material medium but especially its activity as a trans-historical motif. The comprising images and material objects collected from the air might link to »unresolved histories« residing in dust bunnies coalescing into new tangible airborne forms with moisture and opacity. Yet, when viewing this amalgamation of the cloud in the exhibition space right now in certain light conditions, a ghostly entity

4 Anne Duk Hee Jordan, Making Kin, 2020–2022, https://dukhee.de/projects/2020_MakingKin.

materializes, transcending the mere aggregation of dust particles, no? I see another aspect here in connection to Babette Werner's question on what is happening with our collected data from the research process. There is a certain spookiness involved because we think we're just doing something systematically over time. Sooner or later, by not fully acknowledging purpose or utilization while measuring the air and the clouds around us, questions of ownership, economics, and legal issues haunt us. Who holds the rights and the testimony of these events in the future?

• ADHJ Certainly, the notion of a ghost is multifaceted. Traditionally, it embodies a soul or an elusive presence that eludes direct perception, sparking a quest for its existence. This concept varies from the spectral entities portrayed in Stephen King's films, such as *The Shining*, where haunting narratives unfold, leaving an indelible mark. In the realm of my work, the idea of the ghost takes on a different dimension. It involves making visible the imperceptible, a pursuit of rendering tangible the unseen. Unlike the mysterious and potentially untrustworthy specters of horror stories, the entities I engage with, such as beetles or bacteria viewed under a microscope, are tangible and reliable. I endeavor to amplify our perception of these unseen entities, expanding our vision to embrace the invisible aspects surrounding us. Thus, exploring the concept of ghosts becomes a process of rendering visible the trustworthy and often unnoticed elements, inviting a broader understanding. In my creative pursuits, there may be moments where I, too, engage in a form of self-ghosting.

• CB Regarding ghosts, there's an intriguing historical anecdote tied to the advent of photography. In the early days, there was an attempt to capture and make visible the invisible, speculating that photography could bridge science and the supernatural, creating a connection to the past. This anecdote comes to mind, and it sparks the idea of speculation in the information Clemens might gather from our breath today. So, I'd like to pose a rather vague question about the role of speculation within both of your artworks.

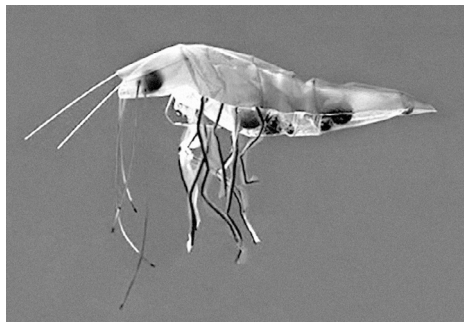


Fig. 6: Anne Duk Hee Jordan, *Water Crab*, detail, 2017–ongoing

• CW Drawing connections to the past via media, like imagery, aligns well with the concepts of my studies in Speculative Design at the Royal College of Art in London. In this exploration, breaking out of established narratives and language is crucial, allowing for the spillage of information, which might be framed as supernatural, as you said. Measurement accumulates as a mode of storytelling, and storytelling plays a vital role in speculating about the collected findings.

• BW Many thanks for this insightful discussion on the notion of ghosts to address the interplay between visibility, history, and the living essence of objects regarding the attempt to capture and make visible the invisible. My research resonates with your thoughts in the sense that I address the practice of (re-)staging process-based art as a media-reflexive curatorial and archival strategy to make the invisible artwork visible again. The framework for this is the notion that (re-)staging—understood as an extended sculptural genre—can be used at the interplay between memory and imagination. I understand the process of (re-)staging as a continuum between prioritizing the immaterial, like an experience or concept, and emphasizing the material in the sense of reconstruction, sometimes thoughtfully mapped out by the artist for future (re-)installations. Yoonha, would you like to share your question with the group?

• Yoonha Kim: As a co-curator of this exhibition, I'm interested in understanding more about your approach to making an exhibition as a research endeavor. In collaboration with curator Pauline Doutreluingne, who is known for her insightful curation, this process seems to have a dual nature, combining aesthetics and research. Clemens, your world seems to embody the aesthetics of research, presenting data and creating an aesthetic envelope of what research entails. It raises the question of whether the exhibition as research is an end in itself, focusing on the curatorial form and its composition, or if it serves a larger purpose, such as altering relationships between entities like humans and worms or reshaping our connection with the atmospheric conditions we're currently experiencing in this space. What does the concept of exhibition as research mean to both of you, and how does it extend beyond the curatorial realm to impact various relationships and dynamics within the showcased elements?

• ADHJ While curator Pauline Doutreluingne is not present here, you acknowledge her unique approach, delving deep into research and uncovering unconventional spaces that are artistically enriching. The work forms a cohesive whole in my practice, not compartmentalized into discrete projects like *The Worm, Into the Wild,* or other endeavors. The interconnectedness is significant. For instance, *Into the Wild* preceded *The Worm,* where I created an edible landscape, exploring ecology, plant history, colonization, and the essential roles of bacteria and worms in plant growth. This venture naturally led me to explore worms more profoundly. Prior to *The Worm,* I delved into *Ziggy and the starfish* (2016–2022), investigating sea sexuality. This exploration uncovered the intriguing abilities of flatworms, such as changing sex and engaging in unique mating dances. The fascination with these remarkable phenomena prompted further questions, such as the transformation of soil into solid material. This journey demonstrates how my work evolves organically, following the questions that arise, connecting diverse topics, and contributing to a continuous exploration of the unknown.

• BW The way Pauline Doutreluingne approaches exhibition topics resonates with my process. Sometimes, you start with a predefined theme or artistic position, and then the journey begins. Or you source content and end up doing it the other way around. One way or the other, each approach is rooted in ongoing research. In conversations with artists and researchers, I envision how the information could be displayed, contemplating various forms of presentation across different spaces, physical or digital. It's a dynamic and interconnected approach that extends to forming assumptions, connections, and collaborations in the broader context of exhibitions. Many thanks for sharing your knowledge and your insightful contributions to the discussion!

Fig. 1: Finissage performance
by Kaaren Beckhof

Fig. 2: Yoonha Kim testing the wearable

Fig. 3: In the making: Deung Deung Geo Ri. Haptic West inspired by traditional Korean climate regulating wearable

Fig. 4: Finissage performance by Kaaren Beckhof

Fig. 5: Connections between OSA members' fields of research

Fig. 6: *The Experimental Zone*, MoA's studio at Sophienstraße, Berlin

Fig. 7: *Structural Textiles* prototypes and *Willow Reality rods* (Natalija Miodragović) next to *Device* (Sabine Huzikiewiz)

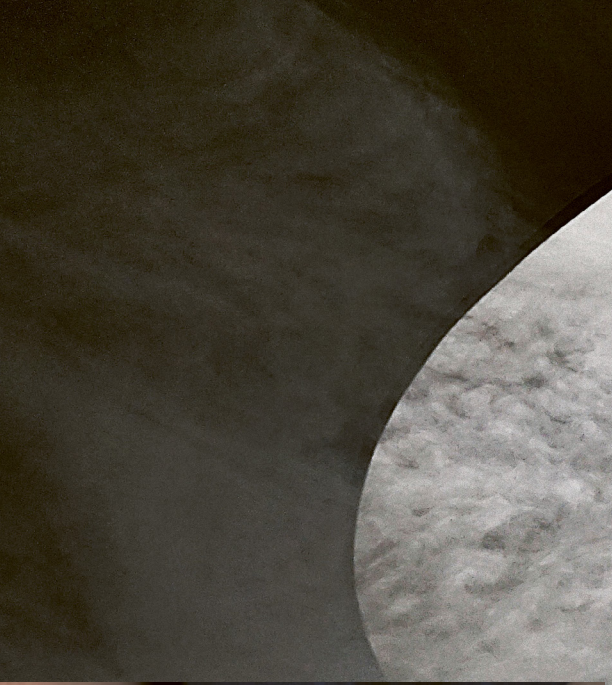


Fig. 8: A PCB board and an olivine stone—both responsive to air and shaping climate, one by code, the other through weathering

Fig. 9: Indoor cloud close-up with latent motions of air flows, convection, and precipitation patterns due to visitors walking and body heat emissions

Fig. 10: Airsampler MAS-ECO 100 in front of the mapping of dust samples, visitor numbers, microbiota

Fig. 11: *stretching senses school* festival at TA T, 26 June 2022, 360° camera view

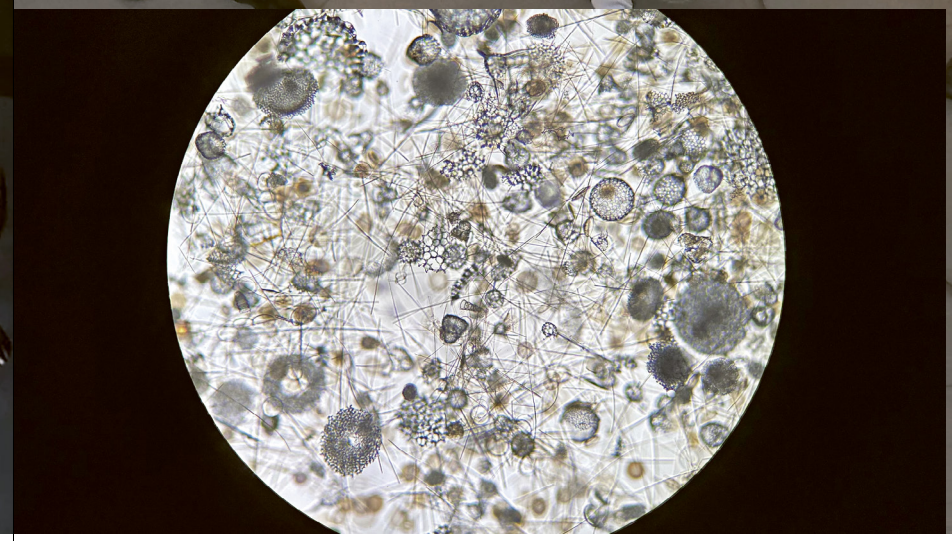


Fig. 12: Inside VR: weathering process of rocks floating around the center. *Geological Performer*, Studio Above & Below, 2021

Fig. 13: Microscopic image of dust particles. A visit to the dust archive of the Leibniz Institute for Biodiversity Research, Natural History Museum Berlin

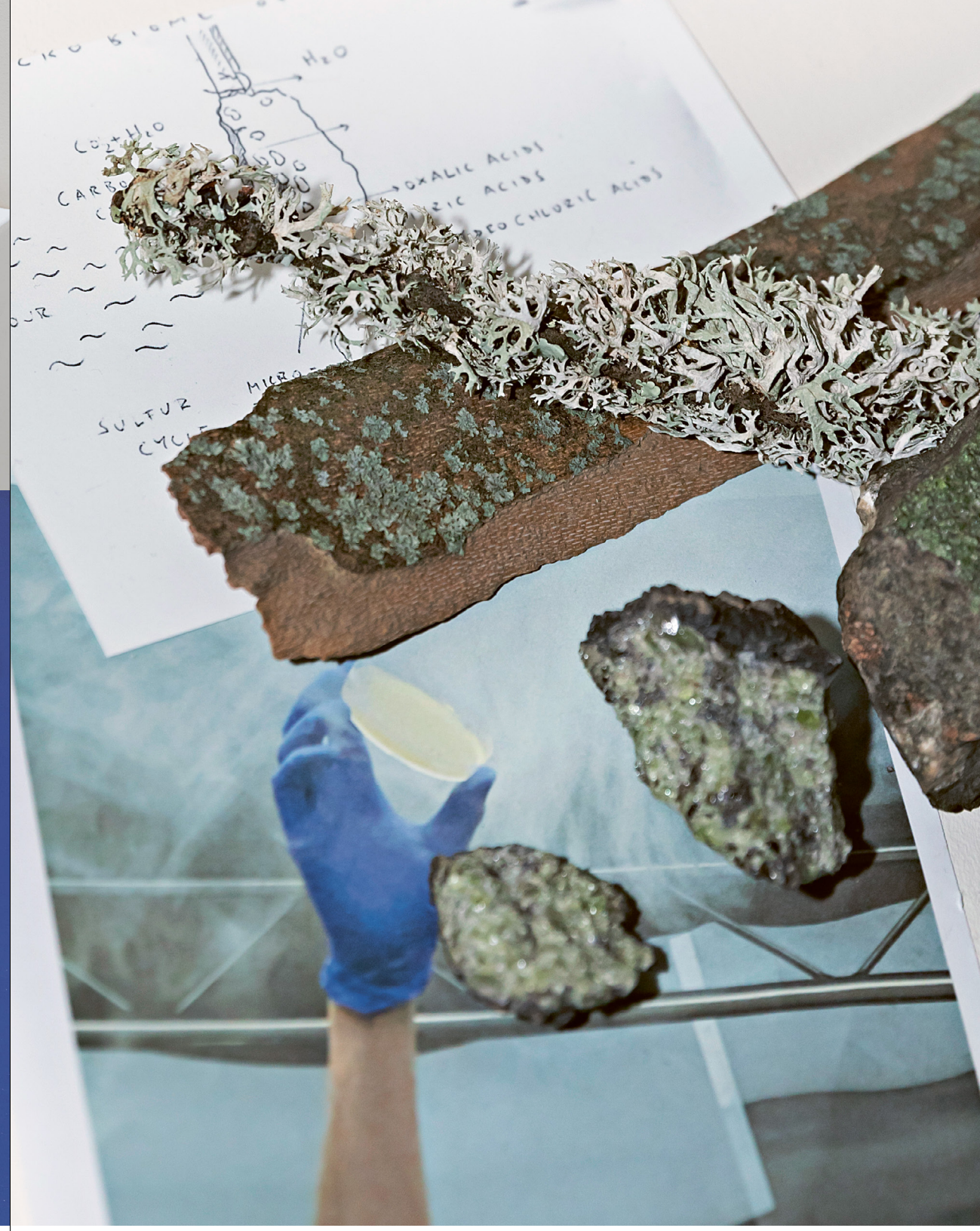


Fig. 14: Designed collection tools: airborn particles, indoor climate data, and dust vessels

Fig. 15: *The Power of Water*, workshop at Objektlabor, TA T, 14 June 2023

Fig. 16: Findings from the nearby surroundings as climate indicators, situated in the exhibition space

Fig. 17: Refurbishment of TA T, 2005–2012

Fig. 18: *stretching senses school* festival, installation view, June 2022

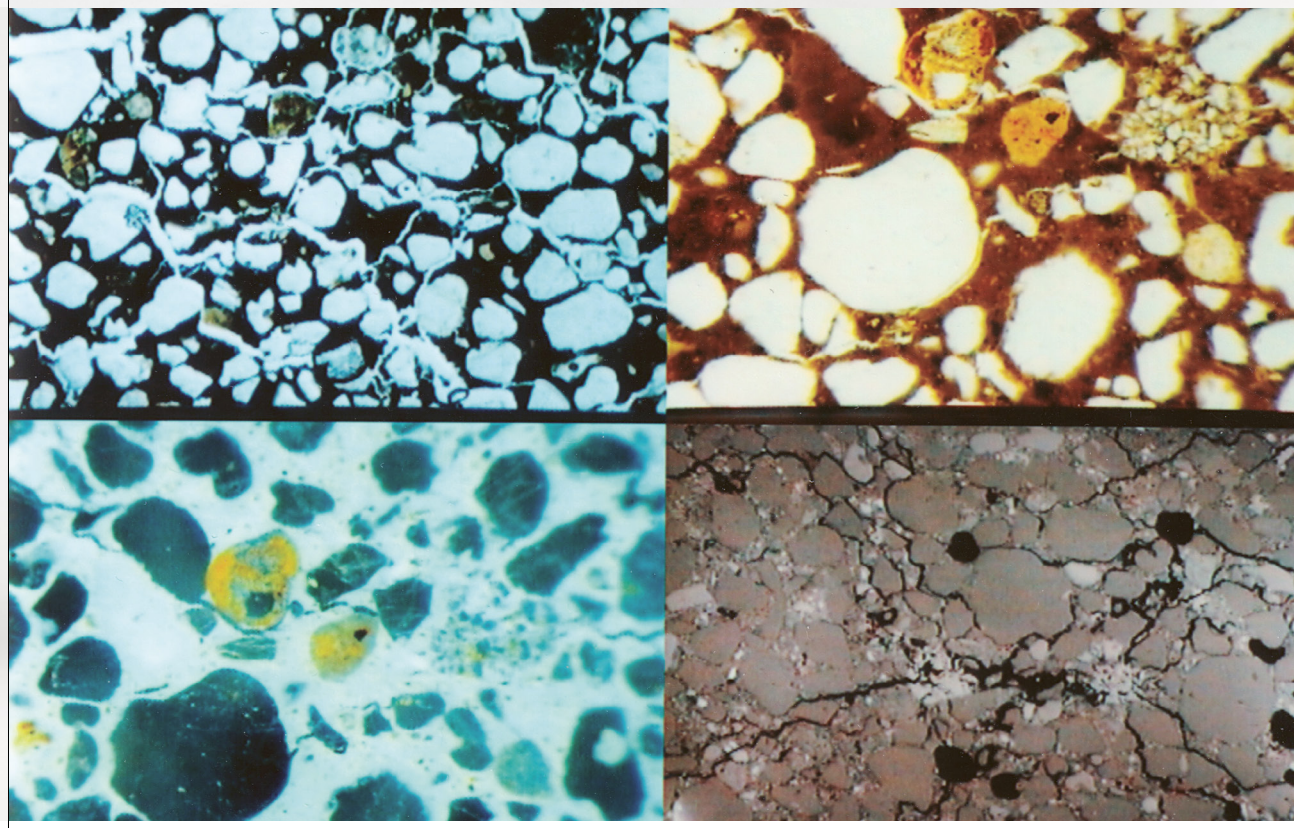


Fig. 19: *Structural Textiles*: The use of different materials programs the elasticity and stability of a structure, ranging from flexible and responsive (a, b) to structurally solid (c)

Fig. 20: Rochus Blaschke: Investigations on microscopy. Images from his lectures. Not dated

Fig. 21: Lena Dues, *Auturgy of Carbamide*, installation shot, 2021

Fig. 22: Making of: *Haptic Hanbock*, September 2021

Fig. 23: Material scientist Michaela Eder and designer Nelli Singer in the lab

Fig. 24: Panel discussion *About Clouds, Robots, and the Sea*, with an introductory talk by Babette Werner at TA T

Fig. 25: Sketching of hypothetical airborne assemblages for the spatial VR experience

Fig. 26: *Willow Funnel* by Natalija Miodragović, with Kaaren Beckhof

Stretching Senses

Stretching Senses and Sounding Neurons: Virtual Reality as Design. Anthropological Probe

Maxime Le Calvé

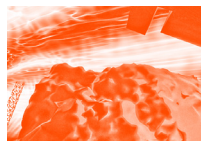
Fig. 1: Inside the last version of the *Virtual Sensing Knife*: interaction of the sensing knife with virtual tissue.

During the COVID-induced break from fieldwork, myself, a graphic anthropologist, and fashion designer and visual anthropologist Yoonha Kim initiated a design anthropology project in collaboration with experimental physicist Fardin Gholami. The *Virtual Sensing Knife* project revolves around an ambitious experiment known as the *Sensing Knife*. The *Sensing Knife* aims at converting the technology of the atomic force microscope (AFM) into a neurosurgical instrument, a machine that could »feel like the hand of a surgeon,« as the project description claims. The hand in this project would be minuscule, however—the machine is set to operate at the scale of the cell. Triggered by the speculative implications of this vision, we imagined an exhibit for the *Stretching Materialities* exhibition (fig. 1). Like other co-curators with their pieces for the show, we displayed the creation process to the public, showcasing several versions over several months. We also published a timeline of the project, which came to include the *stretching senses school*—an attempt at upscaling our experimental collaboration with digital artists. → Intermezzo 5, 343

As anthropologists Paul Basu and Sharon Macdonald (2007) noted, the making of an exhibition brings knowledge processes into a different mode. This is even more so when the format of the anthropological production can take the form of an installation with »new media,« performance, and workshops. The anticipated format between analog and digital brought us to engage with a VR production process. ❑ Exhibition, fig. 6, 126 The installation *Virtual Sensing Knife and Haptic Hanbok*

invited exhibition visitors to an immersive sensorial encounter »down the scale« with free-floating neurons and brain tissues. Inspired by the work of Stefan Helmreich, Karen Barad, and Chris Salter, we invited a sound artist researcher, an interaction designer, and a garment engineer and embarked on an inventive research endeavor. The making process, documented and blogged about in different visual and audiovisual forms, triggered many conversations among us and with the visitors around human-machine perception, soft haptic wearables, force fields, life-energy meridians, and the general process of sounding matter to relate to the more-than-human. This chapter is the first part of the section *Stretching Senses*, which is conceived as a duograph around the *Virtual Sensing Knife* and *Haptic Hanbok*. A duograph presents an elegant solution around the trouble of co-authorship—one fieldwork, two anthropologists, two texts, and two different takes on a topic from very different backgrounds and perspectives, yet thoroughly influenced by discussion and a shared lived experience of the same situation (Howe 2019; Boyer 2019).

What would be the experience of neurosurgeons if they could sense the body material and cut along the microscopic borders of cells? How would a visitor of the exhibition feel if they were sent to the »bottom of the scale« and vibrated with the blade of the instrument as they sense and cut through organic tissues? In order to flesh out the vision of the physicists, we set out to create a speculative simulation. Imagined and produced by a team composed of medical researchers, physicists, designers, and humanities scholars, the *Virtual Sensing Knife* acted as an elaborate »cultural probe.« ❑ Exhibition, fig. 4, 124 The VR experience was presented in the ground floor rotunda of the exhibition space, below the round lecture hall of TA T, and as one of the levels of the Virtual Elevator.« ❑ Process, fig. 11, 274 → Stretching Virtuality, 90 To introduce the project, one would be tempted to disentangle the many threads that brought it into existence and state a clear research question. However, it is important to inform the reader that this journey isn't moving toward a clear hypothesis to be proven right or wrong. A design-led approach to understanding life worlds of users, »cultural probes« are »collections of evocative tasks meant to elicit inspirational responses from people—not comprehensive information about them, but fragmentary clues about their lives and thoughts« (Gaver et al. 2004, 53). Similarly, we insist that this »cultural probe« is not intended to collect systematized data which could be thoroughly analyzed *ex-post*—on the contrary, we wanted to embrace the fact that the probe and its related experiences were



1 One can quote Hans Ulrich Gumbrecht as a pioneer reflecting on this theme, although by different means and anchored in the tradition of media theories, as he studied the production of »presence« in the humanities (Gumbrecht 2004).

ambiguous and open to manifold layers of interpretations. The ethnographic account of this endeavor may therefore come across as polyharmonic and perhaps slightly dissonant.

Our probe was an attempt at inquiry through »other modes of knowing,« to quote a recent work by the sociologist of science, John Law (2016). He hints at alternative ways of producing knowledge that are indigenous to Western cultures. Reading his arguments in the context of this project, they seem so striking and relevant that I feel compelled to sketch the main line of his argument in this introduction. According to Law, even if Science and Technology Studies have repetitively and patiently explored the limits of academic knowledge, its production remains mostly chained to the scholarly traditions, alienated and captured in text and theory. Law issues a call to explore other modes of knowing, taking the baroque as a Western mode which resisted the dominant academic mode, mingling with and addressing questions of otherness, emotions, and embodiment.[1] In his short history of Western scholarship, Law retraces the »purification« of academic knowledge to the reform of the Church and Protestant ethics, which infused the first scientific academies, and from there spread to universities and all other institutionalized venues for academic knowledge-making practice. As a counter-reform movement, the baroque showed an exalted reaction against this purification process, which he illustrates and analyzes by exploring a work of the sculptor and theater maker Gian Lorenzo Bernini. Law describes this alternative mode of knowing by going through six techniques employed in these artworks that all resonate strongly with our own (modest) endeavor. Theatricality is the most important of them: »Its effects, its dialogues, its scenery, and the multiplication of its artifices are theatrical. Indeed, the artifice is self-conscious, which works to highlight the limits of human modes of representation.« (Law 2016, 29) Second, the boundlessness which characterizes these knowing devices means that it is impossible to clearly establish the division between the inside and outside of these works: »You cannot do what feminist Donna Haraway calls ›the God trick‹ of pretending that you can see it all from nowhere in particular. Instead, you are entangled. You are asked to; you're required to submit and to participate.« (Law 2016, 32) Third, we find the technique of heterogeneity, as these works »multiply their media« (Law 2016, 33). Fourth, there's folding: »The inside becomes the

outside, and the outside becomes the inside.« (Law 2016, 34) Fifth, »distribution, movement, and self-consciousness« is especially relevant to our chosen medium, that of interaction design: »Knowing is a matter of moving. (…) What is happening is a multiplication of viewpoints.« (Law 2016, 36) Finally, sixth, the technique of mediation is crucial: »The baroque knowing becomes sensible to otherness—or the absence of otherness—by working through mediation.« (Law 2016, 39) → Stretching Virtuality, 79 → Stretching Practices, 29 He goes further: »So what if we are interested in ways of knowing excess within the contemporary academy? Of recognizing the whole that is, at the same time, a hole in our artefacts of knowing or experiencing? The implication is that we need to imagine particular machineries of transport and mediation.« (Law 2016, 39).[2]

In this chapter, I will tell the story of the building of such machinery, a machine aimed to transport the otherness faced by the biophysicist and the neurosurgeon, playing with heterogeneous media, folding, and movement to create an artifact of experiencing, which requires the spectators to participate, immerse, and modulate their bodies through wearables, sensors, and 3D modeling. At first, I plunge into the conceptual background that has set the tone for making this machinery. I then outline our fieldwork and relay the experience of biophysicist Fardin Gholami, who plays the role of an accomplice and co-dramaturgist of this work. Further, I describe and reflect on the haptic installation and the careful »sounding« of materials and bodies involved in the research process. ❑ Process, fig. 22, 283 In the guise of a conclusive remark, I dive into the making of toys as probes to get in touch with some of the most dumbfounding aspects of our relation to science and technologies. But first things first, so let's start with situated definitions of some of the terms and analogies that are guiding this project.

Modes of Knowing, Sounding, Probing, and Immersing

The word »sounding« becomes a pun, as anthropologist Stefan Helmreich puts it, when the probe used to »sound« a milieu is actually a vibration, which can be translated or »transduced« to the domain of the humanly audible. With his edited collection of essays, *Sounding the Limit of Life* (2015), Stefan Helmreich renders the sensorial, especially acoustic phenomena, a crucial element in the delicate and complex interplay between water, life, and sound. He already explored this notion in a milestone article, *An Anthropologist Underwater* (2007), in the context of his ethnography of the submarine soundscapes, which he tied in artful ways to other important notions for our project: immersion, cyborg perception, transduction, and the ethnographic as a space to conduct similar operations of immersion.

Before the invention of the sonar, however, »sounding« was a relatively low-tech and effort-heavy sea fare operation. A small object, usually made of lead, was sent to the bottom of the sea to ensure that the boat wouldn't wreck, and lines on a rope, used to pull the »sound« back onboard, would indicate to the »sounder« the water's depth below. Other indications, such as the texture of the bottom were also important, for instance, when an anchor had to be placed and moored onto the ocean's floor. A cavity at the base of the object could be filled up with black soap to make the probe stick, encase, and carry up a sample of the material hit by the sounding probe (ideally, sand) or no sample, if the floor was rocky or barren and hence not hospitable to the iron plough of the anchor. Sounding is a relatively tedious activity, which I remember I have occasionally undertaken as a child and which became more exciting when approaching the landing site due to the imminent danger of shipwreck—and my potential responsibility in this latent event. Continuously communicating by voice with my father in the hull of our little sailboat in Bretagne, plunging the yellow plastic line into dark waters, feeling the probe hit the floor, reading from the pattern of black and red marks on the rope, all these were initial intuitive insights into what Hutchins (1995) defines as a distributed cognitive action (only Hutchins misses on the more sensuous aspects of any encounter with the depths and shallows of the ocean and of matter in general).

One of the key aspects of what Law identifies as the baroque mode of knowing is a multiplicity and heterogeneity of interests and materials, and the composite character of these objects and processes. Similar tendencies can be found in the current turn to multimodal anthropology as a way to engage inventively with the research partners into a »sounding« process, which can be framed as a careful, provocative, and wild, subversive endeavor (Le Calvé, Beck & Stock 2025; Westmoreland 2022). This process can also be found in the attempts to bridge different disciplines together in order to get to new breakthroughs, as in the agenda of *Matters of Activity (MoA)*, which provides the backdrop for this project. → Stretching Practices, 52 Like many

2 In a recent review of the research-creation works in STS, also referring to Law and his previous works, the authors state that »sensual and performative practices and resources may be used as methods in such inquiry and become part of the research process, thus contributing to a broader perspective on and understanding of the research subject« (Salter, Burri & Dumit 2017). The authors also quote Michael Fischer as an important precursor of this mode of thinking STS research, as he proposed as early as 2003 to »bring together science and technology with the social sciences, arts, and humanities, which constitute the analytic understanding and cultural commentaries about the societies of (post)modernity« (Fischer 2003, 139).

others, this well-funded initiative is explicitly modeled after previous exemplary instances of successful interdisciplinary collaborations (Bauhaus, Black Mountain College). With *Virtual Sensing Knife*, we take a speculative and imaginative journey into one of these science projects, aiming, with epic ambition, to reinvent the old technique of the neurosurgical cut. As anthropological staff onboard the exhibition, we initiated a design process as a contribution to the research in order to sound the very different approaches and questions which are intersecting in these projects.

The MoA project *Cutting* brings together three main disciplines in three different experimental settings.[3] *Digital Twin* starts from the possibility of advancing neurosurgery by integrating the latest technologies in computerized imaging with computational neuroscience; *Digital Dissection* aims at developing a haptic VR tool to help virtual paleontologists conducting non-destructive investigations inside delicate samples; *Sensing Knife* intends to insert into the operation room a microscopy technique used by macromolecular physicists to scan matter through contact—or rather through the detection of field force, using a minuscule probe. In a perspective article in the journal *Neurosurgery*, clinical researchers alongside biophysicists, neurolinguists, and computer scientists from *Cutting's* project team claim to set a new agenda for the discipline, a surgical cut that will completely avoid any danger for the patient (and the surgeon) by separating and dichotomizing harmful from beneficial tissue through the power of data—sensing, measuring, modeling, and cutting brains in such a precise (albeit delicate) way that we could shift to the paradigm in which the cut would be considered as a treatment. This article, which I co-authored and co-edited, can be read as the crowning dream of the cybernetic modes of knowing and making in the medical world (Picht et al. 2021). Both an aesthetic and ethical value, this characteristic »beautiful data« framework (Halpern 2014) suggests realizing a neurosurgeon's dream: a procedure that would remove all risk, both during the intervention and afterwards during recovery. For the surgeon, this directly addresses an existential suffering related to this permanent uncertainty while making decisions: the comfort of securing the fact that patients will remain »themselves« when they wake up from the operation: speak, walk, and get back to their lives.[4] This project goes beyond these problems and attempts to accommodate through fieldwork the kind of relation that is envisioned with matter—and host that encounter in a virtual experimental setting.

3 Cutting, Matters of Activity. Accessed June 18, 2021. https://www.matters-of-activity.de/en/research/projects/122/cutting.

4 It is also a dream of precision related to machinery, as the title of the project *Digital Twin* reveals, inspired by mechanical engineering. What has been called »redundant precision« in another domain, as software related to 3D visualization design such as that used by engineers to cut out lenses, enables to think and plan surgical cuts.

What would happen if these machines could sense and care like humans at another scale, »feel like the hand of the surgeon?« This sentence of the project description of the *Sensing Knife* invites us into an immersive and haptic encounter with matter other-than-human. The staging process described in this chapter is a direct response to this thought: a speculative phenomenography, aiming at grasping the kind of interaction with (living and non-living) materials suggested in that sentence. The *Sensing Knife* gathers multiple techno-imaginaries related to the project of the *Cutting* group at MoA: non-harming and molecularly perfect surgical interventions—removing a tumor in a way that not a single cancerous cell remains, in a way that the tissues of cells immediately coalesce, using the »activity of materials« to shape the intervention.

As Tim Ingold (2015) argues in his seminal essay on »a world without objects,« an environment perceived exclusively through its edges and surfaces can only provide us with a shallow understanding of the flow of life permeating the material activity of things. The paradigm of the digital image that flourishes today, with the development of omnipresent mesh-based 3D images and segmentation technologies, is structured around the sense of vision, which is based primarily on the external shape of objects, defined by their surface. Developers and designers are developing new devices that can convey a substance and texture into digital spheres. ❑ Exhibition, fig. 19, 139 What kind of transduction processes can be employed to convey the »sounding« of materials through digital immersive apparatuses? As David Parisi (2018) notes, haptics, once a venerable science, have entered a new »marketing« era since the 1990s. Haptics are supposed to save us from our over-digitalized lifestyles. Critics from the humanities, starting with Richard Sennett's book *The Craftsman* (2009) and ranging to the more recent concept of »sensorimotor debility« (Penny 2020), to the »ecology of attention« by Yves Citton (2017) have played the role of whistleblowers in a more academic register.

Immersive Encounter With Matter
»Down the Scale«

Friday, 28 May 2021. Yoonha and I head to Adlershof, a suburban campus of Humboldt University, home to the Institute of Physics. Fardin Gholami, our MoA colleague, is happy to show us his workplace, Jürgen P. Rabe's lab for macromolecular

Fig. 2: Fieldwork at the lab of Jürgen Rabe with Fardin Gholami, Institute of Physics, Humboldt–Universität zu Berlin. Drawing by Maxime Le Calvé

physics (fig. 2). Together, we are preparing a VR installation for *Stretching Materialities*. The work's project name is *Virtual Sensing Knife*. It is a speculative demonstration of the *Sensing Knife*—which is itself a speculation between physics and neurosurgery. The *Sensing Knife* is a project initiated by Jürgen and later expanded by Fardin: the idea is to turn the sensitive probe of an AFM into a neurosurgical tool which would »sense the brain material as it can also cut through it,« as stated in the initial research proposal. To further explore this idea and the imaginary that it encompasses, together with a small team, we developed a VR installation which allows the visitors to encounter representations of brain tissue at the level of the cell and experience the boundary between zones of different densities (the typical case study in neurosurgery is the ablation of a tumor). The coming together of anthropologists, designers, and scientists has opened up unexpected paths for our project. Today's aim is to »listen to a neuron« with one of the AFM—an idea Fardin came up with when meeting Nico Espinoza, the sound designer we hired for our project.

Fardin has just received a few samples of HT22 cells from Thomas Picht's team at Charité's Department of Neurosurgery (fig. 3). Originally collected from a mouse's hippocampus, they multiply and freely float within a pinkish solution that nurtures them—whereby healthy cells actually interact and adhere to the Petri dish's inner surface. In this experiment, we aim to come

to touch and listen, »as if with a stethoscope,« to an individual living neuron. The cells keep on floating, for now, maybe aware of our plans, perhaps already oblivious of their previous form of life and the act of scientific violence that has set them swimming freely. In a comment on an earlier draft of this text, Fardin wrote: »they are sure alive, their perception of environment might change as we perturb it with an oscillating probe… That's exciting for me to think, I like to think that they are aware of mechanical perturbations surrounding them.«

Fig. 3: Box of culture neurons from a mouse, obtained by Fardin from our colleagues and neurosurgeons at Charité. Drawing by Maxime Le Calvé

Fig. 4: Atomic force microscope in its protective box. Drawing by Maxime Le Calvé

The AFM sits in a box that isolates it acoustically from the outside world. This machine consists of two parts: on top, an inverted optical microscope makes it possible to adjust and control the action of the AFM, and underneath is the actual sensing machine with the micro cantilever (fig. 4). It stands on a tripod above the sample, which is moved underneath. Invented in 1986, its technology has been in constant development ever since (Galison 2006; Dufrêne et al. 2017). The device is built around a swappable microcantilever often made of silicon dioxide, probably one of the thinnest, finest, and most sensitive human-manufactured measuring artifacts. It is used to scan objects whose size is so minuscule that they are impossible to see with visible light—because the wavelengths of visible light are literally too large to interact with such entities. The originality of this technique lies in its bringing a sensing needle into close contact with the material in order to scan it: it is a seeing technology that relies on the sense of touch. In the realm of physics, as Karen Barad (2012, 209) reminds us, there isn't any actual »touch« but only force fields: »The reason the desk feels solid, or the cat's coat feels soft, or we can (even) hold coffee cups and one another's hands, is an effect of electromagnetic repulsion. All we really

ever feel is the electromagnetic force, not the other whose touch we seek. (…) Electromagnetic repulsion: negatively charged particles communicating at a distance push each other away.«

With rotating knobs, Fardin is controlling the position of the cantilever's tip. The first generations of AFM were probing the materials' surface by scanning and touching them. »We were destroying a lot of what we were touching«–Jürgen's voice resonates in my head as I write these lines. He has presented this technology several times to the team and told us a few stories linking him, his lab, corporations, and some lucky students who became millionaires by developing the next generations of these costly machines. After destroying many of their objects of study, the physicists adjusted the mode of operation of the machine: the AFM now conducts its scans by hovering directly above the material, rather than touching it, feeling the repulsion and attraction fields and figuring out the resistance and elasticity. The cantilever oscillates, and the scanning is effectively produced by figuring out the perturbation of this baseline frequency. However, the researchers also used it to manipulate protein single ribbons, »blow« circular protein into perfect loops, or carve their initials on the surface of cells. This is how Jürgen came up with the idea of using it as a blade to perform surgery at the level of the cell–a surgical cut which would not harm the organism as it would elegantly separate matter and enable it to bind and cohere again almost immediately through its inherent activity (regarding the »informed cut,« see Picht et al. 2021). Of course, the professor is perfectly aware that this is an extremely, if not overly, ambitious project, and dares to compare it to a grand historical project: »It took fifteen years for the Americans to land on the moon,« he says with a smile when someone raises the question about the feasibility of this project.

Meanwhile, Fardin is observing the cells floating in a pinkish solution. Fardin points to a grid with a red point on the screen: the red point isn't centered and keeps moving erratically–the vibration frequency of the cantilever is picked up using the reflection of a laser, and the red point indicates the alignment of the laser with the photodiode (a sensor to detect the reflected laser, fig. 5). The restless motion signifies a micro perturbation impacting the reading of the cantilever's movements. He checks out the scene directly using the optical microscope: »That cell is hanging to the cantilever!« he says, showing us the culprit. Enacting his words, he mimics with his whole body the cell clinging to a cliff (fig. 6). His understanding of the situation is embodied, he is starting to correspond with both the AFM and the cell by propelling himself onto the microscopic stage.

Fig. 5: View of the monitor of the optical microscope to position the cantilever on the material. Drawing by Maxime Le Calvé

Fig. 6: Fardin enacting the cell hanging on to the cantilever. Drawing by Maxime Le Calvé

As shown in *Rendering Life Molecular* (2015), »molecular modelers' responsive bodies are attuned to subtle molecular forces and affinities; they hitch rides on the molecular movements they model and allow these intricate forms to inflect their gestures and affects« (Myers & Dumit 2011, 240). A leading AFM brand has chosen to call themselves *Nanosurf*: this name immediately conjures up an image of the macromolecular physicists and AFM operators riding the matter's wave as they scan their reliefs, surfing on magnetic force fields.

Researchers probe into material that lies beyond the scope of their perception, their senses augmented by information inputs that can take multiple shapes–2D or 3D visualizations. Their prosthetic crystalline fingers, sensing matter down the scale, are here portrayed as submarines sounding the ocean's floor. The researchers' perceptive bodies scale down concurrently with their instruments, with their hearts and souls: »Modelers *transduce* these affects through their bodywork and propagate these gestures through performative articulations that excite others into action.« (Myers & Dumit 2011, 241)

The company MicroMotion, one of the manufacturers of the cantilevers, has used the submarine as a key visual for its promotional material, which accompanies the expensive boxes with cantilevers. »The content of this box costs 4.500 Euros,« a label reminds the lab visitors in bold characters on a transparent box the size of an old Nintendo game cartridge. A poster of that company adorned the lab's wall on my previous visit (fig. 7). Imagining the immersion »down the scale,« as the title has it, reminds us of the dreams of the 19th-century explorers and their taxonomic enterprises, the discovery of unknown territories: »You never know what you might catch,« is added below the title as a caption to the image. Once more, scaling

down points towards the experimenter's immersion into a fluid medium, sounding the rock bottom of matter. As mentioned in the introduction, calling it a practical »pun,« Helmreich reflects on the etymology of the verb »to sound« which in the sense of fathoming has etymological moorings in the Old English *sund*, or sea, whereas sound as vibration reaches back to the Old English *swinn*, or melody (Helmreich 2007, 624).

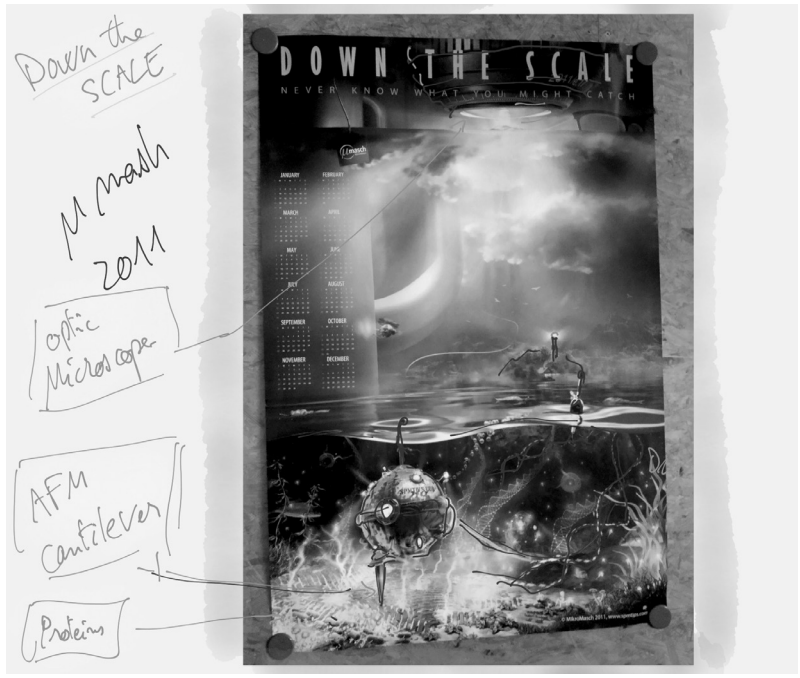


Fig. 7: Annotated photograph from fieldwork: promotional poster calendar from the company MicroMotion (2011) on the wall of the lab

With a small team, Yoonha Kim and I have been toying with and transposing the machinic sensorial immersion of the AFM into a VR installation. Sound soon became an important concern. → Intermezzo 1, 61 »How have underwater soundscapes come into audibility for humans? Devices that permit listening across different media—from water over into air environments (like the inside of the sub)—are key,« writes Helmreich (2007, 624). For *Virtual Sensing Knife*, we are working with sound designer Nico Espinoza and interaction programmer Itaru Yasuda to produce a simulation of Jürgen's vision for a knife that senses and cuts down at the level of the cell. This multimodal anthropological project proceeds as an inventive and iterative »sounding« of the potential intra-actions between physics, design, and neurosurgery. We are exploring techno-poetic paths to relate to the more and less human status of neuronal tissues. We envisioned a virtual reality installation that would invite the visitor of the *Stretching Materialities* exhibition into a tinkered techno-fantasy where the technoscience worlds of biophysics and neurosurgery collide. → Stretching Virtuality, 92 In the last section of this chapter, I will present a portion of this staging process. Here, the probing *is* the making, as the making is driving us to probe and sound in various ways to bring together all these elements into an immersive piece. For half a year, we managed to sustain this nascent stage of the production process (fig. 8). The team experienced it as an extremely productive moment of correspondence between all the disciplines, scales, and bodies involved.

An Immersive Dispositive for an Intra-Active Sounding Process

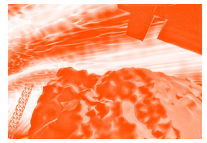
Designer Itaru Yatsuda developed a first prototype with our team over many meetings and as many formulations of our question: what and how should a simulation of the *Virtual Sensing Knife* be like? We decided to first work on rendering just a kind of blob of the virtual material representing the cell, focusing on the interaction of the knife with the surface of that bubble of 3D mesh. Choosing the platform for prototyping was fairly easy as TouchDesigner is the software with which Itaru is most familiar. Itaru is habitually touring with musicians, producing visual effects for their shows—and this program seemed especially well suited to prototype dazzling visuals meant to be reactive to sound.

Early in the process, I was asked to write the story of the *Virtual Sensing Knife* to brief the designers—and to convince them to come onboard. The case study, similar to that of the original *Sensing Knife,* is a neurosurgical one: exploring the contour of a tumor inside the brain with a tiny vibrating blade. The dramaturgy that emerged was rather straightforward: Equipped with a VR headset and handheld controllers, the visitor approaches a blob, and touches it with their »hands,« which are equipped with the *Virtual Sensing Knife*. The visitor would then experience »haptically« the surface of the blob and interact with it. In parallel, we started to work on a »haptic vest« for this installation—Yoonha Kim unfolds this aspect of the project in the following chapter. This set-up would make it possible to encounter the digital material and make it resonate with the *Virtual Sensing Knife,* and more importantly, to sense an invisible boundary inside the material, which can be determined only from the difference in feedback it triggers.

Fig. 8: Interaction designer Itaru Yatsuda and Fardin discussing the texture of the virtual material inside the exhibition space. Drawing by Maxime Le Calvé

The idea was to convey the »intra-action« that should be happening as part of the experience: object and subject resonate together in the encounter, as they make each other—»meeting the universe halfway« (Barad 2007). If the conception of the 3D »digital material« and the interaction concept were taking a visual form, it was the sound and haptic feedback that were the most central concern to the project at all times. How can we translate the AFM's vibration to the user? How can they »sense« the material with their whole being? Early in the process, the sound designer Nico Espinoza came up with a reference for the sound experience (Paul Jebanasam 2015). This immersive and digital graphic workplace noise became central to the experience. »The noise becomes the information,« Nico said. This is how we were making sense of the processing of the AFM signal together. With the AFM, the microcantilever almost comes in contact with the material, sounding it and transducing its texture into a waveform—which can then be transformed into sound. The prototype of the handheld *Sensing Knife*, still at the stage of a confidential prototype, is also producing a certain sound due to the vibrations of the blade. The device records the way this vibration is affected by the material, which gives the user a haptic measurement of the physical properties of the materials. In our case study, the user would have to differentiate the healthy tissue from the tumor. The sound is not only heard but also physically transmitted through actuators that are in contact with the user's skin. Their bodies enter the vibration, resonating with the sounding process—which plays together with the interactive visual to drive the immersive experience further.

After months of playing around with Itaru, we had to hire another creative coder for this project, as Itaru reached the limit of his capacities both in terms of time and of his technical expertise. The project had become very intriguing and we were offered the possibility to work with VanTa, one of the most respected members of the creative coder community, at that time based in Berlin. VanTa, who has since then worked with us on many other fun projects, took over to re-code the entire project over the course of the summer 2021. He elevated our clumsy piece to a level which we would only have dreamt of. We gave him the freedom he needed. We showed him our prototypes and had long conversations with him. He retrieved elements from his own previous works and previous ideas from his digital garage, pointing us to the mathematical equations that he then used to model the interaction of the user's hand with the digital matter. We pondered together about what was and what wasn't possible to do. He understood precisely what we had in mind. He coded a set of shaders in C# from scratch. In the final immersive experience, the sound that the visitor hears, is triggered and modulated by how they interact with the matter, cutting through a wall of reddish cells, softly glowing in the dark. He designed a simple and yet deeply evocative environment: the elevator lands inside of a hollowed human body. The knife appears, small at first, at the dimension of the actual prototype, and it grows—or the user shrinks. The knife follows the hand of the user. ❑ Exhibition, fig. 4, 124



There is always sound in the background, enveloping the user's body, as it is transmitted to their flesh by the haptic wearable. → Stretching Senses, 315 It is the vibration of the oscilloscope of the *Sensing Knife*, ready to feel something at the bottom of the scale. When the tip is brought to touch the material, the tinkling, crisp noise arises, modulated in real time. It reflects, or rather performs, the affect of the material on the vibration of the tip. Through this diffractive perturbation, the user senses the material—maybe they are feeling it, »like the hand of a surgeon,« as they cut through the wall of cells.

The use of VR technology, in particular, strongly shaped our reflection and our practical work. → Stretching Virtuality, 86 In this process, we were joined by many other VR designers grappling with the specific perception conditions and the more general experience that can be created with these devices. On this aspect, a flashback to the early reflections on the technology by philosopher Michael Heim helps to drive the point home:

> The VR artist will need strategies for inducing a more receptive atmosphere, so that the user can be open in all directions, receiving signals from and having empathy for other beings. The user must be able to be touched, emotionally moved, by the non-first person [more-than-

> human] entities in the virtual world. The spear of manipulation must join the cup of sensitivity. If simulators serve to train hand-eye and other coordination skills, VR may take a further step and become a training tool to enhance receptivity. (Heim 1994, 127)

Like the VR artists to whom Heim was refering, we were working on a strategy to induce a more receptive atmosphere. Yet the goal of the manipulation was an operation on the sensitivity of the users, not only during but possibly after the experience, as an sensorial imprint on the user—beyond the discourse around the »empathy machine« often associated with VR installations (see Messeri 2022; 2024). We were developing a way to relate to other non-human entities like the cells of a brain, using VR as a method for elevating our understanding of a vision through a speculative act. Yoonha Kim annotated this passage in a previous version of this text: »I would love to bring this back into a group conversation and feel, discuss the ›mode‹ or ›ways‹ we relate to the brain cell. Are there such things as the scale of empathy with a designed object?« The writing of this text was, at the time, not only a reporting process but an active continuation of the sounding, probing, and spanning, more of the heterogeneous and composite material out of which the work and the knowing process are further proceeding.

Conclusive Remarks

The *Virtual Sensing Knife's* immersive dispositive consisted of several dramaturgical layers, arranged around the visitor's body in lenticular and overlapping ways: the exhibition space of the veterinary theater, the VR setting inside of that space, the VR headset and the haptic wearable, the sound design, and the interaction design. ❑ Exhibition, fig. 25, 143 Exhibition-as-research (Basu & Macdonald 2007; Bjerregaard 2019) is one of the defining topics of the exhibition *Stretching Materialities*: during the six months of the duration of this event (29 June 2021 to 31 January 2022) the curating team has shown their working process rather than present to the public a complete and finished product. Ranging from architecture to art history and history of science, the interdisciplinary team explored the exhibition space, its materialities, and the potential it offers to reach out to other scales: ❑ Process, fig. 18, 278–279

> The built environment of the anatomical theater and its relationship to epistemic virtualities steps into the centre of the stage. A set of experimental sensory situations and of spatial constellations are tested in their significance for the exhibition space: ambiguous voids, lush membranes, multi-scalar bridges. Through a Virtual Elevator at the centre of the anatomical theater, the visitors are invited to travel through scales in space and time, encountering hidden ecologies and unfamiliar zones of metabolic interactions. Stretching the boundaries between the digital and the analog, we open up a way to enhance our receptivity to the more-than-human: exploring the remains, the hybrids, and the borders of the physical and the digital. (Excerpt from a draft of the exhibition announcement)

What is this more-than-human (at least in this context)? Here we are suggesting and staging an encounter with neurons, which happens in parallel in the lab, in the VR environment, and in the design process of what we have termed, in the introduction, a »cultural probe.« This immersive field trip may provide a sense, rather than an adequate description, of the neuron's profoundly alien and »more-than-human« agency.[5]

David Abram (1997) coined the term »more than human« in *The Spell of the Sensuous*. His book was also one of the first philosophical works to connect phenomenology, ecology, and the study of aesthetic, spiritual, and sensorial practices. The notion that the planet was undergoing a catastrophic change, which Morton (2013) later termed a »hyperobject,« was explored through the disruption of the modern (western) relation to nature, naming the many entities with which the spiritual practitioners were maintaining relations with the many creatures and things that weave together the »more-than-human« world. → Stretching Spaces, 184 → Stretching Practices, 25 Going back to the ideas of the young Husserl, Abram tells us how subjectivities are informed about the existence of phenomena outside the range of their own perspective by the intuition that other beings have different experiences of their own. The world is then an »inter-subjective« world, it emerges at the encounter of other points of view—in the work of Abram, it goes beyond the visual to embrace the whole range of the sensorium.

Our VR installation is one of the »levels« that visitors could access from the Virtual Elevator in the theater. → Stretching Virtuality, 91 There used to be an actual elevator in the center of

5 »Each group of neurons, any cut or isolated circuit can be thought of as a subject with relation to the rest,« writes Dumit (2006, see also 2014), hinting at the fact that neuroscience hasn't taken the necessary steps to engage in a true »plasticity« of their modes of reasoning, confronted with the multiplication of subjectivities across scales, species, and forms of life.

the exhibition space. It was originally conceived to lift the bodies of animals into the middle of the amphitheater, one floor up, where they were presented and publicly dissected. In a playful dramaturgical move, we transformed this elevator into a vehicle that transports the spectator to other scales to enable encounters with the more-than-human—not in a positivist Comtian kind of way, working out the perfect and logical hierarchy of beings in the world but rather within a fragmentary and contingent science practice framework. While working on this staging, I was often reminded of a similar device that Roald Dahl, in his opus *Charlie and the Great Glass Elevator*, used to transport Willy Wonka, the narrator and their entire family through a set of ambivalent events and experiences (Dahl & Blake 2016). As Boyer and Morton reflect while analyzing another children's book entitled *Tiny Creatures: The Wonderful World of Microbes* (Davies 2016), playful experiences of this type are imbued with a dangerous power, as well as with the possibility to transform the way we relate to the world:

> There is a kind of scientistic »I'm outside the universe, laughing or terrified« quality to it that is politically very disempowering, while at the same time giving one a feeling of total power. (…) Leaving aside for a moment the design of it and the intentionality of this type of a project—how it explores the dizzying, unsettling dimension of scale is really effective and affective. It speaks to a coming-to-terms-with moment. For the designer/producer/artist of the book, for the child reading this and the parent reading it to the child. It's a very gentle way to try to introduce a new set of aesthetic organs into the hyperobjective, hyposubjective world in which we live. (Morton & Boyer 2021, 36)

Throughout this chapter, I reported ethnographically on our amateurish attempts to toy with virtual reality to translate the multisensorial »spell of the sensuous« that physicists experience through their strange devices. As unusual as this fieldwork can come across to more conventionally minded colleagues, I believe that the design anthropologist among them will understand the value of this endeavor as an exhibition experiment: a »probing« and a »sounding« of the techno-imaginaries embedded in the prototype of a neurosurgical tool sensing tissues at the level of the cell—a coming-to-terms-with a vision of the future, which we were given to accompany and to ponder, as anthropologists and as digital makers.

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Stretching Senses

Stretching Senses through the *Haptic Hanbok*: Mapping the Field(s) of Inquiry

Yoonha Kim

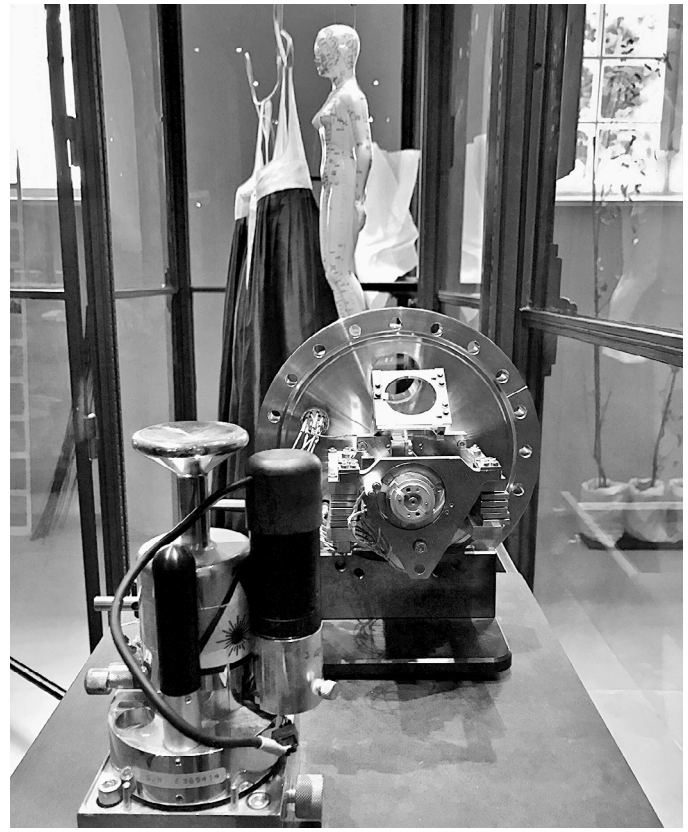
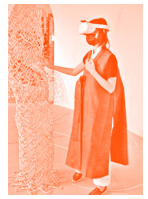


Fig. 1: Display case, *Stretching Materialities*

Exhibition spaces often invite a playful departure from the ordinary, creating a kind of permission slip for visitors to try things they would rarely consider in their daily routines. Imagine stepping into a museum and not just looking at an unfamiliar garment in the display case but slipping it on—perhaps even pairing it with a VR headset! On the opening night of *Stretching Materialities* at TA T, the air was alive, filled with contagious enthusiasm. Visitors hovered around open display cases, drawn to the textures, smells, and possibilities offered by the exhibited objects. One of the displays showcased Korean sartorial heritage, ***hanbok*** (fig. 1). To be more specific, it was a sheer and light ***myeongju*** (silk) ***hanbok chima*** (skirt) in a deep green shade. Gently swinging, the chima was hanging next to a cream-colored acupuncture dummy. Alongside, there were two heavy metal-bodied scanning probe microscopes: a scanning tunneling microscope (STM) and a smaller atomic force microscope (AFM). Two visitors nearby were getting help with mounting light grey colored VR headsets. ❑ Exhibition, fig. 25, 143 A long black cable plugged into the side of the headset connected

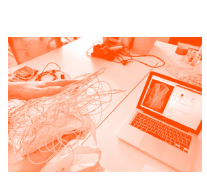


the VR device to a long vest-like garment they were wearing: a *Haptic Hanbok*, and a long purple *durumagi* (overcoat). A few minutes after they stepped into the rotunda in turns, their arms turned into a *Sensing Knife*—at least, that's what it looked like through the VR goggles they were wearing. Parts of their clothing vibrated according to the digital brain tissue they were touching. This seemingly strange assemblage of a ***hanbok***, VR, and the *Sensing Knife* brought into question how different ways of worldings meet. By using the term worlding, I emphasize that the world is not a static, pre-existing backdrop for human beings.

Continuing from the previous chapter by anthropologist Maxime Le Calvé, this chapter illustrates the wearable side of *Virtual Sensing Knife* and *Haptic Hanbok*.[1] While exploring the potential of wearing clothes as sensory device for the public in exhibition spaces, this chapter engages with the following questions: How does exhibition as research that uses clothing challenge knowledge-making practices? How does it stretch senses and inform public understanding and in what ways? Furthermore, what if the *Haptic Hanbok* is more than just a conveyor of vibrations generated by motors in a mixed-reality environment and becomes the stage for its wearer to perceive the world in a different way? As philosopher Yuk Hui (2018) suggests, different cosmologies enable and constrain technological development in unique ways. Cosmotechnics refers to the idea that technology is not universal but shaped by the specific cosmological frameworks that give rise to it—each culture's worldview informs how technology is imagined and implemented. In this light, the *Haptic Hanbok* became a testing ground for such cosmotechnics, where the integration of concepts like *gi* (기 氣, vital energy) with haptic technology offered a space to explore how different cosmological perspectives could interact with, and even reshape, our understanding of technology. The *hanbok* itself, while rooted in a specific cultural heritage, also became a conduit for VR haptic experimentation, illustrating how technology and cosmology are in continuous dialogue. Placed in between and connecting different realms, the *Haptic Hanbok* suggests the wearer to view the body and the world not just as a visible, fixed entity but as a relational flow. The wearer could consequently become more sensitive to how one's energy flows with(in) the surrounding environment. ❑ Process, fig. 18, 278

As Marilyn Strathern (1992, 10) suggests, »It matters what ideas we use to think other ideas.« Rather than solely drawing inspiration from the modern dominant medicine practices or popular sources of first-person shooter games or Hollywood movies, the project listened to what *hanbok* and *gi*-based worlding could bring into the picture.

While collaboratively developing the *Haptic Hanbok*, we explored how different technological practices reflect divergent worldviews. The exhibition's display case displayed two key objects: a microscope and an acupuncture dummy, each representing contrasting approaches to the human body. The microscope exemplifies a worldview that seeks to understand the body through its visible, structural components. Since the 17th century, pioneers like Antonie van Leeuwenhoek and Robert Hooke used microscopes to identify cells and tissues, solidifying the notion that the human body can be analyzed as an assembly of discrete parts observable under magnification. In contrast, the acupuncture dummy illustrates a holistic understanding of the body, one that emphasizes the flow of *gi*—vital energy—through invisible channels, maintaining balance and health. While these two frameworks may seem at odds, the exhibition became a space where such disparate worldviews could interact. By integrating concepts like *gi* with modern haptic technology, the *Haptic Hanbok* brought together acupuncturists, garment makers, anthropologists, physicists, and creative coders. This collaboration demonstrated how different ways of knowing the body could converge, creating new, interdisciplinary forms of embodied knowledge. ❑ Process, fig. 3, 266–267



Haptic garments highlight the »experiential dimension« of clothing (Entwistle 2000; Davidson 2019). Encouraging visitors to »wear« the exhibit, our collaborative project aimed to explore how one's perceptions and movements change when donning a *hanbok* in an exhibition space, rather than considering the garment a static object hung behind a glass display. For Choe Han-gi, a 19th century scholar, who wore *hanbok*, wearing clothes was an engaged interaction with the vital force of energy, known as *gi*. He suggested that through clothing, humans can actively direct their experience in a way that overcomes the bias of *gi* (being too cold, too hot) and that nourishes this energy force. The world is not a given but constantly shaped through actions like moving, sitting, walking, touching, interacting, and breathing (Varela 1999, 8). If so, wearing clothing, which is part of, and also an element that affects these activities through facilitating movements, plays a significant role in the process of worldmaking. → Stretching Practices, 35

1 *The Sensing Knife* is a project of Jürgen Rabe and Fardin Gholami. They aim to turn the sensitive probe of an atomic force microscope (AFM) into a neurosurgical tool which would »sense the brain material as it also can cut through it.« *Virtual Sensing Knife* brings this idea into the virtual realm. Wearing a VR headset and *Haptic Hanbok*, the visitor may sense an invisible boundary inside the material through the different vibrations conveyed by the *Haptic Hanbok*.

STRETCHING SENSES AS A CONCEPT

Stretching senses is experiencing the world in ways previously unimagined or unfelt. Much like how stretching the body activates muscles we rarely use, leaving us feeling refreshed or even surprised, stretching the senses awakens dormant or habituated sensory capacities. In the exhibition context, where participants engage with the *Haptic Hanbok* and VR experience, this sensory stretching not only brings new awareness to bodily perception but also acts as a kind of warm-up—like dipping your toes into water before fully diving in—transforming the very act of worlding. It provides a gentle, approachable gateway to exploring how we engage, sense, and make sense of the world. The unfamiliar sensations created by the *hanbok's* tactile feedback and the immersive virtual environment challenge participants' embodied experience, reshaping their sense of being in and with the world. In this way, stretching the senses is not just a refreshing of perception; it may also be a reorientation that alters how one participates in the ongoing process of world-making.

Not only the *Haptic Hanbok* but the whole exhibition invites the audience to stretch the way they see, smell, walk, feel, and listen to things, ultimately aiming to challenge the way they engage with the world. Stretching senses is a recognition of how sensory experiences are culturally and materially mediated. Sensing is not a passive, brain-bound process. ❑ Exhibition, fig. 15, 137 In the context of this exhibition, where participants wear the *Haptic Hanbok* and navigate a virtual reality environment, sensing becomes an act of doing—an ongoing interplay between body, materiality, and technology. This resonates with Erin Manning's (2013) exploration of movement as a relational process, where the body's sensory capacities are continually stretched through its interactions with other bodies and materials. The *hanbok*, as a tactile, wearable extension of the body, becomes part of this relational meshwork, helping participants to sense not only with their bodies but through the materiality of the garment, reshaping how they perceive and engage with the world. For Manning (2013), the body is always in a state of becoming through its relations with other bodies, materials, and environments. *Hanbok* in this exhibition is a material partner in the act of sensing—a garment that participates in the movement of the body, attuning it to a different flow of sensory perception. Putting on a *hanbok* with a stiff collar and flowing panels helps navigating the VR environment in a way that further stretches

the body's sensory capacities. Rather than fixed perceptions, participants experience a continuous unfolding of tactile and visual sensations, expanding their sensory horizons.

Bringing in Constance Classen (2012) and David Howes (2003), scholars of sensory studies, allows to deepen this theoretical framework by considering how senses are culturally constructed and multiple. For Classen and Howes, the senses are cultural practices shaped by history, technology, and material culture. In this exhibition, the act of stretching senses involves a multisensory reorientation—a way of engaging with the world where different sensory modalities, such as touch, vision, and proprioception, are brought into new configurations. *Hanbok*, with its association to sensing the world as a coagulation and dispersion of vital energy, plays a crucial role in this sensory reorientation, linking the body's present experience in a virtual realm with a *gi*-based understanding of worlding. ❑ Exhibition, fig. 19, 139

Clothing as an Active Mediator of Sensory Experience and Worlding

Clothing actively mediates our engagement with the world by involving multiple sensory modalities. When we wear clothes, we experience a range of sensations—texture, weight, temperature, tightness, and flexibility—that shape how we move, interact, and perceive our surroundings. ❑ Process, fig. 2, 266 For instance, Constance Classen highlights the role of touch in shaping how we perceive the world, noting that the »feel« of fabrics or materials informs our sense of comfort, identity, and how we relate to others (2012, 5). A tight military vest feels different on the skin than a loose silk vest, and these tactile experiences become part of how we sense and engage with our environment. In this sense, the materiality of clothing plays a crucial role in shaping how we move through and orient ourselves in the world. Furthermore, the act of wearing clothes creates a feedback loop between the body and the world. As we move, the clothes shift, tighten, and loosen, affecting how we perceive our own body and how it occupies space. Our clothing often anticipates or accommodates movement, guiding our bodily experience even before actions fully unfold. The fabric's weight or fit, for instance, adjusts how we might turn or bend, subtly directing our embodied experience and affecting how we engage with objects and environments.

2 Parts of this chapter have been published in the PhD thesis of the author.

Clothing does not only shape our experience; it is also shaped by the world. *Hanbok*, for instance, reflects the socio-political, technical, and cosmological dimensions of the era in which it is crafted and worn. In a different environment–like a VR setting–*hanbok* is subject to new forms of sensory engagement, reshaping its significance in relation to haptic technology. Clothes, as worn objects, are central to this embodied perception–they both mediate how we perceive the world and become part of how the world perceives us. This dual role of clothing as shaper and being shaped in the process of worlding suggests that the act of wearing is not static; it is an ongoing, evolving relationship between body, material, and environment. By considering these entanglements, we can begin to see clothing as not just a passive element but an active force in the creation and re-creation of the worlds we inhabit. → Stretching Practices, 25

Before unravelling the making and wearing experiences of the *Haptic Hanbok* and *Virtual Sensing Knife*, let us travel 8,000 km from Berlin to Seoul to delve into how *hanbok* serves as a sensory framework. This ethnographic vignette is a fragment from long-term fieldwork (2021–2023).[2] While different experts have their own opinions on the worldings of *hanbok*, my understandings of *hanbok* are based on spending time with Lee Ki-Yeon. She is an activist who led a movement in the 1980s reviving Korean sartorial heritage, connecting the flow of vital energy and the structure of clothing.

KOREAN SARTORIAL HERITAGE AS SENSORY FRAMEWORK

You Cannot Make Clothes Without Understanding the Body

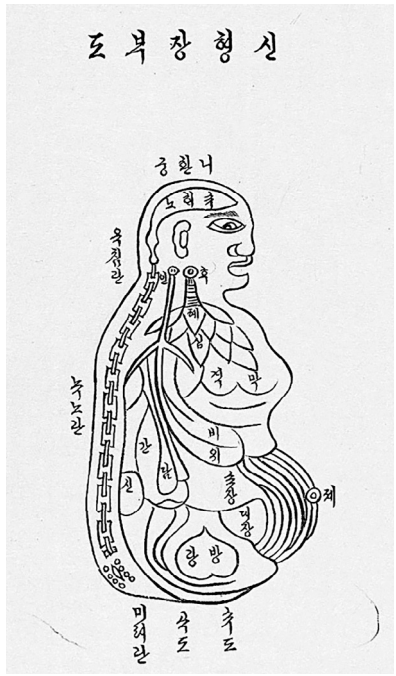
Entering Ki-Yeon's atelier, I noticed a big meridian poster hanging on the wall (fig. 2). The poster depicted a female body from the front, side, and back with an overlayed description of the energy pathways. In the office room next door, where I usually worked on archiving, there was a diagram of the phases of gi–음양오행 *eum-yang-oh-haeng* (Yin, Yang, and the Five Phases theory, also known by the Chinese term, *YinYang Wuxing*) printed on an A4 sheet of paper and pinned to the wall. The sheet further described the relations between the five phases and five organs of the body. I read these wall decorations as an apparent sign that the theory of *gi* is significant in Ki-Yeon's clothes-making process.

3 The nine-head model is a figure whose length is nine times its own head length. This stylized approach tends to elongate the legs compared to the range of proportions found in most human bodies.

Fig. 2: 360° camera view of Ki-Yeon's atelier with a meridian poster

Ki-Yeon talked about acupressure points frequently during our conversations, saying »You cannot make clothes without understanding the body.« The statement sounds reasonable, knowing that clothes are mostly made for human bodies to wear. What she meant by »understanding the body,« however, was not just about knowing the positions of bones and muscles but the flow of vital energy–*gi*. During my earlier education in fashion, where I followed global fashion design principles, I learned about the human body through sketching nudes. I then had to stylize these sketches into nine-head croquis, which are popular in fashion for their exaggerated proportions.[3] However, this design approach did not account for the body's movement and internal energy dynamics. The concept of a body animated by *gi* is vividly illustrated in the 동의보감 *Donguibogam* (*Principles and Practice of Eastern Medicine*), authored in the 17th century by Heo Jun (fig. 3). Its illustrations, with an open mouth and vibrantly moving belly, capture the liveliness of the body, circulating *gi*. This portrayal diverges significantly from the elongated figures of fashion illustrations and the Renaissance anatomical representations, such as the ones by Andreas Vesalius from the 16th century (fig. 4), which emphasize the body's external, visible parts–elements that persist beyond life (Kim Taewoo 2021, 25; Kuriyama 2011, 9). Rather than relying on philosophers' definition of *gi*, Ki-Yeon preferred to understand and use the term through its colloquial usage and practical, bodily understanding of it. According to Korean philosophy scholar So Jeong Park (2019), the term *gi*, in Korean, denotes a fundamental life force which is interwoven in the daily life of Koreans through Korean language. Colloquial phrases such as »기가 살다 *gi-ga*

salda« (gi springs up, to get a second wind), »기를 쓰다 *gi-reul sseuda*« (using gi, giving it one's all), »기가 막히다 *gi-ga makhida*« (gi is blocked, expressing astonishment or disbelief), »기를 돋우다 *gireul doduda*« (to encourage one's gi, to cheer up) reflects how in Korea, »gi is deemed to be stimulated, roused, revived and encouraged« (Park 2019, 157). Through these common Korean expressions, Ki-Yeon's words such as »옷으로 기를 살리다 *ot-euro gi-reul salida*« (spring gi up through clothing) felt comprehensible to me. Her words would mean the wearer's life force is enlivened through the structure of the clothing. For example, Ki-Yeon told me that sharing of a garment is considered as an act of passing energy. When a child is born, the baby's first clothing, (배냇저고리) is made of used clothes from an elderly in the same village. It is because the good energy in the elderly's clothes will be transmitted to the baby's clothes and the newborn will live a long life. Ki-Yeon who practices acupuncture herself translates the flow of energy through clothing. The clothes should make paths for the air and the energy to flow. The loose structure of *hanbok* is only tightened in acupuncture spots that promotes the energy flow. For example, the spot where one ties one's pants is called 복류 *bokryu* (to restore the flow). It is a point that strengthens the kidney, and the point of the socks' pressures 용천혈 *yongchunhyul* (gushing spring) works like a battery charger, recharging one's energy.



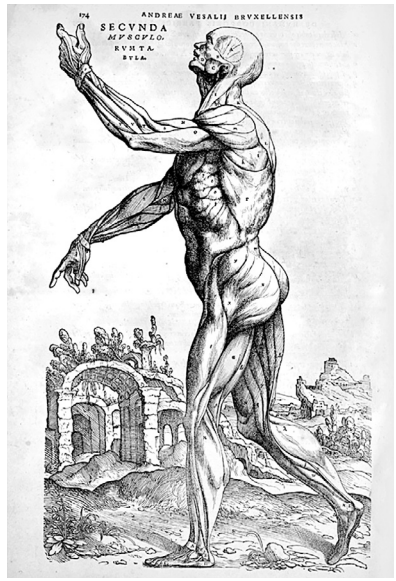


Fig. 3: Shinhyungjangbudo (chart of the overall body, viscera, and bowels) in the opening of the NaeGyeong chapter in Heo Jun's *Donguibogam* (Principles and Practices of Eastern Medicine) from 1613

Fig. 4: An illustration plate from Andreas Vesalius's *De Humanis Corporis Frabrica* (On the fabric of the human body) from 1543

How Is the Flow of *Gi* Supposed to Feel?

In August 2021, I was back at Ki-Yeon's atelier, sitting across the table from her. She stretched her arms towards me to show her hands with traces of acupuncture and moxibustion (therapy which involves burning dried mugwort on particular points on the body). I asked Ki-Yeon if there is a »magic spot« that invigorates energy in all kinds of bodies when pressed. In Berlin, I had been collaboratively working on a garment with vibrating motor insertions and thought if the motors were placed in this magic spot, it could have the stimulating effect of acupressure. ❑ Process, fig. 22, 283 She instantly replied, »The human body constantly changes, so fixing the motors in one spot won't work.« As cells are constantly reproduced, acupuncture points are also slightly different today from tomorrow. »Using acupressure magnets will be better, because you can attach them to the wearer directly,« she suggested. We climbed the staircase to the third floor, dedicated to acupuncture practice. The room was around the size of her atelier. A male acupuncture dummy, shining in the color of copper, was standing tall in the corner next to a coffee machine. There were also several books on acupuncture in Korean, Japanese, and Chinese, further nachos, a kettle, an electric fan, a small bed, three plastic chairs, and a long table.

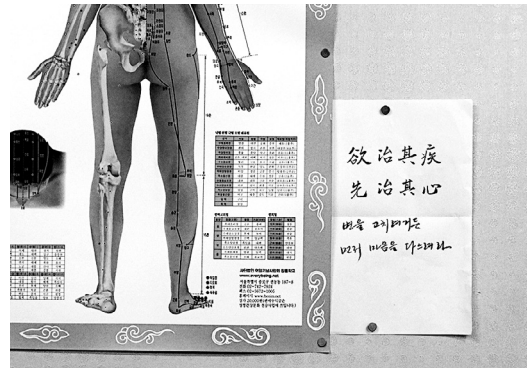


Fig. 5: Poster and handwritten sign in the acupuncture room

There was an acupuncture poster hanging on the wall, similar to the one in Ki-Yeon's office, with a handwritten sign in both Chinese and Korean (fig. 5). It read: »병을 고치려거든 먼저 마음을 다스려라« which translates as »If you wish to heal the illness, first balance the mind.«[4] The sign highlighted the principle of East Asian medicine's holistic approach to health, which considers the emotional, spiritual, and physical symptoms together. Rummaging through a cabinet in the corner, Ki-Yeon found

4 The Korean term 다스려라 (daseuryeora) can carry meanings such as »to govern« or »to discipline,« but in this context it implies bringing one's mind into a state of balance or harmony.

small magnets. Her firm hands gently touched my elbow and went further to reach my inner arm. Ki-Yeon struggled for a moment to pull the magnets apart. Then she attached one with a medical paper tape in between my elbow and the inner crease where the arm folds. »The magnets will attract energy to gather on that point, which is related to the large intestine,« she explained. The magnet felt cold on my skin. I felt somewhat nervous, perhaps because I did not know how I was supposed to feel. Listening to Ki-Yeon's stories, I also wanted to be an advocate of acupressure. However, enthusiastically nodding to her explanation on acupuncture is one thing; bodily understanding is quite another. Do I have the sensibility to feel the flow of *gi*? My grandmother told me that my great-great grandfather was an acupuncturist. Should I have that sensibility as a family trait? Maybe scrolling the glossy surface of my smartphone had numbed my sensory organs and overwritten how I was supposed to feel when receiving acupressure. If senses and perception are related to immersing oneself into a particular sensory framework or cosmology, the disconnection from the sensory model of my grandparent's generation seems to have led to my sensory impoverishment. Unsure of how to feel, I honestly responded to Ki-Yeon that I did not feel anything. Unaware of my internal monologues, she said maybe it is because I did not have any problems with my intestines.

When I asked Ki-Yeon how she understands *gi*, she replied, »It is difficult to put into words… Try shaking your wrist.« Following her rhythm, I shook my wrist. »Can you feel something 몽글몽글 *mongle mongle*?« she asked. Indeed, after repeating it for a while, I felt as though I could touch an invisible force that was rounded, soft, and fluffy—or *mongle mongle* in Korean, an onomatopoeic expression. What I felt might not have been exactly related to *gi*, yet the bodily experience gave me an idea of how this invisible energy could be understood in a sensorial realm. Similarly, Kim Taewoo (2021, 52), an anthropologist of East Asian medicine, demonstrates the varying manifestations of *gi* not through verbal description but through the physical act of punching the air. He exemplifies this by alternating between a languid, drooping fist moving slowly from left to right and a rapid, forceful thrust of the fist upwards. *Gi*, while elusive and intangible, can thus be interpreted and perceived through embodied experiences. Understanding the concept of *gi* also involves honing one's sensory awareness to understand the body in a different manner.[5]

5 David Howes (2022) also underscores the importance of exploring the »sensory world« as culturally mediated, thereby challenging the Euro-Western focus on ocularcentrism.

For most Koreans, acupuncture is not a foreign subject; self-administrated treatment of acupressure, acupuncture, and herbal medicine is popular among the general population (Baek et al. 2013). Even when I was in middle school, fourteen-year-olds knew that pressing in between the base of the thumb and index finger would help when food is sitting heavy on the stomach.[6] Coming home from school, I used to see my grandmother practicing acupuncture and moxibustion, or ***chim-tteum***, as Koreans call the two practices together.[7] Despite my limited exposure to Korean medicine, which consisted of knowing only two acupressure points for digestion and receiving acupuncture for a foot injury once, I understood the flow of *gi* not as basic units of reality but as something that only became effective when discussing unexplainable muscle pain or colloquial situations involving *gi*.

As Ki-Yeon's explanation of *gi* and ***hanbok*** entailed vocabularies of Korean medicine, such as the names of acupoints, it seemed to be a suitable way to understand her view of *gi*. When I expressed my interest in learning the basic principles of acupuncture, Ki-Yeon pointed me in the direction of her acquaintance, Son Joongyang, who teaches the fundamentals of Korean medicine to those without a medical background. Although my time in the field was limited, and I could only attend the introductory classes, I found myself constantly reflecting on how this new way of engaging with the world might influence the *Virtual Sensing Knife* and *Haptic Hanbok* project. The transformative potential of these insights lingered as I navigated both the academic and sensory dimensions of the research.

TRANSLATING *GI* AND FLOW

Back in Berlin, I faced the challenge of conveying what I had learned in Korea to my colleagues working on the project. *Gi* is an expansive concept—one that countless philosophers have spent lifetimes studying. How could I possibly encapsulate this deeply philosophical idea? I soon realized that striving for a precise definition of *gi* was not necessary for the goals of our project. Instead, our focus was on stretching the senses—provoking participants to experience new ways of relating to entities. By interacting with a virtual environment while wearing a vibrating ***hanbok***, we aimed to offer a tangible sense of a flow

6 This acupoint is called 합곡 hapgok (合谷 HéGǔ in Chinese) which translates as »union valley.«

7 Chim, which directly translates as »needles,« refers to acupuncture. Tteum refers to the curing practice of burning mugwort on particular parts of the body.

of energy that differs from, say, the experience of wearing a heavy rigid haptic vest resembling body armor. Throughout the collaborative exhibition making process, I encountered various interpretations of *gi* among my colleagues, each shaped by their repertoire of experiences. Here, I will explore how the practice of translation—across international and disciplinary lines—both illuminates and obscures meaning, showing how material works like a boundary object during the process. → Stretching Practices, 25

In *Matters of Activity* (MoA), where researchers from diverse backgrounds shared the studio space, exchanging ideas often emerged contingently. In the MoA cluster, some researchers worked by writing, while others engaged their bodies with materials like rattan, interacting with the entire space. Architect Natalija Miodragović was one of them. Under the title *Structural Textile*, Natalija with design researcher Nelli Singer and architect Daniel Suárez explored the activity of rattan and willow branches—the cellulose microfibrils in cell walls of the wood that swell with humidity. Long, outstretched rattan branches would sometimes reach over to the next table, greeting the cut pieces of fabric to be made into *hanbok*. Stemming from Nelli Singer's *Living Beings*, the *Structural Textile* project welcomed willows' and rattan's bendable and formable material characteristics and made knitted structures using such material activity.
→ Stretching Spaces, 170

Fig. 6: Natalija looking at *Deung Deung Geo Ri* on the screen

While observing the woven willows piled up on the table next to where I sat, I realized how they mirrored the form of 등등거리 *Deung Deung Geo Ri,* a type of vest-like *hanbok* made from rattan. This garment, worn under the outer *hanbok* layer during hot summers, creates a gap between fabric and skin, allowing airflow to regulate body temperature. When Natalija saw a picture of it, she exclaimed, »This is a personal cooling device! It is a climate device!« Her architectural perspective offered another way of translating *Deung Deung Geo Ri* as a facilitator for airflow, much like how architecture manages climate in buildings (fig. 6). Preparing for the exhibition together, working on different projects in the same space facilitated cross-cultural and cross-disciplinary exchanges, allowing different frameworks to coexist and interact.

Deung Deung Geo Ri exemplifies how the flow of *gi* parallels the movement of air, acting as a material embodiment of balance. It recalls an insight shared by Ki-Yeon during my fieldwork: »In the past, we believed that if your clothes were too tight, there wouldn't be space for luck to enter.« This wisdom points to an understanding of allowing *gi* to circulate freely, supporting health and harmony. In East Asian cosmology, the *gi* of the greater cosmos, known as *yuk-gi* (six *gi*), arises from the interplay of the five phases. It conjures memories of Son Joong-yang's teachings, where six energies—wind, cold, heat, humidity, dryness, and fire—correspond with conditions like temperature, humidity, and atmospheric pressure. → Stretching Practices, 46 These forces must be in balance; warmth is necessary in the cold, but too much heat becomes harmful energy. Similarly, by creating a buffer between the body and the outer layer, the *Deung Deung Geo Ri* embodies the principle of regulating *gi*, harmonizing disparate energies. This perspective views the world not as a collection of isolated entities but as a connected flow. The way we experience these connections matter—especially in times of ecological crisis—as they determine our sensitivity to the meshwork of life. Cultivating this ecological sensitivity means attuning ourselves to the rhythmic exchanges of energy within our surroundings. In contrast to extractivist approaches, *gi*-based worldings call for reciprocity and balance, recognizing that thriving depends on maintaining these flows. Clothing, seen through this lens, becomes not just something we wear but something that allows us to feel the interconnectivity of *gi*-based worlding, offering a sensory rather than purely intellectual understanding of our place within the flow of life.

Deung Deung Geo Ri, when worn by Natalija, functioned as an in-between object, offering a sensory connection to the concept of *gi*. ❑ Process, fig. 2, 266 Natalija's experience with the vest, first as an object to be observed and later as one to be worn, opened up another way of understanding the flow of *gi*. By understanding *Deung Deung Geo Ri* as an architectural element,

Natalija framed it within her own repertoire: as a device that regulates airflow and acts as an »extended protective membrane of the human body.« This interpretation mirrors the metaphysical circulation of *gi*, where air and energy both need to flow freely around the body to maintain balance. For her, the concept of *gi* became more comprehensible when viewed through this architectural lens, which meant that the concept *gi* can be translated into material practices.

Later, I brought an actual rattan *Deung Deung Geo Ri* from Korea, and hung it within the *Stretching Materialities* exhibition, attached to the ceiling with an elastic nylon strap. Visitors could pull it down, adjusting it to their height, and experience it for themselves. By trying on *Deung Deung Geo Ri* alongside other *hanbok* pieces such as *durumagi* or *qweja*, visitors physically engaged with a tangible metaphor for the flow of *gi*, experiencing firsthand how these objects create space between the body and its environment, allowing airflow and energy to circulate freely. *Deung Deung Geo Ri* became an accessible material as a wearable exhibit that makes one physically sense how concepts like *gi* might integrate with contemporary approaches to climate regulation and design.[8] Natalija's interpretation of clothing as a climate device also influenced the design of the *Haptic Hanbok*—decisions around fabric and structure aimed to evoke similar principles of temperature regulation, energy flow, and balance.
→ Stretching Space, 171

Still, trying to convey my understanding of *gi* to my colleagues in Germany felt like a clumsy translation of the Korean words of my interlocutors and their actions. I recall the moment I had a conversation with Fardin. Introduced earlier as a macromolecular physicist, → Stretching Senses, 305 Fardin is a research associate at Humboldt University who studied polymer engineering in Iran and India. In his doctoral studies, Fardin deals with carbon based 2D membranes using scanning probe microscopy. I was on the phone with him trying to verbally convey what Ki-Yeon told me or what I experienced in my field site regarding how a *hanbok* connects the body with the universe, and how it holds and transmits *gi*, which I translated into English as »energy.« The conversation was not easy, nor was finding the right words to convey the loaded terms used in my field site. After listening to my sweaty attempts of mumbling, repeating, and lots of silence in between, Fardin said, »Talking about energy, I get it. Excess energy to no energy, transmission from one state to another, energy flows.« Somehow the space between two evolving entities was

8 However, despite the richness of these insights, the project raises critical questions about their capacity to challenge entrenched global systems. Can shifting perspectives on *gi* and ecological sensitivity truly disrupt the deep-rooted forces of industrial capitalism? Without structural changes in politics, economics, and social behavior, even the most heightened awareness of energy flow might struggle to alter the trajectory of environmental destruction. The *gi* framework enriches our understanding and engagement with the world, yet it must be paired with systemic efforts to transform the structures that drive environmental exploitation.

intra-acting through *gi* theory and the logic of physics in terms of »energy,« where one was more elevated than the other. Intercultural assemblage contains underlying power structures, where certain terms such as »energy« were intentionally adopted in the Korean language to explain European-Western institutional structures and concepts but not the other way around. Alongside I questioned if I was trying to validate Korean cosmology by relying on physicists' acknowledgement. However, I realized that the point was not validation but to be in conversation. The worldings of my interlocutors did not require external authorities to examine whether they were reasonable and worthy. And yet it was the power imbalance that led me to think ever so slightly about such questions. The worldings of my interlocutors make connections across different scales. Here things exist in correlation, whether collaborative or antagonistic. To demonstrate such relationality in an accessible way to natural scientists was in itself an achievement. Borrowing words from Josh Evans (2023), who works with fermentation practitioners and microbiologists, »the concept of holobiome is not new, yet the idea of getting accepted in technoscience opens a different way of relating scientism to the world.« Social science and humanities talk about relationality frequently, yet it doesn't travel far enough to natural science disciplines. To change how science works and impacts the technosphere, such interdisciplinary conversations are crucial.

EMBODIED DIGITAL TECHNOLOGIES: CRAFTING THE *HAPTIC HANBOK*

This section explores the creation of the *Haptic Hanbok*, emphasizing how the process reflects not distinct worldviews but rather overlapping and evolving possibilities. ❑ Process, fig. 22, 283 The making of the *Haptic Hanbok* required careful deliberation over two primary components: the long, vest-like garment and the integration of vibrational motors. Decisions were made regarding the shape and materials of the *hanbok*, alongside the precise size, placement, and intensity of the vibrational feedback. This crafting process was not just technical; it was a performative act that simultaneously shaped and was shaped by differing perceptions of embodiment, materiality, and technological interaction.

Preparing a garment for visitors of a public exhibition requires a certain form of generosity. To ensure the clothing fits different body forms in various sizes, the *hanbok's* spacious and open structured design was favored over tight-fitted clothing. Still, this was a contradictory choice when making a haptic garment. Most haptic suits aim to adhere closer to the body to maximize the impact of vibrations. *Qweja*, a long, vest-like *hanbok*, was chosen for the *Haptic Hanbok* due to its versatile and open design, allowing for a comfortable fit across diverse body shapes. Its sleeveless form, fastened by a single front ribbon, accommodates varying arm lengths and physiques, making it inclusive while enhancing interaction between the wearer and the integrated haptic technology.

In terms of clothes making techniques, *hanbok* is a flat garment that only comes to life when draped onto the body, creating its distinctive shape. Because of this, we needed someone with a strong understanding of flat pattern construction. Daniel Otto, highly skilled at interpreting flat patterns, joined our team to work on the *Haptic Hanbok* in Germany. Despite his lack of prior experience with *hanbok*, his keen eye for pattern making allowed him to grasp hanbok's flat structure intuitively.

The fabric for the *qweja* and *durumagi* was carefully chosen from Hamchang Myeongju, a silk weaving site in the Southern part of Korea, where I conducted fieldwork. Weaver Hu Ho takes part in rituals honoring the silkworm's spirit and develops mechanical looms that allow to continue Hamchang's wet weaving heritage. Daniel remarked, »This *myeongju* (silk) has a fascinating weight—it feels heavy and light at the same time, with a certain density to it.« Daniel's observation reminded me how aesthetics and sensory qualities can communicate more than just function, even evoking emotional or intuitive responses.

When selecting the fabric for the inner garment to be crafted in Germany, we sought something soft against the skin yet durable enough to withstand the demands of a participatory exhibition. We had to ensure that we could re-stitch, tailor, and adapt the garment as the design evolved throughout the research process. It also had to be breathable and regulate temperature well.

The *qweja* and *durumagi* were crafted by artisans at Saemi Hanbok in Korea, based on the recommendation of the master weaver Hu Ho. To provide flexibility for a variety of museum visitors, we offered three sizes—large, medium, and small—so participants could choose the one that fit them best. The emphasis was on ensuring that the garment didn't restrict movement, aligning with the idea that energy (*gi*) needs space

to flow. Although the two layers were constructed separately, we kept in mind that *hanbok* is itself a form of technology—one that influences how we engage with the world. In this sense, the *Haptic Hanbok* was a dialogue between two different technologies: the open structuring, *gi*-based worlding embodied in *hanbok's* material and form, and the vibrational motors programmed to vibrate according to the sound generated through the VR experience. Together, they shaped a new way of engaging both with the physical world and virtual experiences.

The current landscape of haptic wearable technology encompasses various strategies for delivering sensory stimuli. These systems are designed to engage the sense of touch in more immersive ways, employing a variety of techniques such as vibrations (e.g., vibrational motors embedded in gloves or clothing), force feedback (mechanical resistance or pressure applied to the skin), pin-array stimulation (arrays of pins or tacks that create pressure points on the skin), and electrocutaneous feedback (using small electrical currents to stimulate nerves). Each of these methods targets specific tactile receptors, and the technology is deployed on different body locations depending on the application context. The choice of body location for applying these stimuli varies, depending on the desired effect and application. For example, the arm is a common site for general-purpose wearables that need to deliver broad or low-fidelity feedback (Yao & Schaal 2015), while the finger is often targeted in designs that require high sensitivity and fine motor feedback (Pacchierotti et al. 2017).

The technical integration with VR was handled by Fardin. He guided the rest of the team to build a device that drives vibration motors using Arduino, a small programmable microcontroller often used for interactive projects and prototyping. Together with the *Virtual Sensing Knife* and *Haptic Hanbok* team, introduced in Le Calvé's chapter and part of this duograph, we explored different types and intensities of vibrational motors (fig. 7). → Stretching Senses, 305 We first tried different commercial haptic wearables such as a Woojer vest for gaming and a low frequency massager attached to one's neck. We then experimented using a small breadboard (a construction base used for prototyping electronic circuits) leading to an Arduino board, audio analyzer, 21 vibration motors, bass shaker, amplifier for bass shaker, jack connector that connects the audio input from VR, micro-USB connector, and a USB power bank. The weight of

Fig. 7: The *Haptic Hanbok* making table

the motors mattered as they directly influenced the strength of vibrations. Heavier shakers were placed inside a pocket with straps, positioned around the lower chest area. This placement was an experiment to test vibrations that travel around the whole body, less focusing on direct contact with a precise location. If our aim was to amplify the vibrations we should have gone for the comparatively big and heavy bass shaker. Instead, we decided to opt for the smallest and lightest motors we could find, which are similar to the ones inside smartphones. Rather than shaking the body, we thought a gentle vibration would better suit our attempt to cultivate sensitivity and differentiate our approach from commercial haptic vests for video games.

The integration of VR technology into the *hanbok* introduced a novel embodied experience, reshaping both the sensory dynamics of the virtual system and the garment's structure. Through experimentation, we discovered that the placement of bass shakers and vibrational motors on specific parts of the body was crucial for enhancing the tactile experience. → Stretching Virtuality, 92 However, acknowledging that everyone's body is unique, we needed a design that allowed the motors to be adjustable and easily accessible. Sealing the motors between layers of fabric proved impractical, as it would hinder flexibility and accessibility. Instead, we opted for an open design, enabling the motors to be repositioned or adjusted according to the wearer's needs.

Drawing on research about the impact of vibrations on various body regions (Zeagler 2017) and considering which areas of the loose *hanbok* fabric maintain constant contact with the body, we selected key points for motor placement: the neck, shoulders, and upper center back. Daniel led the pattern-making process, designing the *hanbok* so that the motors could be easily attached and removed during the exhibition.

Various experiments were conducted to determine the best pocket design for holding the motors. These pockets were not just functional; their materials and structure affected how the vibrations were felt. Some prototypes included filling the pocket with rice to dampen the vibration, others were inspired by the traditional *bokjumeoni* drawstring pouch from Korea. The final design opted for a slit pocket for easy insertion and removal of the battery and boards, while the motors were secured with modular square patches that could be hand-stitched onto the garment. Additional pockets were created under the fabric to guide the wires, keeping them organized.

When everything finally came together—the sound, visuals, and vibrating motors integrated into the completed *Haptic Hanbok*—what had once been a series of experiments became a cohesive sensory experience. Over time, we became accustomed to this combination of stimuli, the way the *hanbok's* movement and vibrations complemented the immersive environment. Yet, I often found myself questioning whether the vibrational motors were truly necessary or convincing enough. Were they adding something essential or simply a novelty? I also nurtured a deeper question throughout the project: Can wearing something truly stretch the senses so profoundly that it transports the wearer into an entirely different way of engaging with the world? → Stretching Practices, 31 This unresolved question would only be answered through the experiences of the exhibition's visitors. ❑ Process, fig. 24, 286

VISITORS AS CO-PERFORMERS: SENSORY RECEPTION AND ITERATION

After the lively buzz of the opening night, the exhibition settled into a rhythm of quieter days mixed with moments bustling with groups of visitors. These shifts allowed for more intimate encounters, where the exhibition mediators and I had the chance to introduce people to the *Haptic Hanbok*. Even before putting on the VR goggles, people start the sensory experience of *Virtual Sensing Knife* and *Haptic Hanbok* while wearing the clothing. Before it becomes a haptic device that connects the virtual world with the physical body, the *Haptic Hanbok* is something people wear, and in doing so they also become part of creating the scenery of the exhibition for other visitors. The *enclothed cognition* framework of social psychologists Hajo Adam and Adam D. Galinsky (2012) has been helpful in understanding the impact of wearing *hanbok* on the wearer's behavior and perception. They posit that clothing affects the wearer's behavior only when physically worn (not just imagining wearing it), and when the symbolic meaning is clear. The embodied research presented here suggests an alternative understanding where the world is a coagulation and dispersion of *gi*, with *hanbok* facilitating this vital energy flow.

The symbolic meaning of *hanbok* was conveyed through the words of mediators while helping the visitors to get dressed. The exhibition mediators were mindful of the meanings ascribed by various *hanbok* wearers and makers I have encountered during fieldwork. They played a key role in explaining the context of *hanbok* creation and assisting visitors in dressing, transforming their experience from mere observation to direct engagement. For the mediators to be more confident in guiding the audience, we prepared a document with some basic explanations of the *hanbok*, and a step-by-step video guide that showed how to wear the *Haptic Hanbok* and plug it to the VR device.

Fig. 8: 360° camera view of exhibition audiences wearing *Haptic Hanbok* and VR headset at TA T

More than other types of participatory activities within an exhibition space, inviting visitors to wear a certain garment highlights the aspect of transformation and performativity. → Intermezzo 5, 351 By considering the audience as co-performers, the exhibition became a dialogical space, where visitor responses—whether physical, verbal, or emotional—add layers of meaning to the research (fig. 8). This perspective encourages a reflexive approach to research, where the researcher is not only studying an object or concept but is also studying the interaction between the object and the participant. By maintaining this reflexive, adaptive stance, the researcher can harness the exhibition as an evolving research space, constantly shaped by the interactions between participants, guides, and the exhibited materials.

Through varied interactions, I observed a spectrum of responses—some visitors were reluctant, while others embraced the experience fully, wearing the *hanbok* even after disconnecting from the VR headset. The tactile qualities of the *hanbok* and its interplay with movement provoked diverse reactions. Some participants, unfamiliar with the cultural context, hesitated to try it on, while others reported feeling a sense of integration, as if wearing the *hanbok* allowed them to become part of the larger narrative of the exhibition.

One visitor expressed how wearing the *hanbok* offered an opportunity to »bodily think and feel,« describing it as both stiff and flowing at the same time. The mediators played a crucial role in highlighting the *hanbok's* design to encourage movement, which many visitors embraced by stretching their legs or walking around more freely. One participant even remarked that the act of wearing the *hanbok* felt akin to a ritual, likening the experience to a tea ceremony. The exhibition space also hosted events like the *XenoFauna Ceremony* in 2022, which further heightened the ritualistic and sensory exploration of the *hanbok*. This ceremony, led by Korean herbal alchemist Dambi Kim, combined tea, incense, and the history of the TA T space to create modern rituals that intertwined the *hanbok* with the spirits of sacrificed animals. These ceremonial events, although brief, added a layer of spiritual reflection, emphasizing the *hanbok's* role in connecting visitors to more-than-human experiences.

Despite the immersive nature of the experience, technical issues were inevitable. Visitors wearing the *Haptic Hanbok* occasionally encountered difficulties—whether the VR headset's volume was too low to activate the vibrations or the battery of the *hanbok* was depleted. These interruptions, however, served as opportunities for iteration and learning. → Stretching Virtuality, 98 The guides and I adapted to these glitches, refining the visitor experience in real-time. Each technical issue became a moment of discovery, shaping new understandings of the delicate interaction between the body, garment, and technology. Interestingly, the fact that only one hand of each visitor turned into a knife in the VR world created a choreography of movement. Visitors reported feeling more at ease after completing the cutting sequence, moving more freely as they explored the virtual tissues. Others, however, expressed discomfort with the virtual knife, some feeling disturbed by the harsh, crispy metallic sound it produced. A few visitors even recoiled in the elevator after discovering their hand had transformed into a giant knife, unsettled by the virtual-physical boundary blurring too strongly.

The *Haptic Hanbok* consistently encouraged deeper reflection on how our bodies engage with the environment. Many visitors shifted from passive observation to active participation, transitioning from intellectual to bodily engagement. Over time, the *hanbok* and VR headset became a familiar pairing, with visitors almost intuitively understanding how they worked

together. Lara Ladik, a frequent presence in the exhibition space as she worked on her master's thesis, commented, »I can't think of a VR headset without the *hanbok* anymore,« underscoring how the exhibition transformed these two distinct objects into a singular sensory experience. → Stretching Virtuality, 85

Toward the end of the exhibition, I spent time with Daniel, repairing parts of the *Haptic Hanbok* that had worn down, particularly the loosely stitched pockets holding the vibrational motors. Daniel reflected that the *hanbok* itself, even without the motors, felt »alive« in a strange way. He remarked that the vibrations added a layer of magic, like giving the garment a heartbeat, but wondered if the *hanbok* might already possess a sense of vitality without the need for electronic augmentation. Despite the *Haptic Hanbok's* technical complexity, some visitors found the vibrational feedback less distinct than expected. When asked if they could differentiate between the vibrations in different locations, several participants reported feeling a vague, unified sensation rather than discrete vibrations. This ambiguity led to ongoing reflection about whether the haptic feedback successfully conveyed its intended meaning–whether it enhanced the perception of *gi* flow and helped the wearer sensorially distinguish between different parts of brain tissue, or whether it simply resulted in a sensory overload, blurring the experience into indistinct noise.

Crucially, the visitors were not just passive observers but co-performers, shaping the exhibition as much as it shaped them. The interaction between body, fabric, and technology fostered a new level of sensory engagement, as each visitor's movements, responses, and reflections became integral to the evolving research on the *Haptic Hanbok*. The exhibition space became a site of embodied discovery, where the lines between subject and object, participant and researcher blurred and reformed with each interaction.

CONCLUSION: IMPLICATIONS FOR PLURAL TECHNO-FUTURES

The exhibition itself functioned as a space for research, where the act of making and wearing the *Haptic Hanbok* became a method of inquiry. By stretching sensory boundaries, the exhibition invited visitors to explore alternative modes of being, enabling them to step beyond the familiar. The act of donning a *hanbok*–an unfamiliar garment for many–alongside the immersive VR technology allowed participants to engage with a relational cosmology, where the body, materiality, and digital environments interact in new ways. This sensory engagement highlights the role of exhibitions in creating safe, non-judgmental zones for experimentation, where individuals can challenge the limited material and sensory experiences typically encountered in their daily lives.

The fusion of Korean sartorial heritage, embodied through the *Haptic Hanbok*, with VR technology presents a powerful example of how pluralistic futures might be shaped by reimagining sensory experiences. This blending of »traditional« garments with immersive digital environments points to a future where technology does not exist in isolation but rather evolves in dialogue with diverse cosmologies. By engaging with this intersection, we open up possibilities for enabling sensory experiences that challenge the limited frameworks of everyday life.

The entanglement between heritage and technology deepens our understanding of both. Through the exhibition, participants stretched their sensory capacities, not only learning about Korean heritage but also experiencing new modes of interaction via haptic and virtual technologies. This created fertile ground for future transdisciplinary and transcultural research, where collaborations between fields such as heritage studies, technology, and design can lead to more diverse modes of how we engage with material and digital worlds.

Ultimately, the sensory experiences of the exhibition, rooted in the tactile and visual realms, open up broader conversations about alternative worldmaking. *Stretching senses* in this context is not merely an individual act; it becomes a collective exploration of how heritage and technology can co-create new ways of perceiving and engaging with the world. This exhibition acts as a reminder that future technologies do not have to be uniform but can be shaped by the richness of diverse cosmotechnical strands, leading to more vibrant, pluralistic techno-futures.

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STRETCHING SENSES SCHOOL

Maxime Le Calvé and
Yoonha Kim

Intermezzo 5

The *stretching senses school* was an education-as-research project at Tieranatomisches Theater (TA T) in the context of the exhibition *Stretching Materialities*, co-partnered with the Node Institute Berlin. Through a workshop-based contribution to the exhibition, we have engaged in collaborations with digital artists and creative coders in order to raise the public's awareness of the multiscalar and embedded interconnections between humans and other earthly beings. These connections unfold through electromagnetic currents, drifting clouds, and the traces of time beyond human perception etched in limestone and soil. In Virtual Reality (VR), visitors interacted with these dynamic processes that are invisible to the naked eye. We started from a relatively simple statement that engaged with the exhibition's thematic while opening to bigger ecological issues: the severity of the climate crisis is well recognized, yet the slow and prolonged nature of these changes often escapes our immediate perception. Can stretching senses help to better understand the presence of non-human entities, and could such heightened awareness lead to a shift in a human-centered relationship? Playful approaches beyond the realm of rigid academic ways of knowing—such as heavily theoretical and often text-based forms of analysis that prioritize rationality, objectivity, and standardized methods—may offer an alternative pathway. In this brief ethnographic, almost telegraphic report, we present an account of the activities that we have curated part of the *stretching senses school* collective. The collaboration of digital artists, creative coders, and researchers was structured into three distinct groups: *Antennas*, *Leaking Bodies*, and *Subterranean Matters*. Each group's work culminated in a final festival that showcased high-quality immersive artworks, documented in the radical open access publication »*stretching senses school*.« In the following log book, we narrate the experimental framing we established for the members of these three teams. Amidst the urgent political, social, and radical responses to climate change, this seemingly light-hearted approach may be seen as insufficient by critics who argue for more direct actions. While political action is crucial in addressing climate change, our approach complemented it by cultivating awareness and reorienting perceptions. In this context, awakening sensory awareness through alternative approaches became essential. This approach explored how perception can be stretched beyond the immediate and the visible through making and experiencing VR: listening to magnetic waves, sensing the world through antennas like insects, or studying the slow formation of limestone. → Stretching Time, 224 These transformations occur not only in ecological consciousness but also in recognizing the porosity between art and anthropology, between digital production processes and scenographic experiments. In the documentation, readers can browse through the varied inquiries that designers/producers need to conduct in order to address the imperatives (and possible trade-offs) of the human perception of the visitors and the contingencies of the time-pressured bricolage of nifty art science projects that were partly developed independently and outside the *Stretching Materialities* exhibition.

Digital devices and their multisensory experiences, like VR, offer new ways to sense and coexist with non-human entities. For instance, one may learn more about trees in the rainforest and empathize with them through turning one's arms into tree branches in VR like in Xin Liu's collaborative project, *Tree* (2017). However, these technologies, designed within human-centric frameworks, carry embedded assumptions and biases that reflect existing power dynamics. Their use is often restricted to privileged groups with access to such tools, reinforcing inequalities and limiting broader participation. Moreover, while they stretch our sensory faculties, these technologies simplify non-human experiences to fit human understanding, failing to capture their full complexity. Despite these challenges, the *stretching senses school* aimed to explore still new ways of engaging with immersive approaches, believing these experiences can inspire new forms of awareness and help reimagine our coexistence with other-than-human beings in the more-than-human world. As Anna Tsing (2015, 37) reminds us, anthropomorphism can be useful if it helps foster environmental care.

Fig. 1: Warja Rybakova in VR experience of the project *Subterranean Matters*

A portal-like VR elevator was built into the center of the round exhibition space. Visitors could hitch rides across temporal and spatial scales with it. Early on, we envisioned this device as a platform for collaboration. Through the *stretching senses school*, we were sharing and extending this toy with other artists, programmers, and digital activists who were interested in stretching senses and blending the physical and virtual in hybrid setups—producing compelling experiences, which help to challenge our anthropo-centered imaginations and acknowledge our hypo-subjectivities in the face of the climate crisis (fig. 1). We wish to keep attending to this community of »members,« who, we hope, will pursue their activities in the years to come, fostering playful and excessive collaborations between ecological humanities, creative coders, and digital artists. With the intention to build participation of the Berlin-based artist community, we have designed a process in collaboration with the Node Institute and mentors in order to balance and »contain« the project in a manageable working process.

Fig. 2: Preparation of the *stretching senses school* festival

In 2021, we received around thirty applications in response to our call directed primarily at visual creators, 3D artists, programmers, and sound designers based in Berlin. The participants were all young professionals. Some were teaching in art schools, some were undertaking graduate studies, and all of them were working as freelancers. Among them were freelancers working for some of the finest digital studios in the city. We selected a balanced group, using the criteria inclusivity, variety of skills, levels of experience, and working contexts. Not surprisingly for the Berlin scene, we counted 14 different nationalities in a group of 15, curators included. The members of the school received modest financial compensation for their time and accepted to take part in the activities and complete the production of artworks. The school's design mentors shared their

Fig. 3–4: Workshop »Leaking Bodies« during the *stretching senses school* Festival, 2022

experience and engaged on equal footing with the school members to produce research and design works in collaboration with Object Space Agency (OSA) within the Cluster of *Excellence Matters of Activity* (MoA). They were offered to exhibit their results and collaborate on interdisciplinary research publications. We communicated a set of instructions in the call for participation. Re-reading these instructions after the collaborative work, it is surprising how accurately we already formulated our demands to the participants: »Use immersive technologies to challenge our commonsensical/modern perception of materials (stones/air/silk) and non-human/more-than-human beings (neuron cells/rattan plants/air-borne bacteria) and their intrinsic activity. Visualize/sonify/evoke interaction with more-than-human beings at radically other scales, turning perceptive information from scientific instruments at the levels of nano/micro/macro/cosmo into sensorial (and therefore interactive) experiences. Visualize/sonify borderline, equivocal boundaries (between the virtual neuron cell and the probe/rattan surface and the moisture of the room) exploring its virtual/temporal/spatial dimensions in alternative sensorial/synesthetic manners.« Yet, the willingness of the group to follow the programmatic lines that we had traced in advance, aligning with the concept of the exhibition *Stretching Materialities*, has shown to be quite extraordinary (fig. 2–4).

A FIELD LOG

PRELIMINARY EXPERIMENT: Fermentation as Attunement

- Date: September 2021
- Objective: Establish initial group cohesion through a non-verbal, embodied practice that resonates with more-than-human agency. Rather than discussing »more-than-human agency« in abstract terms, we will explore what it actually means through direct, hands-on engagement.
- Method: Participants engage in a collective fermentation workshop, a practice tied to the ongoing research of the Ferment-Activity Club at MoA. The slow transformation of food serves as a metaphorical and material grounding for the upcoming VR-based explorations.
- Observations: The shared act of chopping, pressing, and sealing vegetables generated an unexpected sense of intimacy, fostering non-discursive communication within the group. The microbial transformations underway in the fermentation jars mirrored our own transitions from individual practitioners to a collective research unit. Along the way, the unexpected eruption of microbial life—when an entire jar of peppers burst into bloom with mold—presented a reminder that material agency unfolds beyond human intention.
- Outcome: The lunch activated a trans-scalar awareness of food as an ecological assemblage, reinforcing the research premise that immersive experiences extend beyond digitality.

EXPERIMENT 1: Sensory Calibration and Spatial Immersion

- Date: 14 October 2021 (Kick-off Workshop)
- Location: Tieranatomisches Theater (TA T), Berlin
- Objective: Develop an embodied sensitivity to material entanglements through guided meditation and scenographic exploration
- Method: Initial meditation focused on bodily interdependencies with the environment, followed by an exhibition tour emphasizing the research processes of OSA.
- Observations: Participants demonstrated heightened perceptual awareness, engaging deeply with the materiality of the exhibition space. The weight of stone surfaces, the movement of air, and the presence of unseen forces became tangible through somatic attention. This exercise validated our hypothesis that an aesthetic mode of engagement can serve as an epistemic bridge between anthropology and digital art.

Secondary Procedure: Experimental Lunch

- Date: 14 October 2021
- Location: Tieranatomisches Theater (TA T), Berlin
- Facilitator: Akko (Roku Berlin)
- Objective: Explore human—non-human food relations through a performative meal using the ferments of the first workshop

EXPERIMENT 2: Photogrammetry as a Sensory Prosthesis

- Date: 15 October 2021
- Facilitator: Mickey van Olst
- Objective: Introduce participants to photogrammetry as a method for transposing physical objects into malleable digital forms
- Method: Workshop participants used photogrammetry techniques to capture objects, transforming them into interactive 3D environments.
- Observations: The exercise reinforced the research question: Can immersive technologies challenge human-centric perception? Photogrammetry enabled an estrangement from habitual ways of seeing, turning objects into fluid digital entities. The analogy presented by van Olst—»climbing a fence to a special place at night with your camera«—resonated with our broader inquiry into sensory extension.

EXPERIMENT 3: Narrative Architectures of Immersion

- Date: 15 October 2021
- Facilitators: Jemma Woolmore, Nayeli Vega
- Objective: Examine the role of storytelling in constructing immersive experiences
- Method: Participants analyzed literary and cinematic examples before generating their own micro-narratives around stones.

- Observations: Narrative structuring proved fundamental to creating immersion. Participants' engagement with stones as narrative objects expanded the concept of storytelling beyond human actors, aligning with the project's interest in non-human agency.

EXPERIMENT 4: Digital Toolkits and Collective Composition

- Date: 16 October 2021
- Facilitator: VanTa
- Objective: Equip participants with technical skills for VR-based artistic research and establish our endeavor into the notion of digital materiality
- Method: Overview of state-of-the-art creative coding tools, followed by team formation via online collaborative mind mapping
- Observations: VanTa introduced not only creative coding tools but also explained what happens inside computers when making VR—how the CPU (Central Processing Unit) acts like the brain, coordinating different things at once, and the GPU (Graphic Processing Unit) works like a muscle, handling images and animations. This made visible the physical work behind digital images, from electricity use to the materials inside the hardware itself. This awareness of digital materiality added a new layer to the participants' understanding of what it means to create immersive environments. The digital platforms themselves quickly became evolving archives of research-in-progress. This was essential because the VR works were sensory and nonverbal, defying conventional documentation. To capture both process and ideas, participantsplaced images next to texts, scaled visuals, and drew connecting lines—creating a web of relationships. This process not only documented the work but also shaped the creative flow itself, constantly balancing artistic freedom with technical limits.

Interim Review: Progress Check-Ins

- Dates: 16 November, 5 December 2021
- Objective: Assess the development of research and creative processes through structured feedback sessions
- Method: Two scheduled review sessions in which teams presented their progress to mentors, curators, and MoA members (Clemens Winkler, Natalija Miodragović, Nina Samuel, Habakuk Israel, and Robert Stock). Discussions focused on conceptual clarity, technical feasibility, and multimodal storytelling approaches.
- Observations: The iterative review process facilitated an emergent form of collaborative ethnography, in which digital tools such as Miro boards became integral not only for coordination but also as evolving repositories of shared knowledge. These platforms served as living archives, capturing the flux of creative decision-making and reinforcing the dialogic nature of our research framework. The sessions also highlighted the necessity of balancing experimental freedom with structured milestones in order to maintain coherence across the different artistic research trajectories.

FINAL PRESENTATIONS AND EMERGING HYPOTHESES

- Date: 16 December 2021
- Objective: Assess the artistic research outputs and their alignment with the initial conceptual framework
- Method: Hybrid presentations combining in-person and online formats
- Observations: The exhibited works demonstrated a convergence between the project's theoretical aims and the experimental outputs. The use of immersive technologies successfully challenged human perception of materials and non-human agencies, albeit with persistent epistemic constraints imposed by technological mediation. → Stretching Senses, 124–125

stretching senses school Festival: Full-Scale Deployment

- Date: 23–25 June 2022
- Objective: Expand the research findings into a public-facing event integrating VR, performance, and theoretical discourse
- Method: Site-specific VR installations, lectures by digital and environmental scholars (Dominic Boyer, Lisa Messeri, Tim Morton, John Tresch), opening performance, and participatory workshops by the three sub-projects teams, who shared with the public key elements of their explorative process (fig. 5)
- Observations: The festival emerged as a lived expression of our experimental framework. Notable contributions included:
  — *Willowalks*: A sound exploration workshop using willow branches to translate vibrational frequencies into auditory experience (Lee et al. 2022) → Stretching Senses, 271 → Intermezzo 3, 194
  — *Leaking Bodies*: An engagement with the permeability of material forms (Roschka et al. 2022) → Stretching Senses, 273
  — *Subterranean Matters*: A tactile investigation into geological processes (Pekcagliyan et al. 2022, fig. 6)

The event validated our initial premise that sensory extension can destabilize anthropocentric perception, fostering new modes of ecological relationality. ❑ Process, 278–279

REFLEXIVE ANALYSIS: Non-Doing and the Trickster Anthropologist

Throughout this process, a counter-intuitive insight emerged: the most generative moments arose not from structured methodologies but from pauses, hesitations, and acts of non-doing. The fermentation workshop, the mindful attunement to the exhibition space, and the performative lunch—all instances of slowing down—proved foundational in recalibrating perception. Presence, rather than intervention, becomes the mode of engagement.

It echoes Ingold's (2011) argument that »knowing from the inside« is cultivated through sustained attention rather than instrumental control, a perspective that challenges traditional ethnographic fieldwork models predicated on extractive observation and structured analysis.

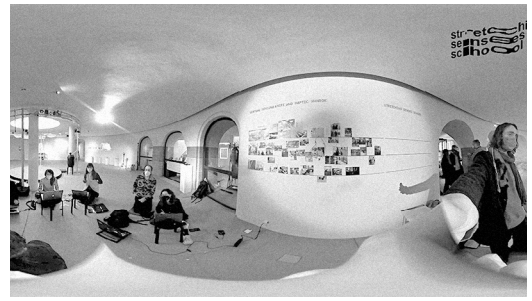

Fig. 5: 360° camera view of the *stretching senses school* festival

The anthropologist in this context operates as a trickster figure, unsettling conventional epistemic boundaries. Trickster methodologies, as developed in anthropological theory, suggest that knowledge is not

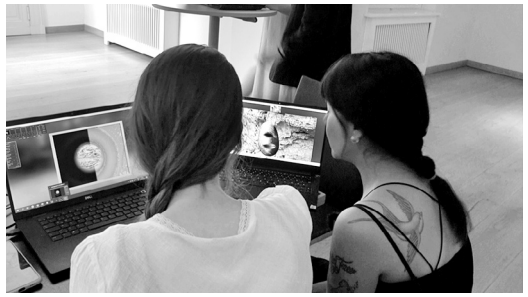

Fig. 6: Workshop *Subterranean Matters*

only transmitted through linear discourse but also emerges through disorientation, failure, and play (Wagner 2010; Law 2004). Rather than merely documenting or facilitating, we played with the elasticity of the research framework itself, actively intervening in the porous zones between disciplines. The *stretching senses school*, by its very name, became an exercise in boundary-pushing: between art and anthropology, digital and physical, cognition and sensation. In line with de Certeau's (1984) everyday tactics, our approach privileged the improvisational and the contingent as valid epistemic modes. In the end, it was not only senses that were stretched but also the ways we imagine knowledge production—a reminder that anthropology is at its most productive when it resists closure and instead embraces generative uncertainty. The project continues; rather than presenting a finished conclusion, it offers an invitation to dwell within these tensions, to keep stretching, and to embrace the possibility of an anthropology that moves beyond the seen and the said into the embodied and the enacted.

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FROM PERFORMATIVE MEDIATION TO DANCING CACO3

Claudia Blümle in conversation with Kaaren Beckhof

Intermezzo 5

• Claudia Blümle: After the opening of *Stretching Materialities*, the research group Object Space Agency (OSA) quickly realized that, due to the exhibition's processual and interactive character, various forms of on-site mediation were necessary. Kaaren, you were the conceptual director for this task. Not only do you have many years of experience in museum education, but you are also artistically active in the field of performance art. Experiencing your guided tours, which I attended and accompanied several times, I found it interesting that there was no linear narrative, analog to our exhibition. As the exhibition changed over several months, your starting points and references for mediation were also constantly in flux. In particular, I remember you made the role of humidity a topological pivot. For example, humidity and water are important for Natalija Miodragović to be able to soften the willows and stabilize them again, and this humidity was in turn perceptible in Clemens Winkler's cloud. You also emphasized the humidity, temperatures, and airiness when you wore Yoonha Kim's *hanbok* clothes during your tours.

• Kaaren Beckhof: The hygrometer also works via humidity, which expands the length of the horsehair used.

• CB Yes, exactly. In other words, there were connections that ranged from the temporal, spatial, and physical to the ecological level. What connections do you remember coming up in the exhibition constellation? As a bridge between the different positions that were exhibited and could be experienced?

• KB In addition to humidity and temperature, aspects of perception generally run through the exhibition as a cross-cutting theme: the described perception of time but also the perception of movement, sound, weight, (surface) structures and patterns, proportions. We are offered the opportunity to become aware of our everyday perspective and to expand it or leave it altogether. Let's take the proportions: Natalija's willow structures, for example, take up patterns for architecture with which we are familiar from handicrafts in small formats. It is surprising when these are suddenly enlarged many times and reproduced with willow branches. What happens when we transfer the shapes of our clothing, which protects and warms us, to architecture? You could crawl through the tunnel in the archway. ❑ Exhibition, fig. 11, 133

This created sounds, the structure expanded and contracted with your own movement, a new experience. The size corresponded with a nest for us, larger, more stubborn than textiles, less comfortable, and not as nice and warm but more reactive, more flexible than buildings as we know them here. In southern China, there are renewable, self-regenerating bridges that have been maintained for over 150 years and have withstood every earthquake. With the cloud in the rotunda, »enveloping atmospheres,« Clemens makes perceptible the materiality and activities of the air, which we often refer to as »emptiness.« First, there is the cloud that forms every twenty minutes, moves gracefully, and dissolves again. But it also collects organic and inorganic particles with an air collection filter. These are made visible and described scientifically with images from scanning electron microscopes, as well as becoming more actively perceptible through role-playing games with names and stories. Nina Samuel's geological collection was later expanded at the suggestion of a visitor. The scanning electron micrographs of weathering processes of stones taken by the visitor's father, the founder of building material microscopy, show the ambivalent zones between inorganic and organic materiality. → Stretching Time, 247–252

The general aim of the exhibition was to discover materials' hidden activities, and it was initially important for you and then for us in the mediation to activate the visitors' perceptual abilities and, to some extent, their ability to move. For us, however, it was first and foremost important to convey that the exhibition was active, namely processual: an interactive laboratory of transdisciplinary research made accessible to the public. In a city with over 250 museums and a multitude of exhibitions, this meant redirecting expectations when visiting the exhibition. The exhibition as such was never »finished« in the sense that it was completed at the vernissage or at the finissage, because we tested the exhibition as a scientific method. It continued to develop in a lively way during the day-to-day research and exhibition activities. Open communication and offers on many levels of participation testified to the honest and determined processual nature of the exhibition. I have already mentioned the importance of personal mediation for the especially innovative VR format. The constantly changing exhibition reality showed that intensive personal mediation was indispensable for the functioning and success of such an exhibition project. It was also important to be quick and to make decisions according to the situation for conventional media communication channels to be able to keep up. Personal mediation was therefore needed to accompany the research process, but above all, to uncover it in the first place! It ensured liveliness and helped the audience to feel comfortable and safe. The exhibition demanded a high degree of personal initiative and responsibility. The doors of the showcases were mostly open. Many exhibits were intended to be touched and used. Others, however, such as electronic devices, were not. Visitors often didn't know how sensitive the individual items were. The bottom line was that a healthy balance of courage and caution had to be actively found when handling the objects. This was sometimes taught through instruction but more often through our example and cooperation. Free trial and error was difficult here as the primary method. Well-practiced conventions of not touching exhibits, for example, hindered visitors just as much as the lack of limits to handle objects completely freely with the risk of destruction.

• CB As it was a transforming and developing exhibition, interdisciplinary exchange with all participants was necessary throughout. How was this realized?

• KB There were extensive communication channels and constant exchanges between the research and education teams. Here too, the »rules of the game« were negotiated and newly developed. This was supported by an online protocol in which we exchanged information with each other on a daily basis. The ultimate success of *Stretching Materialities* as an exhibition was due to the fact that the audience was constantly expanding to include new target groups, primarily through word of mouth. The results of many workshops and other events were integrated, as were the artistic works by myself and my mediation colleague Maria Mascha Kobylenko. This integration made the mediation work stimulating and powerful. There were not only dialogue- and action-oriented guided tours and other planned mediation offers but also situational ones at all opening times. Interested visitors were addressed and initially referred to the exhibits and topics they were interested in or about which they had questions, or they were simply offered a guided tour for the time they brought with them. We built bridges everywhere. In summary, I identified four cross-cutting themes for myself: 1. perspective sense, 2. perspective virtual, 3. perspective activity and 4. perspective stage. The theme of perspective sense posits that perceiving materialities as active and powerful requires all the

senses and that leaving the human perspective stimulates an altered perception of the familiar. The perspective virtual theme was close to Christian Stein and his VR team from gamelab.berlin. They collaborated with all the research groups involved in the design of the individual floors. From the virtual dimension, it was possible to transition between research projects. The hidden activities of matter were actively discovered by visitors in an acting research exhibition laboratory. The fourth cross-cutting theme addresses the spatial aspect, which has always been central to my art. I derive it from my ideal-typical guided tour, which presents all seven exhibition projects one after the other. I initially called the cross-cutting theme perspective habitat because it was about localization (as a human being). Later, in reference to the location of the exhibition, TA T, it became a perspective stage. From here, the references to stretching emerged in relation to stretching time, or the temporal dimension of matter, such as stones, or in the historical sense and a time beyond human. Or stretching size and changing dimensions, stretching and extending the body, stretching spaces, stretching the environment, stretching reality in the sense of analog virtuality. I understand virtuality here in the artistic sense, i.e., something that goes beyond the self-evident, that has experienced a special setting, has been »made special,« as anthropologist Ellen Dissanayake (1988) would put it.

• CB The finissage was just as important as the vernissage, which is why I would like to continue our conversation with your performance *dancing CaCO3*. Would you like to start by briefly explaining the initial situation and concept?

• KB When I got to know your exhibition project, I immediately recognized clear links to my artistic work with a South Indian scattered drawing technique (fig. 1). After more than four months of exploration and mediation in *Stretching Materialities,* my performance literally wove itself through the exhibition, from the general impulse of research to the most important cross-cutting themes formulated for my mediation in the exhibition, to references to all the research projects involved. *Stretching Materialities* was about making matter an active and powerful experience. My performance title *dancing CaCO3*, read »dancing calcium carbonate,« ties in with this. On the one hand, it describes my relationship to my most important artistic material for years, marble powder. This consists almost exclusively of calcium carbonate, (carbonic acid) lime. I use it to scatter temporary drawings on the ground while standing in a forward fold. As soon as a drawing is finished, it begins to disappear, just like life itself. Beyond traditional genre boundaries, I create local-spatial situations that evoke specific aesthetic experiences. By »dancing« the chemical formula of calcium carbonate in the title, I emphasize the intrinsic activity of my drawing material—independent of my actions as a draughtswoman. On the other hand, by »dancing CaCO3« I refer to the performance, which I conceived as an open, participatory choreography. Alongside me, the audience follows the staged impulses of the material as »dancing« performers. They »dance calcium carbonate« by engaging in exploring its activity in the exemplarily presented manifestations with all their senses. The ceremonial performance was staged at the finissage of *Stretching Materialities* in three runs of 45 minutes each at one and a half hour intervals. Each run was divided into two parts of roughly equal length. In the first part, I introduced the audience to the »ceremonial performance« in terms of concept, content, and practice; in the second part, it was performed in a ceremonially focused manner.

Fig. 1: *dancing CaCO3*: Kaaren Beckhof drawing a stylized coccolith from million years old coccoliths using calcium carbonate in its manifestation as ground marble

• CB It was a performance that could be received passively but also invited active participation. Would you like to describe this relationship between passive and participative performance on the sensory-perceptual side?

• KB I had developed five stations for the exhibition to stimulate the audience's curiosity about the sensory exploration of CaCO3: *Shell Song, Shadow Drawings, Osmotic Fingers, Flavors of Marble,* and *Bending Organ*. Picture the second part: The light dims as the audience, now the performers, move into the rotunda space with me. At first, delicate sounds can be heard, which they produce themselves using shells. Extremely focused on these soft, grippy sea almonds, real hand candies that I collected on the Atlantic, they devotedly explore their sound possibilities. Some press them firmly to their ears to listen to their inner sounds, the familiar »sound of the sea« (fig. 2–3). They linger or meander through the circular space with attentive senses. The acoustic signals are picked up by the sound artist and composer Wingel Mendoza. For *Shell Song,* he performs on a floor cloth with objects that are also part of the exhibition. He uses microphones at different locations to record and incorporate the incoming sounds live into his improvisation. This creates a unique spatial sound fabric in direct resonance with the performative events. It is unobtrusive and has the effect of the clicking and crunching of subterranean rock strata, the sound of the sea, or the noise in space, a living, three-dimensional sound environment.

Fig. 2: *Shell Song*, station of *dancing CaCO3* is inspired by the sounds of calcium carbonate in its manifestation as sea almonds. Electronic live composition by sound artist Wingel Mendoza

Fig. 3: Audience performs while listening to, exploring, and creating the sounds of sea almonds in a ceremonially focused manner

The metal bowls I use as containers for the marble powder resound like bells, solemnly. Meanwhile, leaning forward, I myself continue to scatter a larger floor drawing that I started earlier and which winds its way around the rotunda. The graphic patterns are based on wavy lines and loops, picking up on the labyrinthine patterns I usually use, as well as related patterns that are

present and significant in the exhibition. Many performers place their shells in self-selected locations, others pick them up again or move on to other activities. They follow their individual rhythms, choose their own sequences, decide what to do according to the situation, while maintaining their concentration on the calcium carbonate present and their open, undirected perception of the space. In short, the shells refer to the oceanic background of the marble. Together with the exoskeletons of crustaceans and protozoa such as coccoliths, they were deposited in primeval seas. They became limestone, i.e., sedimentary rocks like chalk. Under the special effects of pressure and heat, a metamorphic rock, marble, was formed in some places.

Fig. 4: *Osmotic Fingers*, station of *dancing CaCO3*, uses a paste made of calcium carbonate in its manifestation as chalk and water

Fig. 5: Inspired by the ever pointing fingers spotted during the exhibition, particularly when using VR and the *Virtual Sensing Knife*

I then led everyone back into the rotunda and gathered them together. For *Osmotic Fingers* (fig. 4–5) I placed calcium carbonate in the archway to be used as a paste—Rügen chalk powder mixed with water in a bowl—so that performers could spread the mushy chalk on their index fingers. The evaporative cold is clearly noticeable and accompanies the first movements of the now white-marked fingers. They are an echo of the many isolated index fingers in the exhibition, like the tip of the *Virtual Sensing Knife* or the »blind« visitors with VR glasses when they select the floor in a Virtual Elevator. Later, the fingers trace wavy lines of my scatter drawing, point to or into a cloud that is actually floating above them in the rotunda, they notice its humidity, its undulations, and much more. The index fingers, emphasized in isolation, remain a striking aspect of the performers. Meanwhile, they are inevitably permeated by the ingredients of the Rügen healing chalk used here. Some fingers point to the gigantic enlargement of a coccolith that I have scattered, from which the chalk was once formed. In the end, the crumbling of the dried chalk leads to new sensations and movements in the room—and to particles that are continuously collected, measured, and determined in the exhibition.

• CB In addition to these sensory experiments and spatial measurements of the body, the senses of taste were also involved, weren't they?

• KB Yes, with *Flavors of Marble*. That was a station where you could taste calcium carbonate in the form of my marble powder. Nobody expects a taste explosion here. But something surprisingly different is revealed: the haptic sensitivity of our mouths when eating. The marble particles have the ability to move around freely in the atmosphere of our mouth, to »dance,« if you like. When ingested as a powder, they are initially very dry and love our saliva, which mobilizes them. They become difficult to control, and our movements initially spread them further into the oral cavity. It takes quite a while for them all to disappear (fig. 6–7).

Fig. 6: *Flavors of Marble*, station of *dancing CaCO3*, introduces the tasting experience into *Stretching Materialities*

Fig. 7: Particles will dance around in the atmosphere of the mouth

• CB How did your performance with the active materials in our *Stretching Materialities* exhibition become a dance?

• KB The cloud's humidity relates to the wet, white fingers, chalk and marble to the exhibited stones; powdered and drawn with, these limestones transform into the bows of the willows, the latter followed by the pointing fingers typical for the Virtual Elevator, the cautious movements of the VR experience transform into the ceremonial style. Performers meander; white, osmotic fingers explore, swinging lines, clicking shells; attentive, exploratory gazes; movements carried by sound like strange-looking forward folds (fig. 8). The *Bending Organ* is where gravity comes into play, the exploration of the weight of the marble flour. ❑ Process, fig. 1, 265

Fig. 8: *Bending Organ* as part of *dancing CaCO3*. Audience-performers follow the impulse of marble powder's weight

Placed on the floor of the rotunda, there are white belts with weighted bags that I designed in relation to the Korean robes (*hanbok*) in the exhibition. Performers tie them carefully around their waists. Where the stiff collar of the *hanbok* stimulates an upright posture at a point on the neck (more on this later), here the weight of the marble flour on the kidney area stimulates the correct, relaxed forward fold. The performers bend forward alone, in pairs, or in groups. Now and again, individual performers also pause. They follow the solemn, whimsical goings-on for a while as if in a strange, mysterious world: people, absorbed in their forward fold, others who slowly, very slowly bend forward and then straighten up again, others who seem to mirror my forward fold or comment on it. What are they bowing to? A very slow, graceful up and down. Rhythms emerge. People moving carefully, trying to trace their connection with something unknowable, with something that surrounds them, even moves through their bodies. With calcium carbonate, one of the most widespread compounds on Earth. With its sounds. At every moment, however, their own position, their own perception is unique.

A celebration of the here and now evolves. The door opens. The next audience enters and watches from the sidelines for the last five to ten minutes. They witness the ceremonial performance, a »dance,« as the others allow themselves to be moved through the room in an astonishing way by something still undefined for them. I think that this has created its own atmosphere and a new aesthetic in this space that was not previously present in this exhibition.

• CB Yes, that's how I remember it too. Especially the fact that not only the light but also the different placement of objects in the room and the emphasis on the floor with the drawings made of marble flour created different weightings and constellations that once again changed the topological relationship structure of the exhibition. With regard to the exhibition as a whole, I would like to ask you about the different stages and the paths of the various stations in the exhibition. The first thing I would like to pick up on is Natalija's willow structure. The interwoven lines resulting from the weaving were recognizable in your drawings on the floor. These were direct paths that emerged between you. Sometimes one had the impression that the shadows of Natalija's willow cult traces merged seamlessly with your drawings. Would you like to say something about these references?

• KB I immediately felt connected to Natalija's large willow shapes. They are based on similar linear curves as some of my labyrinthine patterns. Natalija bent the individual willow branches and then interwove them. To form the high tower structure, she needed lots of individual willow branches, which only grow to a certain length. I interweave similar line elements two-dimensionally to form complex patterns by arranging them on top of one another, limited by how much powder I'm able to hold in my hand. The shadow cast by Natalija's *Willow Tower* inspired me to follow its lines. The willow structure also reflected light, creating a similar network of lines. Then one day we discovered a light reflection of a similar kind near the entrance area. It must have come from outside. But we couldn't be sure where it came from before it disappeared again. I see these line patterns everywhere.

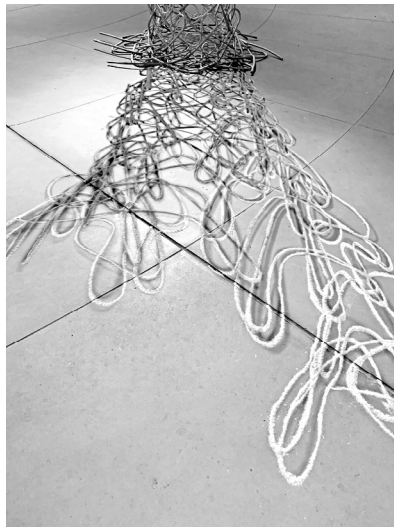

Fig. 9: *Shadow Drawing* as part of *dancing CaCO3*, developed before the finissage and performed repeatedly

• CB So there was both a shadow and a light projection?

• KB Yes, and both are extremely ephemeral phenomena. In contrast, my scattered drawings are made of tangible material, but they are just as ephemeral. Tracing the shadow of the *Willow Tower* was my first scatter drawing in the exhibition space in February 2022 (fig. 9). A few days later, two children curiously asked whether they could touch the drawing. They then began to trace lines, just like me. This time not with stone powder but with an outstretched finger (!) in the stone powder. They followed the sweep of my scattered lines, but at some point they detached themselves from the original—until the mesh became a blurred, white surface (fig. 10). They improvised long, lustfully swinging lines into it, inspired by the previous movements and the lingering shadow of Natalija's willow structure. The shadow now fell on the children's bright »stone flour cloud.« Clemens' floating cloud could be seen in the distance that also formed from ever-changing, oscillating lines of bright water vapor. ❑ Process, fig. 9, 272

Fig. 10: The lines of *Shadow Drawing* transformed into a »cloud« through visitors' interaction

• CB The location of Clemens' cloud was the result of climate investigations of dust, humidity, and temperature in the round exhibition space, which came into co-existence as a divine level mediating between the situated exhibition and Christian Stein's Virtual Elevator. During *dancing CaCO3,* you transformed the rotunda into a stage, from which you performed the movements with a weighted belt around your hips. In addition to these references, touching by hand also played a role. What references did you make to the stones and their haptic contact with Nina's showcases?

• KB I would like to briefly describe a mediation situation with her eight-part touch box. → Stretching Time, 224 At the beginning of my guided tours, I liked to ask a volunteer to put their hand into one of these openings without any indication of what they would find. I had them describe in detail what they felt there, size, exact shape, surface texture, weight, and temperature impressions, color (*sic!*) etc. It was not about guessing the material, naming the unknown but experiencing it in its concrete materiality, feeling it. Later, we could see downstairs what we had felt in the eight boxes: the stages of weathering from large river pebbles to sand and silt to clay. A series of unusual and attractive examples in Nina's display cases shows how rock weathers and is formed again. Shell impressions were visible on a limestone, and its calcium carbonate content could be chemically detected with diluted hydrochloric acid.

• CB Here you also have a photo of individual stones laid out on the wall. ❑ Exhibition, fig. 1, 121 What significance does this have for you?

• KB In a workshop organized by Lara Ladik, these stones were picked up by visitors, examined, and placed in different locations. This inspired me to give my audience performers the shells, which have a similarly handy size, to carry around, put down, and carry around again. The same happens to shells and stones in the open air, they have no legs and yet they move. And they are much more persistent than we are, namely millions of years. I also transferred other movements that appeared in the exhibition into my performance, as previously explained: the index finger. Incidentally, the stones in the picture are on the red sandstone wall, the first passageway to the rotunda.

• CB The materiality of stone is often forgotten when it is used and transformed

for objects or architecture, in other words, when you work with stones and use them. At that moment, the materiality recedes into the background again and that is the hidden aspect that I referred to by *Hidden Activities*—our subtitle for the exhibition. The materiality as such is made visible and brought to the fore again. Can you elaborate on the materiality of the stones and their different ways of being?

• KB Three different types of stone come together here. The weathering stages of the river pebbles that we saw before are part of a cycle without any necessary human influence. The sandstone wall in the picture is worked stone, which in turn has its own history as sandstone. And below we have tiles. Stone, but put together, shaped, glazed, and fired by man. An ancient cultural technique! CaCO3 lent its name to a geological age (the Cretaceous period), and now we're living in a geological age named after man, the Anthropocene. Nina's exhibits also included a 3D print of a sand rose. These attractive stone shapes can form under very specific weather conditions, usually in desert regions. The print surprised not only by its enormous lightness, comparable to a pumice stone next door, but also by the fact that on closer examination it has only the size and only very roughly the shape in common with the original, which was also on display, but not the surface structure, which clearly showed the individual plastic layers of the printing process. The printed object feels completely different, its weight, temperature, and smell are different, it behaves differently, falls, tumbles, and tastes differently and does not only reveal its otherness when it is sanded or cut up.

• CB In what way were you able to performatively integrate materials such as stone?

• KB Nina's showcase, which you could reach into, was about the cycle of rocks, how igneous, metamorphic, and sedimentary rocks are constantly transformed into one another through geodynamic processes such as erosion, rock metamorphosis, or sedimentation, and, of course, human influence. The transformability of the material had to be discovered again and again in the exhibition. In doing so, it was central for me to sensitize the perceptive abilities of our body, all our senses. What we have referred to as the sense of touch since Aristotle has been reduced in our text-based i.e. concept-based and increasingly audio-visually dominated culture. When I took lessons from the American dance legend Anna Halprin during my studies in San Francisco in the 1990s, I was astonished to learn that she differentiated the sense of touch into around 36 senses. Without wanting to list them all individually here, or even go into the further processing of sensory impressions in the human body, which is described by sensory and perceptual physiology, we distinguish, for example, surface sensitivity (haptic and tactile) from deep sensitivity (proprioception), we can distinguish between pressure, vibration, touch, stretching, and pain and have cold and heat corpuscles for temperature perception, we also perceive the position of the joints—the sense of position, the tension of the muscles, and vision, the sense of force of their movements—the kinesthetic sense. Visceroception enables us to perceive our internal organs, while the sense of balance in the ear enables us to move in space without getting confused.

• CB Did this also manifest itself at other stations within the *Stretching Materialities* exhibition?

• KB Yoonha's exhibition project ties in well with this. The focus was on the potential of wearing traditional *hanbok*, which literally means »Korean clothes.« → Stretching Senses, 275 They are very valuable, handmade from different silks, and require a special bow tie. I really celebrated dressing in the exhibition. This later inspired the subtitle of *dancing CaCO3—a ceremonial performance*. The ceremonial element also worked well as a ritual to introduce the mediation. One not only visited an exhibition but was also involved as a research object and subject. I introduced the dressing of the *hanbok* comprehensively with perception and posture exercises, such as »Feel where your current clothing rests against your skin. What sensations do your clothes trigger there? Where do you feel particularly soft, hard, delicate, or scratchy skin? Is it warmer somewhere? Colder? Or is there a draught somewhere?« The variety of »tactile senses« enables us to connect with objects in a very differentiated way, including the *hanbok* in this case. When dressed, it is possible to observe how the *hanbok* influences the position of the body in space, sometimes even determining it. Visitors were able to observe how its width and openness and also the fine sound of the fabric invite free, easy movement and promote a straight posture via a stimulus from the stiff collar at the neck. Here we were sensitized to the »agentivity« of the *hanbok*, which manifests itself in interactions, movements, and changes. I tried to stimulate the feeling of the materiality of our own body with *dancing CaCO3,* by offering to taste my drawing material, marble flour, or use it as healing chalk, which penetrates our body during spa treatments. Along with transfer functions, calcium provides strength in our skeleton and teeth.

• CB Now that we have arrived at the aspect of the body, I would like to ask you how the materiality of the body, as self-perception and as perceived by others, analog and virtual, could be experienced in Christian Stein's position?

• KB On the five floors of the VR elevator by Christian Stein and gamelab.berlin, you could walk through landscapes and enter rooms in which all the research projects were presented at the end. For example, you could test the *Virtual Sensing Knife* from Maxime Le Calvé's project. Your own arms were transformed into very sharp, sword-like scalpels with which you could scan, i.e., scan and cut, cells floating in space. You became a virtual surgeon but on a nanoscopic scale. This VR experiment refers to the actual atomically fine tip of atomic force microscopes, for which a single carbon monoxide molecule is used. Here there was even the addition of a sensor-equipped *hanbok* shirt that supported the audio-visual VR experience with vibrations. → Stretching Senses, 305

On another floor within VR, man-sized stones weathered to dust in a matter of seconds when touched.

If you had previously visualized the duration of erosion, including touching river pebbles, in eight stages to clay dust, this extreme time-lapse made you feel, as some visitors remarked, god-like. Or like an even older or more solid stone, bearing witness to the weathering of others, or simply hard-to-imagine-old. I particularly liked using one function. ❑ Exhibition, fig. 18, 138 I let visitors place their hand on the red sandstone wall for a while. When they took it off, a glowing red handprint appeared on the virtual sandstone wall, which they could then watch fade away. This suggested the ability of the sandstone wall to actively communicate its heat sensation, while the human hand had absorbed the coolness of the wall. In many encounters in the exhibition, and especially in the feedback on my performance, visitors expressed a special sense of well-being. This seems remarkable to me, because recognizing activity and effectiveness in the material in an unusual way could also be perceived as a painful

loss of control. Mind you, the audience was very heterogeneous. But can it not also be reassuring and liberating to leave the anthropocentric horizon? I think with Epictetus that this can succeed if we recognize and accept what is not subject to our influence. Metaphorically, I try to draw that.

• CB You basically had a dual role—on the one hand the task of performative mediation and on the other your own artistic performance during the finissage. Normally these are activities that you perform separately. For you, this was the first time that you took on both roles in an exhibition. What was this experience like for you, combining mediating and artistic practices for the first time? Was it also experimental and exploratory for you? And what new impulses did this give you? In both directions?

• KB Above all, the obviousness of the dual role was new for me. The fact that I was officially involved in an exhibition as a mediator and artist for the first time was also made clear in the two-part structure of my performance. In the first part, I led my audience along a classic course (introducing them to their task), in the second part I acted exclusively as a performer/drawer. Just as a change of costume is usually used as a means of illustrating a change of role, I emphasized the connection between my »double role« by wearing a white lab coat throughout, like the one Clemens always wore in the exhibition. As an art mediator, I have always incorporated artistic moments into classical exhibition tours alongside workshops. During my first mediation assignment in 2000 for *Seven Hills* and *Theatrum Naturae et Artis*, the Federal Millennium Exhibition at Martin Gropius Bau, I used seven and eight fresh lemons, respectively. In 2005, for the big *Stanley Kubrik* exhibition in the same building, I boiled a femur calf bone, cleaned, and prepared it. About 40 cm long it was classified as a weapon by the house management. In the end, with support from the very top, I prevailed against all odds and was able to give it to visitors during my guided tour of the exhibition so that I could later use their experiences for a key moment in Kubrick's cinematic oeuvre, one of the most famous match cuts as time jump in film history. An ape throws the cudgel-like bone high into the sky where it seemingly transforms into a similarly shaped spacecraft. It frames the evolution of men from an early use of tools to the travel through space. My interpretations of the respective exhibitions thus took on an artistic form. They were participatory mini-performances based on multi-sensory perception and interaction with the specific materiality of the objects brought along during and in the context of the tour through the exhibition. Over the past two decades, both the influence of mediation on curation and the possibilities for artistic mediation in exhibition venues and museums have changed considerably. However, the possibilities at *Stretching Materialities* as a publicly accessible, interactive, transdisciplinary laboratory were quite unparalleled.

• CB And from an artistic perspective?

• KB As an artist, I have always realized participatory art projects. Examples include *Überall! ist unser Zuhause* with several dozen long-distance truck drivers on the disused AVUS Nordkurve in Berlin or *zwischen Himmel und Erde.* with a village of 1300 souls in Münsterland for my work series *Performative Drawings*. These are designed to last for weeks or months and include mediating activities. Already in my theater days I was interested in invisible »stages« of everyday life, places where something new or unknown subtly emerges. My art studies in California in the 1990s were influenced by what Nicolas Bourriaud later called Relational Art. These were contemporary artistic practices that took human relationships and their social context as their theoretical and practical starting point. In *Stretching Materialities,* we spent months intensively exploring and experimenting with the exhibition, its positions, themes, location, and audience, i.e., with the relationships between active materials in the field of objects, actors, and spatial structures. I found that to be a great privilege. It was above all your research topics that inspired me to create a chemical perspective and new forms, such as *Osmotic Fingers, Shadow Drawings, Bending Organ*, etc., and other works that I did not integrate into *dancing CaCO3*. What was new about my dual role in *Stretching Materialities* was that my artistic and mediating activities apparently oscillated and how strongly they influenced each other. The scientific-creative dimensions, in which you understand matter as active and capable of action, as a dynamic force that unfolds and organizes itself, were enormously inspiring for me. I can't say whether I will continue to develop a performative double role as in *dancing CaCO3*. I would rather merge the roles further.

• CB What role do activity and liveliness play in establishing a connection between your performative work and the movements and stretchings, which in turn were the themes of the exhibition itself?

• KB This is where the oscillation I just mentioned gains central importance for me, because my artistic work has always been based on theories of process philosophy. One of the basic assumptions is that material things are nothing more than a temporally limited, stable order of processes. Important aspects for me are therefore time, movement, change, flow, and emergence as well as transitions and thresholds. Kolams are originally understood to be daily renewed threshold drawings that celebrate the transition between inside and outside, private and public, night and day, the sacred or special and profane, etc. And so *dancing CaCO3* was also about transitions, moving back and forth and through: from the molecular (the abstract chemical formula) to objects that trigger concrete multisensory experiences, from concentrating on the moment to opening up into dimensions of Earth ages, from the strong individual focus of attention (perception with the help of one's own body) to the communal component in space (security, trust), from active doing to surrendering, being guided and allowing oneself to wander through the material, from the laboratory to the ceremony.

• CB As a final question, I would be interested to know whether your participation in our exhibition *Stretching Materialities* has left any traces and whether, in retrospect, there have been any repercussions for your own artistic work.

• KB I had actually taken the enforced corona break as an opportunity to leave my mediation work behind me. However, in addition to the fascinating subject matter, I immediately accepted the request from *Stretching Materialities* precisely because of its conceptual openness. The collaboration in *Stretching Materialities* therefore had no effect on my mediation work for the time being but all the more so on my artistic work: last summer, I pragmatically incorporated the idea of the ceremonial performance into the exhibition *Erdflug,* which I realized in intensive collaboration with the performance artist Klaus Boegel at Wasserturm Geldern. This could be the beginning of a new series of works. The participation in *Stretching Materialities* inspired me to expand my artistic concern of redefining atmospheres with your concern. I wanted to make tangible that non-living objects can have their own »agency,« which manifests itself in interactions, movements,

or changes and how human and non-human entities participate together in the shaping of realities. The reduction of my stone powder to its main chemical component was inspired by the numerous scientific observations of matter in the exhibition. I definitely want to pursue calcium carbonate further but also explore a possible material side of infinity forms. *Stretching Materialities* rekindled a long-held desire to work with mathematicians on the kambi kolam patterns. After all, they can be described mathematically in many different ways, via the Euler path, certain fractals, tiling, Lissajous figures, waves, and symmetries in general.

But finally, and most importantly: the process-oriented concept of an exhibition as a laboratory inspires me to open up my »Kolamschule,« which is activated for participative projects, to a »Kolamlabor.« The »Kolamschule« played a central role, for example, in the above-mentioned works *zwischen Himmel und Erde*. and *Überall! ist unser Zuhause*. I taught performing and drawing skills as well as practical and theoretical philosophical exercises. It was not the artistry or originality of the drawing that was important to me for the final performance but the conscious and reflected devotion of the performers to the materiality of the form, as in *dancing CaCO3*. The performers participated with their context-related identity, here: villagers and truck drivers in their everyday environment in my transcultural intervention. By taking the South Indian form into environments where it was unknown, I changed the parameters of this experiment. There I used documentary means to observe how the atmosphere changed. My studio is actually already a »Kolamlabor.« I experiment here with specifically selected aspects of kolam-making. However, a »kolam lab« could become a place where people are invited to conduct joint experiments, e.g., mathematicians on questions of embodied mathematics... Last summer and before that, I hung upside down and tried my hand at Lissajous figures. I'm interested in how we perceive ourselves simultaneously as matter and as part of the material—and of processes.

• CB Dear Kaaren, thank you very much for taking the time to talk about our exhibition *Stretching Materialities,* your central involvement in the performative mediation, and your artistic performance *dancing CaCO3* in retrospect.

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STRETCHING MATERIALITIES IN BUENOS AIRES

Christian Stein in conversation with Chana Boekle

Intermezzo 5

• Christian Stein: Hello Chana, it's nice that we can reflect on *Stretching Materialities* in Buenos Aires again today. The exhibition came to Buenos Aires in the art museum Sivori after it had already been shown in Berlin, with the idea of adapting it to the new environment and seeing this adaptation as a learning process within exhibition making. What does it mean to transplant such an exhibition, which was made specifically for one space in Berlin, to another place, to another culture with a different audience and a different team? And I would like to hear from you briefly about what you remember, how the project actually began and how this cooperation started over a long distance—also across disciplines.

• Chana Boekle: Yes, at first it wasn't quite clear to us what the idea was and we actually thought that we would host your project and just show it. And then, through our long interdisciplinary discussions, we came up with the idea of involving an artist. Luckily for us, the artist Daniela Castillo Cortez was very enthusiastic about the project and had a lot of ideas, so it developed into something bigger than it was at the beginning. The idea was originally to exhibit the VR headsets and show the different levels of the virtual exhibition as originally shown in the *Stretching Materialities* exhibition in Berlin, yet it then developed into a large installation which included live art, which doesn't happen very often in museums. A lot of things came together that are not normally on display in a museum or an art museum, and certainly not in Buenos Aires. In Argentina, this type of technology is generally not as widespread as it is here in Berlin. One of the ideas behind involving the artists was that they would adapt the project to the institution, because Sivori is already a museum. It actually shows art in a fairly traditional way up to modernism. And *Stretching Materialities* was a pretty good fit to not only show science like art but also relate science to art. As the artist Daniela Castillo Cortez herself had exhibited a work in the exhibition space, the timing was also very good (fig. 1).

Fig. 1: Creating the initial weaving structure in the exhibition space in Buenos Aires

• CS And what do you think was important for this interdisciplinary collaboration to work? It might not have worked with every institution in Buenos Aires.

• CB Exactly, one of the things that was important was mutual trust. First and foremost, it was important for me to have the institution's trust. We started just before the Christmas break and most of the staff were already on vacation. Of course, I had to communicate a lot, but trust was pretty much the key for us being able to continue working. And then trust developed very quickly between the three of us, Christian, Chana, and Daniela. I remained close friends with Daniela, the artist, after the project. We worked together professionally and knew that everyone was working in their own lane and not hindering the other parts and perspectives of the project. So this constant communication was really important. I was more of a producer than a curator, so to speak. The constant contact with you and Dani was central for me to see what could be realized. Dani and I lacked the knowledge of what could be done. We had several meetings to understand what we were actually doing. Somehow our personalities were also a good fit. I think we three actually often like to say »yes« and »we'll try this now« instead of seeing it differently. That's why it was a good fit.

• CS And what impression did you have of the ideas that we then developed together in several discussions, actually mainly the three of us? Did these ideas also come across to the audience, or was it really just an unusual technological experience?

• CB We were actually able to convey a lot to the audience. Of course, the decision to always have someone from the education sector present was also very important. Or, above all, the decision to ensure that visitors can contact someone if they have any questions. So just having this option makes a big difference, I think. That's why this really was a project in which we placed a lot of emphasis on communication. First of all between us in the team, but then also between Daniela, the artist, and Valentina, our colleague from the education department, who was really there to answer the questions.

One of our goals was to show the democratization of knowledge, and it was important that, in order for knowledge to be democratic, you could also ask someone and discuss it. As a result, there was a lot of communication, including questions and comments from the audience. That's what we wanted to achieve with the project, if only because there were several people there to talk to. The idea of democratization was important because it would allow people to approach the topic rather than be frightened. It was important that there were approachable people signaling their willingness to discuss. This also meant that the exhibition couldn't function with its full discursive potential the whole time. So we had times when the artist would work live in the exhibition and could be approached and others, in which the artwork spoke for itself (fig. 2).

Fig. 2: Live Performance of VR and live-weaving of the network by Daniela Castillo Cortez with *Structural Textiles*

• CS Do you have the impression that this live development of the network, which Dani worked on, could also have had a repercussion on her understanding of art or even that of the museum as an institution?

• CB In any case, that became clearer to me when I was working directly with the artist, clearer than when I was working with the institution. A public museum also has different institutional ways of implementing things. Sometimes it's not so easy to break new ground. For us, these were completely new ideas and approaches. Even just the idea that we could combine art and AI so well, for example, was a great and novel experience for us. Many new questions arose for Daniela, and she also incorporated a bit of technology into her artwork. She actually creates textiles, using a very old technique knotting strings together to a spreading network—every string is woven into its particular connection point. She has shown the value of this technique once again. That alone was a great accomplishment for her, as she recognized that her work is also a kind of technology, just different. This realization was very interesting for me to observe. I also liked the way she familiarized herself with other technologies.

• CS There were many parallels, although at first glance you would have thought that the understanding and approaches were very different. We also brought a wicker structure from Berlin to Buenos Aires and combined it with Daniela's thread textures. How did you feel about that? It was actually an attempt to connect structures across very distant places and to bring them into an integrated form.

• CB I have to talk from an aesthetic perspective first because that's more my area, so aesthetically speaking I thought this connection was a clever strategy to alter the museum space by inserting a central object from a different context. Having this structure on site supported the whole installation. I personally found it interesting because I was able to get to know the details of the structure and the artist too. Unfortunately, this part was not so easy for the audience to understand. We had done a lot of research in advance and therefore had a multi-layered insight. A large part of the audience asked themselves questions, as the structure was also mentioned in the text. There were specific questions about its meaning and modes of fabrication, but I don't think the whole scientific background was understood so well, partly because it was really very complex and a completely new experience for most people. And I think that most people first realized that they were dealing with a completely new technology that they don't normally have at their disposal. When we got the structure, we realized in quite a material way that we were working with scientists. And the connection between Buenos Aires and Berlin also became clear through a material object.

• CS Yes, the objects also connected the places. I have more questions about the processual aspect: the exhibition had been developing continuously, all of us carried out the work directly in the exhibition. Were there any questions from the audience? It was an experiment. Did it work? Can you actually start something in the exhibition that is not yet finished and develop it over a longer period of time? How do you think this approach was perceived? Was the process even perceived as participatory or as a performance? Or perhaps even as unfinished (fig. 3)?

• CB What you just described was very important to me and Daniela. The visitors actually had the feeling that they were involved, and that's normally not the case in the art world, which I personally think is a shame, because it really sparks interest when you feel that you're actively participating. That was the first reaction we got from the audience. Sometimes they said it, sometimes they didn't, but that was the basic feeling. Visitors left the exhibition with the feeling that their knowledge, their data, or something they have done has had an impact on the work. And that also changed the audience's relationship with us a lot. You could see that, for example, when people took selfies in the museum. Then, out of curiosity, when we were allowed to, we looked to see what effect these selfies had on us and other commentators when they were posted.

And that was very often »I was there, I've seen this work.« It was interesting for us to know that it really makes a difference for the audience to feel involved in the artistic work. So it's a decision to involve the audience. That was also one of the aims of the project, to overcome the distances between institutions and visitors, to make people feel involved and raise their awareness and interest. There were visitors who came back and recognized the changes in the artist's work.

As a result, the artist Daniela also made other decisions that we hadn't even considered at the beginning. In the beginning, we talked a little about abstraction from an aesthetic and curatorial perspective. Because the audience felt so involved, at some point we made the decision to move from abstraction back to the figurative, because that simply strengthens the relationship between the audience and the artwork. Daniela did a great job and took it to the extreme. Sometimes she even incorporated the faces of the audience into the work.

Fig. 3: The woven structure after a couple of sessions some weeks later

• CS This involvement also changed the artwork and the way of making art. So on the one hand, of course, we had the faces, the impressions, the conversations with the audience, even while Daniela continued to weave the artwork. And on the other hand, we also had an algorithm implemented in the VR app, which translated the audience's movements in VR into instructions for Daniela in an abstract way. For example, if they moved a lot, this translated into a »dense network« instruction for Daniela and the other way around. So it really was a connection that wove the virtual directly into the physical, so to speak. How did you perceive that? Was this a purely metaphorical connection or did it also change Daniela's work?

• CB I think these instructions, this part of the exhibition, had an effect on Daniela in particular, more than on the audience. The project or what they saw in VR was already exciting enough for them. But I think it made sense for Daniela to find an instruction somewhere and get started somehow. Sometimes the freedom is too great otherwise. Yes, and then you're a bit overwhelmed. And for her it was something nice, something good, and something practical to actually be able to start there too. She then also started to pay attention to the audience herself and then perhaps sometimes made different decisions.

• CS Would you say that your perspective on what art is changed as a result after the project for you?

• CB I think the experiences within the project have brought about very big changes, especially to the concept behind artworks. Which is very important. We're noticing that ourselves right now, we're still working together, that our bibliography has changed, for example, or that we have a different idea of how we can incorporate technology, and that we're no longer so afraid or scared of it, now we know that it can be a real enrichment and that we can live together very well. That has already changed a lot. Technology-related art has also changed our professional future, because we didn't choose technology-related projects before. But we've already started working in a more multidisciplinary way than before because the idea of multidisciplinarity has also changed a bit for us. You're a bit in the ghetto in the art world and you assume that as a curator you only work with artists, but since we were also able to show something scientific, it was very important for us to realize that everything has become bigger.

• CS Yes, the discussion should be about a dialog between art, science, and museum in this triangle. And perhaps I'll ask something else about the mutual learning processes: did you have the impression that we as the Berlin team also learned from you and took something away from the artistic and museum sector?

• CB I hope that you have. That's a difficult question that I can't answer very well because I don't know what exactly you had in mind. But I think it was definitely an invitation to include art in scientific projects. As a curator I see that every exhibition is an opportunity to go on stage and show things that raise questions and not necessarily just show answers. And we were pretty much on the same track. For both the scientists and us, it was more important to raise questions than to show answers. And then I think that every exhibition or every presentation is important because it's an exercise in thinking about how we communicate. And sometimes it works very well through art.

I also hope that you have come to this realization from your side. These are different strategies, visual strategies, which also have to do with how we humans perceive information and how information has developed today. The fact is that we are more focused on the visual than on the written word, which is one of the many ways to show something visual.

• CS I find exciting what you just said in relation to visuality. Do you think we have reached a different audience than perhaps an audience that would go to see a science exhibition? Or how would you describe the audience? You are an art museum in the heart of Buenos Aires, so maybe you normally have a different audience or a specific audience?

• CB Yes, in any case, our exhibition has expanded the audience, we could see that immediately. Daniela and Valentina's event was on Wednesdays and Saturdays and you could tell from the number of people alone that it wasn't always the same people who came but also new ones. And I think the fact that you could find different points of contact was also a strength of the project. You could link it to art, or for someone who is more interested in science, to science, and those who are more interested in digital technology came for that reason. There were very different levels and points of contact. It was an enrichment for the audience and it was really well attended.

Fig. 4: Visitors exploring the VR experience with hand tracking and gestures

The exhibition was extended because it worked very well. And for me personally, it was important to see that there is a very traditional art audience that gets the opportunity to try out digital technology like VR, which they probably wouldn't have done otherwise. Equally, the institution in which this happens is important because it gives a kind of confirmation that this is culture, art, so to speak. So they accept it. It was interesting to see, for example, how a group of older women kept coming back several Saturdays in a row, who would normally, as we discussed with them ourselves, not have been interested in this at all. A scientific museum would not have interested them at all, but the fact that it was an art museum, which they regularly visit, changed their impression, and they told their friends about it. Every Saturday there was a large group of art fans of different ages, who you wouldn't necessarily expect to be interested in digital technology (fig. 4).

• CS I have another question about space. Our Berlin exhibition placed strong emphasis on the exhibition space, TA T, the veterinary anatomical theater. And that was also an important question for the exhibition's journey to the Museo Sivori, right from the start. Do you think that the location had an influence on the way the exhibition turned out? We found a special corner in the museum with strong light effects due to the sun's illumination of the structure. This also resulted in difficulties with the VR, as the hand tracking failed at times. How would you describe the relationship between the exhibition's realization and its location?

• CB I think it was a well-chosen location, especially because it became a bit intimate. It was open because the walls were made of glass and you could also see the beautiful garden. And I think that also had the effect of not feeling cramped. All the artistically woven webs around it could have created that feeling. With regard to what I said earlier, I think it was also important that the communication aspect was also very suitable. I don't think it would have worked as well in the large room, where the work also connects with other works. The exhibition was staged in an extra room, which is not actually a room, it was part of the corridor. We turned it into a hall and it was very important to have this intimate feeling.

• CS For me, this willingness and that we were able to do this at all was also really important. Perhaps this relates to the trust you mentioned in the beginning. In the end, crucial parts of the exhibition were literally stapled onto the walls. Of course, it was invasive, in a way, for the space, to say that you actually accept this damage to the museum walls in order to redesign and realize this space and really create an impact on the materiality of the space. It wasn't just hanging up and exhibiting things, but actually really changing the space through the installations, connecting the work with the space, that's what you accept.

• CB Yes, that was a very important part of the exhibition, also for the artist and for me, that through this networking there is also the idea of actually changing the walls or the space. That also has to do with the fact that we both have a lot of experience with installation and production and that we knew it had to do with the museum's trust, of course, but we also trusted our skills that we'd be able to undo everything afterwards.

• CS Thanks for the conversation, Chana.

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Biographies
Object Space Agency

Claudia Blümle is tenured Professor of History and Theory of Form at the Institute of Art and Visual History of the Humboldt-Universität zu Berlin since 2014. She taught Aesthetics and Art Theory at the University of Fine Arts Münster from 2009 until 2014, where she also acted as appointed Vice Rector of Scientific Study and Research from 2010 to 2014. Together with Beat Wismer, she curated the exhibition *Behind the Curtain. Veiling and Unveiling since the Renaissance. From Titian to Christo* at Kunstpalast Düsseldorf in 2015. In 2024 she co-curated the exhibition *Dora Hitz. Fighting with the old for the new* in cooperation with Villa Liebermann am Wannsee. Claudia Blümle co-edits *Regards croisés. Deutsch-französisches Rezensionsjournal für Kunstgeschichte, Literaturwissenschaft und Ästhetik* and *Bildwelten des Wissens. Kunsthistorisches Jahrbuch für Bildkritik*.

Yoonha Kim is an anthropologist with a background in design. She is a research associate at *inherit. heritage in transformation* focusing on the theme Decentering the Human. Her recent project explores alternative worldings, addressing ecological sensibility and diversifying technological imagination through wearing and making Korean sartorial heritage. Her previous education in fashion design at Central Saint Martins–University of the Arts London (GradDip) and Visual and Media Anthropology at Freie Universität Berlin (MA) led her to deploy a range of multimodal forms of anthropology, from curatorial practices to filmmaking and sensorial workshops with emergent technologies. She has also conducted various modes of interdisciplinary research within »Matters of Activity,« where she is an associated member.

Maxime Le Calvé is an anthropologist of art and science working as research associate at the Cluster of Excellence »Matters of Activity.« He is the Co-Founder of the Speculative Realities Lab. He trained in general ethnology in Paris Nanterre and holds a PhD in social anthropology and in theater studies from EHESS Paris and FU Berlin. In his latest ethnographic project, he explores navigation practices in neurosurgery, using drawing and digital prototyping as field methods. He is the author of *Golden Pudel-Ethnographie,* a monograph on an alternative creative venue in Hamburg, and has published on the ethnographic study of atmospheres (*Exercices d'ambiances*, 2018), performance art, music, the city of Berlin, brains, and ethnographic training. You can see his visual work and current exhibitions on his blog at maximelecalve.com.

Natalija Miodragović is an architect whose interdisciplinary and experimental work starts from an understanding of art and space as vehicles for social change. Her work focuses on perceiving and using space and lightweight, flexible, and textile structures. As a researcher, she has taught at the Institute for Architecture–Related Art at Technische Universität Braunschweig, Weißensee School of Art and Design Berlin, and Frankfurt University of Applied Sciences. She works in cooperation with artists, e.g., Tomas Saraceno, and researchers and co-authored a series of projects and exhibitions, such as the Serbian Pavilion *EXPO 2010* and *dreidreidrei Organ* for Zionskirche Berlin.

Nina Samuel is an art and science historian and curator with a PhD from Humboldt-Universität zu Berlin. Her thesis *The Shape of Chaos* investigates visual epistemologies in the field of complex dynamics and fractal geometry and drawing as a mode of thinking. She held various research positions, among others with Technisches Bild (HU), Embodied Information–»Lifelike« Algorithms and Cellular »Machines« (Freie Universität Berlin), and at the Bard Graduate Center in New York City. Samuel has received scholarships and research grants from the Fulbright Program, eikones Basel, and the Max Planck Institute for the History of Science. Before joining »Matters of Activity,« she was program director of the museum-centered PhD program »PriMus–Promovieren im Museum« at Leuphana University Lüneburg. Since 2024, she has been head of the department »Fostering Knowledge Exchange« at the Berlin University Alliance, where she actively shapes the interfaces between research, art, and society. Her work includes curatorial conceptualization, such as designing a series of performative and participatory knowledge exchange events on the topic of water in urban space.

Christian Stein (editor) studied German and computer science, received his doctorate in literary studies, and has since been active in the border area between the humanities and the technical sciences. He is employed at the Cluster of Excellence »Matters of Activity,« where he leads the Object Space Agency project, among others. He was the head of the research area »Architectures of Knowledge,« consisting of six projects, at the Cluster of Excellence »Image Knowledge Gestaltung,« which concluded in 2019, and is co-founder of gamelab.berlin, which deals with games as a cultural technique. In this context, he has focused on the development of game prototypes in the field of museums and medicine. This includes the development of innovative museum games (e.g., *game+ultra* and *Mein Objekt* at Humboldt Forum) and VR applications (e.g., *Neurosurgery 360* and *Kenia VR*). In addition to his focus on games, he is working on artificial and natural languages (semantic web and modeling) as well as an interdisciplinary theory of interface, on which he is currently completing his habilitation project.

Clemens Winkler (editor) is a design researcher at »Matters of Activity« and since 2022 Visiting Professor of Digital Media at the University of Performing Arts Ernst Busch, Berlin. He studied at the Royal College of Art, London, as well as at the MIT Media Lab, Boston. His research focuses on the vulnerability and resilience of materiality in the context of eco-social, affective, and planetary concerns. With his students, he develops pre-enactments of knowledge cultures and playful dramaturgies for multispecies collaborations. He led the curatorial collective in *Stretching Materialities* as co-lead of Object Space Agency. Clemens runs his design studio *Material Narratives*, contributed to research platforms such as *Enactive Environments* (ZHdK/ETH Zurich), and *BauKunstErfinden* (University of Kassel). He has exhibited internationally, including at V&A London, Kiasma Helsinki, and the Design Museum Zurich.

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Stretching Materialities is an experimental approach to rethinking exhibitions in terms of »active matter:« not as a presentation of material knowledge and practices per se, but as an interactive and participatory research approach to new forms of activity emerging from the poiesis of the material. The interdisciplinary exhibition by the Cluster of Excellence »Matters of Activity« at Tieranatomisches Theater (TA T) Berlin experimented with curatorial processes, the existing environment and its material-energetic resources, sound performances, the interweaving of physical and virtual matter, and a constantly changing exhibit.

With highlights such as a physical cloud in the middle of the exhibition space, virtual tours through six unique VR floors, experiencing decaying rocks, inhabitable woven fabrics, or haptically enhanced hanboks as a special wardrobe, visitors were entangled as active contributors and recipients in an ongoing process. This publication documents the exhibition's theoretical foundations, the process itself, and valuable insights gained.

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