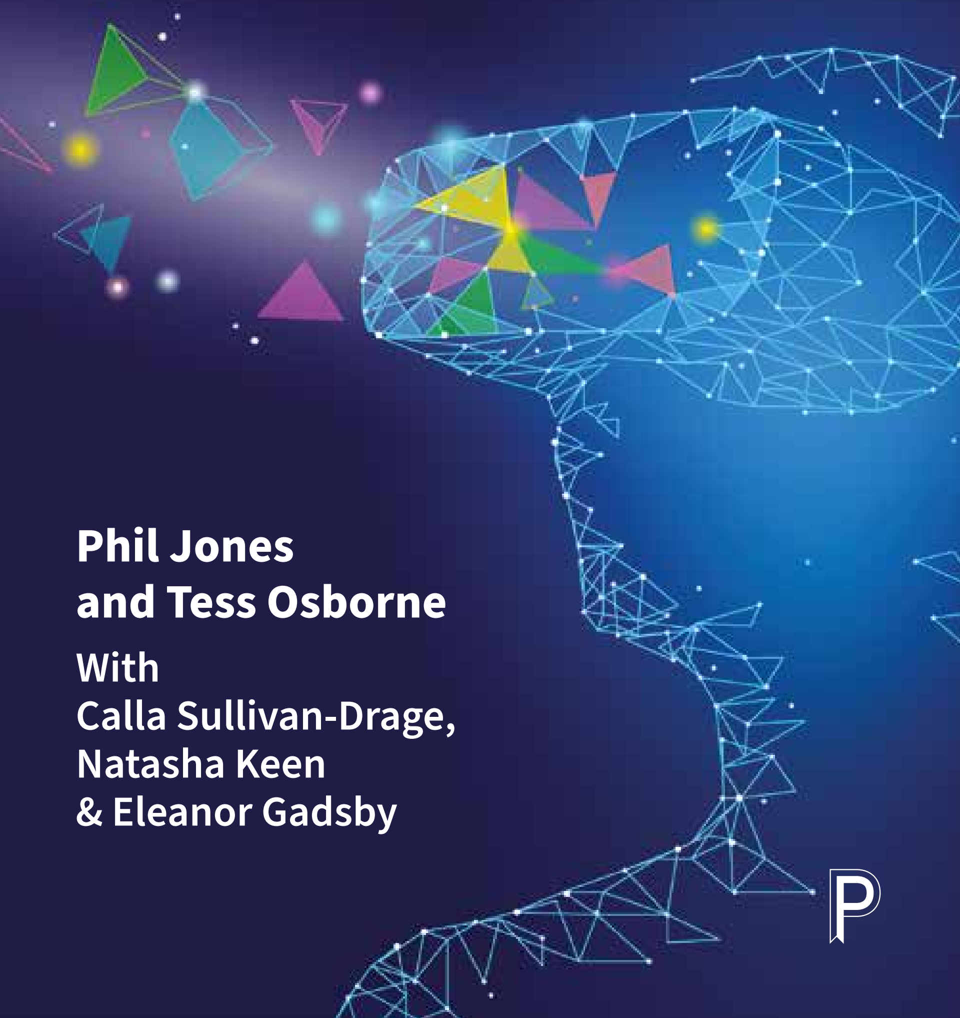
VIRTUAL REALITY METHODS

A Guide for Researchers in the Social Sciences and Humanities



**Phil Jones
and Tess Osborne**

**With
Calla Sullivan-Drage,
Natasha Keen
& Eleanor Gadsby**

PHIL JONES AND TESS OSBORNE
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List of abbreviations

AR	augmented reality
CAVE	cave automatic virtual environment
EEG	electroencephalogram
FPS	first-person shooter
HMD	head-mounted display
MR	mixed reality
POMS	Profile of Mood States
PTSD	post-traumatic stress disorder
VR	virtual reality
XR	extended reality

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ONE

What is VR and why use it in research?

Introduction

The appeal of popular entertainment is to let us escape our mundane everyday realities and slip into another world filled with excitement and adventure. From TV and films to novels and games, different forms of media allow us to picture a different life. One of the reasons why the idea of VR appeals so much is because it goes beyond merely *imagining* ourselves in a different world and allows us to actually *be there*, living a different life in a digital realm. The classic William Gibson novel *Neuromancer*, TV shows like *Caprica* and many movies, from *Lawnmower Man* and the *Matrix* to *Ready Player One*, have created fictional futures where we can plug our consciousness into digital platforms and be transported into a virtual world.

Sadly, however, the reality has never quite managed to live up to the fiction. VR is a clunky, imperfect experience. Head-mounted devices (HMDs) for viewing VR material, along with associated technologies for monitoring bodily movements and reproducing them in virtual environments, can be expensive and awkward to use. Despite decades of hype, consumers have not rushed out in huge numbers to buy the equipment required for immersive VR experiences, which remain of relatively niche interest. Nonetheless, these technologies can offer incredibly compelling experiences, where you really do believe that you are being attacked by zombies, flying a plane or wandering around a fantasy kingdom. It is these qualities of believability and immersion that means VR offers some very exciting research opportunities for social scientists and humanities scholars, even those who have little interest in the technical details of how it works.

This short book is intended to serve as an introduction to using VR within research projects. There can be a perception that work using VR requires a great deal of technical expertise; indeed, the majority of projects in this area to date see researchers coding their own customised virtual experiences. This does not, however, need to be the case. We examine a variety of possible methodological approaches to using VR, building in complexity as we go through the book. Each of Chapters 2 to 6 undertakes a critical review of approaches in different methodological areas and includes a worked example taken from our projects within the University of Birmingham's Playful Methods Lab. The lab serves as a base for postgraduate and postdoctoral research examining different ways to integrate new technologies into qualitative social science projects.

This introductory chapter explores the research potential offered by working with VR technology and seeks to demystify VR for non-specialist scholars. Following brief definitions of terms, we explore the reasons why researchers may wish to employ VR within their projects before we go on to examine questions of immersion and presence. We then situate current VR research within a brief history of how the technology has evolved. Finally, we give an overview of the chapters in the remainder of the book.

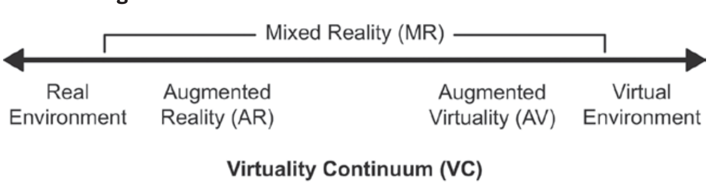
Defining terms

Our everyday activities combine sensory inputs from both the material and virtual worlds. From a Zoom call with colleagues to finding a restaurant using a smartphone, much of this material–virtual crossover is now so routine as to be unremarkable. VR and related technologies scale up this blending of the physical and digital by creating whole virtual environments that we can interact with. One of the problems with working in this field, however, is a dense thicket of terminology that can be somewhat off-putting for all but the most technically minded. Virtual reality (VR), augmented reality (AR), mixed reality (MR) and extended reality (XR) are commonly discussed, sometimes with overlapping or even contradictory definitions. We outline these briefly here to help clarify our focus within this book.

XR can be thought of as an umbrella term for different technologies that blend together the virtual and the material worlds to different degrees. According to Milgram and Kishino's (1994) original definition of MR we can therefore consider MR and XR to be essentially equivalent. They argued that MR represents a 'virtuality continuum' (Figure 1.1) that exists between completely material and completely virtual environments. Indeed, Microsoft use 'Mixed Reality' as a brand name for a number of products that blend the virtual and material in different ways.

Broadly speaking, AR can be thought of as a range of systems that allow digital objects to appear within material spaces. An example of this technology is in combining images from the

Figure 1.1: Milgram and Kishino's (1994) Virtuality Continuum shows how mixed realities blend material and virtual elements to different degrees



Source: Redrawn by Chantal Jackson

camera of a mobile phone with 3D digital models such that, for example, you could see what a particular sofa will look like in your living room (Viyanon et al, 2017). More sophisticated systems use occlusion, which means that a digital object can seem to disappear behind a physical object – for example if a person walks in between the camera and your virtual sofa. Some authors argue that where AR uses occlusion it should be defined as MR (Irvine, 2017) despite this going against the original notion of MR as a wider continuum.

This kind of ambiguity is not terribly helpful in what is already quite a confusing field. We do not even have a clear agreement about how VR itself should be defined. It sits at the end of the spectrum where the virtual world takes primacy over the physical in terms of the dominant experience for users. Even at an early stage, however, there was a discussion as to whether devices like a head-mounted display (HMD) and hand controllers were crucial to experiencing VR (Steuer, 1992). Again, this leaves some ambiguity as to whether looking at a traditional monitor showing a virtual environment, such as a 3D model of a building, or a video game, can be considered to be VR.

To avoid confusion, our primary interest in this book is in the kinds of research projects that can be undertaken where virtual environments are viewed through an HMD and this is what we will be referring to when talking about VR. Most of these environments can also be viewed using a traditional monitor, but, as we explore throughout this book, there is something tangibly different about experiencing these through an HMD, with its sense of immersion, which we believe adds significant value when employed within research projects.

Why undertake research using VR?

The social sciences and humanities rightly pride themselves on using a variety of research approaches and techniques for collecting data and discovering more about the world. VR is a tool with a great deal of potential that could be more widely used by scholars but is hamstrung by perceived technological complexity. The main opportunity it brings is in allowing people to explore experiences beyond the constraints of the physical world that nonetheless *feel* as though they are really happening. VR can therefore be used both by researchers and their participants to explore a wide range of social and embodied experiences in both realistic and fantastic environments.

Throughout this book, we demonstrate the two overlapping ways that social scientists and humanities scholars can engage with VR and the richness it can bring to our work: VR as an object of research, and VR as a methodological tool. As a research object, VR is an emerging experiential medium that warrants critical examination. As a methodological tool, when we put on an HMD, we are seemingly transported into environments and scenarios limited only by the imagination and skill of the content creator. The sense of being *present* in a VR environment shapes emotions and physical responses and can transform social interactions. This quality alone offers an exciting range of potential research opportunities to scholars.

Conducting research outside a controlled lab setting can be messy, with plenty of 'noise' and unplanned distractions. VR is a wonderful research tool to mitigate the untidiness of real situations because it allows researchers to work with immersive environments and scenarios in a highly controllable manner. We can create, or replicate, inaccessible or unavailable spaces (such as mountain peaks or restricted heritage sites) and we can work in different virtual locations without the unwanted disruptions that can occur in the real environment (such as the sound of traffic in a park). This engineering of virtual situations and spaces not only extends experience but allows interesting phenomena to be isolated and subjected to rigorous examination.

A great deal of VR research focuses on its technical performance and industrial applications. It is not our intention to examine this work here, although Jung et al (2020) have produced a useful collection that examines cutting-edge projects of this kind. What this does indicate, however, is that working with VR opens many doors for collaboration. VR has been extensively employed within many disciplines and sectors, from computer science to medicine, psychology to the military, as well as in a range of educational and industrial applications. This means that there are exciting opportunities to collaboratively create, test and implement VR projects developed in other disciplines, while building in theories, practices and constructs from the wider social sciences and humanities that could add real value to research.

Looking at projects where VR is used as a methodological tool, these tend to fall into two broad camps, being primarily interested either with effects on the user's *embodiment* in VR, or, more generally, on user interactions with the virtual *environment* – although, of course, both types overlap. We explore some of the history of VR later in this chapter, but note here that there has been a significant acceleration of research in this area following the commercial release of HMDs from Oculus and HTC in 2016. These 'third wave' devices resulted in significant reductions in cost, greater ease of use and a large quantity of newly produced VR content to examine. The shift that this represents offers a very clear research gap for a wider group of social science and humanities scholars to engage with VR beyond the usual suspects working in psychology, archaeology and education.

Decreasing cost is a major potential driver here. Although VR does require some investment in equipment, the new generation of HMDs are of an order of magnitude cheaper than the equipment that was available to researchers in the 1990s and early 2000s. In the past, specialist simulators for motor-racing, aviation and military applications could easily run into the millions of dollars (an early review of flight simulators estimated that the most expensive facilities could cost up to $100 million, Baarspul, 1990). HMDs were very large and required highly specialised computers to run them. Likewise, cave automatic virtual environment (CAVE) systems, where images were projected onto the walls and ceiling of a dedicated room or wraparound screen, were complex and expensive to operate. Not only has the hardware reduced in cost since the 2010s, so the software is no longer in the realm of the hyper specialised, with many more existing VR applications available for scholars to work with and customise to their own needs.

Nonetheless, applied VR research projects did not suddenly begin in 2016. Much of the earlier research work was dominated by medical and psychological experiments, but these studies can be of real interest to social scientists and humanities researchers, not necessarily for the science being explored but because they show how powerful VR can be when working with participants. Reger et al (2011), for example, recruited veterans who were suffering from post-traumatic stress disorder (PTSD), and used VR to deliver exposure therapy. Participants were exposed to simulated convoy and patrol scenarios, with the HMD augmented by a controller shaped like an M4 rifle, along with a vibration plate and simulated smells of burning rubber, bodies and weapons fire. The project was considered successful in producing a drop in self-reported symptoms of PTSD among veterans. Although this is an extreme example, it demonstrates how using VR to immerse participants can allow them to explore a scenario in a way that *feels* very real while remaining in a safe space.

Clinical research using VR tends to take a trials approach, exploring the difference that using these technologies makes compared with traditional therapies. Again, although the specifics of a study like Henderson et al's (2007) examination of VR in stroke rehabilitation may be of less interest to non-medical researchers, methodologically the use of a controlled trial is quite interesting. It also highlights the fact that, depending on the type of applications, VR may prove less valuable and does not guarantee improved outcomes over traditional approaches. Thus, in contrast to the apparent success of using VR in treating aversion and PTSD, Henderson et al found only weak and mixed evidence of VR being more effective than conventional therapy in rehabilitation for stroke victims.

A great deal of applied work has been undertaken around VR use in education and skills enhancement. There is an obvious advantage to training for dangerous or expensive scenarios in a controlled virtual environment where there are no serious consequences to participants making mistakes. Again, much of the research investment here has been for high-risk situations, such as surgical training (Gallagher et al, 2005) or military interventions (Lele, 2013). A review by Jensen and Konradsen (2018) concluded that, although the evidence was not overwhelming, there were particular scenarios related to skills acquisition where the use of an HMD could be useful. These included memory, spatial tasks, observation and learning to control emotional response.

Makransky et al (2019) offer a note of warning, however, in reporting on experiments where they gave students simulated lab classes both via a traditional monitor and using an HMD. A combination of self-reporting and recording participant electroencephalogram (EEG) while in the simulations showed that, while the sense of *presence* in a virtual lab increased when using the HMD, the capacity for *learning* was actually lowered. This serves as a useful reminder that virtual presence in and of itself does not necessarily bring added value. Again, it depends entirely on what outcomes an applied project is concerned with generating. It is also important to think about who your participants are. As Hayes and Johnson (2019) comment, now that VR simulations are increasingly used for training, so designers need to think about how to build in representations of bodies with diverse gender and ethnicity options. Having a virtual body that looks like your own enhances the sense of connection to the learning experience and increases the likelihood that lessons will be transferred to life outside VR.

Archaeology and the heritage sector have enthusiastically embraced the possibilities of VR as a tool for reconstructing past environments. It is a relatively short step from creating a digital 3D reconstruction of a site to making that virtual environment available to explore in an HMD. Reconstructions within archaeology have a long history, including institutions such as open-air museums, like Stockholm's Skansen, which can be used for both visitor education and research projects. As Schofield et al (2018) point out in discussing a VR exhibit of a 9th-century Viking camp built by their team, the danger is that users may not be able to tell the difference between those elements grounded in sound historical evidence and more fanciful or dramatic interpretations. Nonetheless, archaeologists use many of the same tools as game designers in producing accurate digital models of existing buildings and landscapes, including laser scanning, photogrammetry and drone-based aerial surveys. Where game designers are unashamed about the degree of invention and imagination they inject into representations of real locations (Jones and Osborne, 2020), the 2006 *London Charter for the Computer-Based Visualisation of Cultural Heritage* set out methodological principles for the creation and use of digital models within research (López-Menchero Bendicho et al, 2017).

One of the key reasons for wanting to record archaeological sites digitally is because many are fragile and difficult to access. High-quality digital records allow students and researchers to visit sites that would otherwise be off limits. The value of using an HMD here is the sense of presence, such as a project that allowed participants to walk around a photorealistic reconstruction of the 5th-century-BC Etruscan Bettini tomb that few would ever be able to experience directly (Jiménez Fernández-Palacios et al, 2017). It is perhaps little surprise that there have also been a number of archaeological VR projects examining maritime heritage (McCarthy et al, 2019). Some of these have cleverly reused older datasets, such as Secci et al (2019) taking historic photogrammetry surveys to create an immersive experience of diving the wreck of the brig *Mercurio*, which was sunk during the Battle of Grado in 1812. Costa and Melotti (2012) have even gone so far as to argue that VR heritage assets have created new forms of virtual 'hyper-tourism', disconnected from the real locations that have been captured. Custodians of the Newgrange stone-age tomb in Ireland, for example, hold a lottery each year for visitors to witness the winter solstice dawn, the experience of which is considered spiritual by some. Exploring Newgrange in VR is a very different experience, but allows this heritage asset to become disconnected from the constraints of its physical location, meaning that many more people can potentially 'visit'.

Geography is another discipline interested in the spatial qualities of environments. A great many people working in geography create and use different kinds of 3D environments, from climate and river-flow models to visualisations of complex geographic datasets. Mike Batty (1997; Lin and Batty, 2011) discusses these as being virtual geographic environments. Despite the fact that many researchers within different parts of the discipline create virtual geographic environments, surprisingly few geographers have explored the potential for using more immersive forms of VR within their research projects. An important exception to this is the work of the Serious GeoGames Lab at the University of Hull. Building off geomorphologist Chris Skinner's (2020) gamified 3D flood simulation, for example, historical geographer Briony McDonagh and literary scholar Stewart Mottram have collaborated to build a VR experience. 'By the tide of the Humber' reconstructs 17th-century Hull and river flooding at the time of the poet Andrew Marvell as part of the much wider 'XR Stories' initiative that seeks to bring storytelling and new technologies together to boost the creative economy in the Yorkshire and Humber region of the UK.

McDonagh and Mottram's project is unusual in coming out of the qualitative and humanities side of geography because work using 3D modelling is more commonly employed by physical scientists. In part, this reflects an issue that we explore throughout this book, where the technical nature of creating

VR experiences tends to exclude social science and humanities scholars unless they can find a skilled collaborator to work with. Many of the case studies that we explore in the subsequent chapters, however, make use of existing VR resources rather than developing new ones.

A really nice example of this approach is a teaching project undertaken by the geographer Patrick Hagge (2019). Undergraduate students were asked to prepare a guided tour of a global location to share as a presentation with the rest of the class. The twist was that they could give the presentation through Google Earth VR. Drawing on the same database as conventional Google Earth, the VR version presents a highly detailed, stereoscopic rendering of different landscapes and settlements. The student presenter wore an HMD and navigated the virtual site that they were giving a tour of, while the rest of the class watched the output of the headset on a traditional screen. This mode of navigation gave the class a more 'in-person' perspective than simply zooming around on Google Earth as normal, though it was not without drawbacks as an approach. Some female students in particular were less keen to engage in this voluntary activity. A common concern was the fear of looking ridiculous while cut off from the class they were standing in front of. Again, this is an important point to consider methodologically – not all participants will be happy to don an HMD in public.

Most of what we have discussed so far has related to computer-generated environments presented in an HMD. One can, however, record 360° photos and videos of real environments that can be viewed in a headset. As a technique, this has relatively low barriers to entry in terms of creating content and experiences for participants to engage with – as we will discuss in more detail in Chapter 5. Some professional film-makers and media organisations have created high-quality 360° content that can be reused within research projects. Thus, news reports can give some sense of being in a site at a particular point in history (Watson, 2017), for example the

BBC's 360° report from the Calais 'Jungle' migrant camp in 2015. The journalism scholar Sarah Jones has undertaken some really interesting projects in this area, not least examining whether the claims that this technique generates greater empathy among viewers stand up to critical scrutiny (Jones and Dawkins, 2018b). She has also experimented with questions of immersion in 360° media, which is sometimes claimed to generate less sense of presence because it lacks interactivity. Adding heat and smell stimuli while viewers were watching a documentary film shot in Hong Kong's Chungking Mansions notably increased the viewers' sense of being present in the scene (Jones and Dawkins, 2018a). Thus, when considering the use of existing 360° footage in a research project, the powerful effects on sense of presence created by the non-visual senses should be borne in mind.

Immersion and presence

One of the reasons why HMDs are so appealing is the 'wow' factor (Heim, 2017). Putting a headset on for the first time and being able simply to turn your head and look around a virtual environment that completely surrounds you is genuinely impressive. If you are wearing a more expensive device, realising that you can physically *move* in that virtual space – walk around, crouch, see the movement of the hand controllers reproduced in front of you – can be genuinely magical. A common response by novice users is literally to gasp.

Once you get past the initial shock, however, one quickly begins to wonder about the *point* of VR; essentially, what is one supposed to *do* in these virtual worlds? This lack of obvious applications proved to be a real problem and, after an initial flurry of excitement around 2016 to 2017, a number of companies subsequently abandoned their VR efforts because of customer disinterest. Inexpensive VR devices such as Samsung Gear VR and Google Daydream have been discontinued, with no rush by their manufacturers to create new versions. Nonetheless, from a *research* point of view, the capacity of HMDs to generate a sense of being *in* virtual space is a fascinating quality that creates interesting opportunities for projects.

We should, however, briefly pause here to distinguish between immersion and presence. *Immersion* is a relatively objective measure, determined by the kinds of technologies being employed in a VR system, both hardware and software, that are intended to generate a sense of being located within a virtual world. *Presence* is more subjective and dependent on the perception of the individual. Different participants can each feel more or less present in a virtual world even when using technologies with the same immersive potential (Bowman and McMahan, 2007).

There are multiple, competing definitions of presence in VR (for a review, see Schuemie et al, 2001). Lombard and Ditton (1997) give a useful starting point for thinking about this, identifying six different markers of presence:

- Presence as *social richness*: the warmth felt when interacting with other people in the virtual environment.
- Presence as *realism*: whether the medium appears to accurately reproduce elements of the material world.
- Presence as *transportation*: the sense of *being there*.
- Presence as *immersion*: the extent to which the senses are convinced by the virtual medium.
- Presence as *social actor within medium*: whether the user responds emotionally to a representation of a person within the environment.
- Presence as *medium as social actor*: whether the environment itself can be perceived to be a social actor.

Not all of these elements have the same significance at the same time in different VR scenarios. What is interesting, however, is that the emphasis is not simply on how sophisticated the graphics are – although this can be important – but also on the sense of socialisation and co-presence with other people, both real and computer-generated. This is a theme that we will return to in Chapter 4. It is also clear that not only can VR be highly effective at generating emotional response, but emotional response and sense of presence are mutually reinforcing (Riva et al, 2007).

Early academic work on VR focused on its psychological effects and the capacity to fool our different sensory perceptions into reporting that we are in a different location, even going so far as to claim that, 'The intent of all this [sensory] input is to sensitize the computer to the user, to turn every movement into a creative tool and means of communication' (Biocca and Delaney, 1995: 63). Commentary about VR in the 1990s was filled with this kind of utopian language, despite the technology being a long way from being able to deliver on these ideals. Even at that early stage, however, experiments showed the power of immersion, with HMD users shown to be significantly faster at an orientation task than those viewing the same virtual environment via a monitor, because of this much greater sense of presence within the scene (Pausch et al, 1997). Users can even develop a sense of physical connection to virtual limbs as depicted within an HMD – a connection that indicates the malleability of our body image (Yuan and Steed, 2010). This illusion that the body itself exists within the virtual environment has been used in clinical contexts, with burns victims reporting significantly less pain when immersed in VR (Hoffman et al, 2001). This sense of connection to the virtual body can be even more noticeable when reinforced with minor haptic effects – a slight vibration of the hand controller when firing a virtual gun adds a sense of *solidity* to the experience.

The evolution of VR

Histories of VR explore different precursors, from Plato's cave to Victorian stereoscopic images and Morton Heilig's

Sensorama (Burdea and Coiffet, 2003). The Sensorama was a fascinating (if slightly Heath Robinson) demonstration device that mixed stereoscopic film with sounds, smells and vibrations to give a convincing illusion of being in a remote physical space. Its patent application emphasises potential uses within training scenarios (Heilig, 1962). By the 1970s, the first HMDs were being produced that were the clear predecessors of the devices we use today. The fundamental design principles have not evolved a great deal, with users strapping a box to the front of their head, containing lenses and a pair of screens projecting stereoscopic images to users' eyes. As the technology developed during the 1980s, different techniques for tracking head and body movement were added. By 1991 Virtuality had produced a high-end VR games machine for use in video arcades (Delaney, 2014) while Sega announced it would be selling a headset for home use by 1993.

The Sega VR never actually made it to market. Like similar contemporary products, such as Nintendo's Virtual Boy, these 1990s consumer VR headsets failed in part because they made users ill (Rebenitsch, 2015). To make VR work, the screens inside the headset need to have a very high refresh rate, otherwise they appear to flicker, causing nausea. This problem becomes even worse if there is a lag between the user's head movements and those on screen because this creates motion sickness. It was simply not possible with the technology available in the early 1990s to deliver a product that could track and refresh quickly enough so as not to create these unwanted effects while still hitting a consumer price point.

Although commercial VR flopped in the 1990s, the decade saw rapid development in the power of computer graphics and new possibilities for creating 3D environments, both for gaming and a range of industrial applications. The use of computer graphics within the film industry revolutionised visual effects, while engineers, architects, planners, the heritage sector and others benefited from the ability to create and manipulate realistic digital models. By the early 2000s, consumer-facing games consoles and PC graphics cards had appeared that could render 3D environments in incredible detail. Within a few years, the mass market for smartphones helped to drive the creation of small displays with very high resolution and refresh rates, which would prove to be perfect for HMDs. The first Microsoft Kinect, released in 2010, showed the mainstream potential for computers to track the movements of objects in the physical world and relate these to virtual environments (Zhang, 2012).

The technological pieces were therefore starting to come together to revisit the idea of consumer VR. In 2012, Palmer Luckey founded Oculus VR and sought crowdfunding to develop the prototype HMD he had been experimenting with for several years (Clark, 2014). One of the prevailing jokes about VR at the time was that it had been the next big thing for about 30 years. Nonetheless, there was so much interest in the possibilities of VR that the Oculus Kickstarter campaign was spectacularly successful, meeting its target many times over. To the surprise of some, social media giant Facebook subsequently bought Oculus in 2014 for over $2 billion. This investment reflected the significant advance that the Oculus technology represented over previous efforts in VR. Facebook's involvement gave a global platform to push it forward.

Oculus Rift developer kits were made available from 2013 and the finished headset received a commercial release in 2016, the same year that HTC released its technically more sophisticated (and expensive) Vive headset. Other companies have also brought headsets to market with varying degrees of success, some using Microsoft's Mixed Reality platform which built VR support into the 2017 update of Windows 10. These more recent innovations have been characterised by some as the 'third wave' of VR (Heim, 2017).

VR systems from the 1970s to 1990s tried a variety of different mechanisms for fooling the senses to convince the user they were present in the virtual world. Data gloves and even full body suits were developed to allow multiple sensory inputs to be synchronised with a virtual experience. In the third wave of VR, however, these approaches have been simplified into combining hand controllers alongside the HMD as the primary mechanisms for interacting with the virtual environment.

The different platforms have applied different technical solutions to tracking bodily movement. First-generation Oculus and HTC headsets used external beacons, which had to be arranged around the space in which the HMD was being used in order to track the user's movement. While these allowed for accurate tracking up to the scale of a medium-sized room, they were also a nightmare of trailing wires and worked best when there were no other objects in the room (Figure 1.2).

Figure 1.2: VR demonstration set up for public display. Note the tracking beacons mounted on tripods at the edges of the game area creating a trip hazard of trailing wires, here fenced off with a collection of stools

Source: Phil Jones

Other HMDs use inside-out tracking, which is not reliant on external beacons. Cameras built into the headset work out how the user is moving around a room. This is a less accurate solution for room-scale movement, but much easier to set up and so can be quite a good compromise for research projects undertaken by non-specialists. Most VR products now use two handheld controllers that can be tracked in space either through the HMD's cameras or external beacons. Older, budget devices used a single 'pointer' with basic movements tracked using an internal gyroscope. Newer technology now makes it possible to track hand movements without the need to hold a controller, just using cameras on the HMD. This means that gestures can control different functions within the virtual world in a more naturalistic manner.

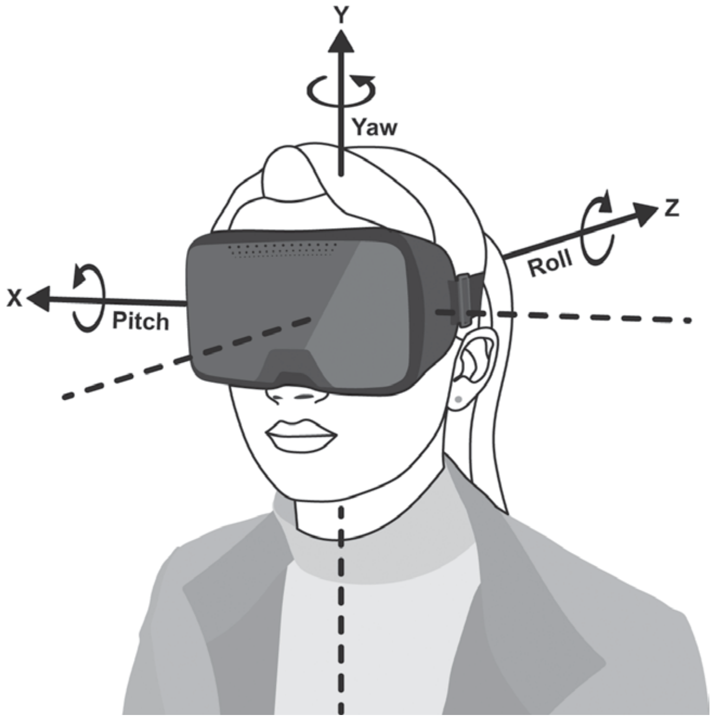
There is, however, no getting away from the fact that VR can be temperamental and fiddly to get working. Oculus, HTC and Microsoft all use different software platforms, which are not interoperable. One can buy VR games through Steam – the dominant online marketplace for PC games – but this adds yet another layer of complexity. To give an example of this problem, within the Playful Methods Lab we have done some work using a gaming steering wheel and pedals for driving within VR. Although a very compelling experience when it all works, adding another device brings even more problems to a VR set-up and it can be difficult to persuade all the different components to communicate with each other without a good deal of time spent tweaking, adjusting and resetting. The impression is often of a technology that is really only one step up from the prototype stage.

Beyond the different manufacturers involved, there are different types of HMD that require some consideration when designing a research project, as they offer different costs and benefits depending on what you are trying to achieve. The most powerful set-ups are generally tethered by wire to a computer with a high-specification graphics card. These give the most complete VR experiences, but are also expensive since you need both a headset and a powerful gaming PC. There is also great potential to literally trip over the tether connecting the HMD to the computer while moving around.

Stand-alone headsets, conversely, have lower graphical capability since all the computing power is contained within the headset itself – effectively using the same processors and sensors one finds in a smartphone. At the start of the third wave, smartphone makers briefly experimented with VR platforms where phones could be slotted into a 'dumb' headset that was essentially just a box to hold over your face with a lens for each eye – Google's Cardboard and Samsung's Gear VR were the best known of these, although they never really got much beyond the gimmicky stage. There are also some examples of more hybrid devices. Some HMDs have an optional wireless transmitter that allows a PC-based VR experience without needing a cable to connect to the gaming computer. Others can be used either as a stand-alone device or plugged into a PC for more advanced experiences.

Most modern HMDs offer tracking with six degrees of freedom (Figure 1.3). This means that the device can not only detect head movement (yaw, pitch, roll) but also positional movement of the body in space (forward-backward, up-down, side to side). Older stand-alone HMDs and the now mostly obsolete smartphone-based VR systems could only track with the first three degrees of freedom, allowing users to turn their heads but not walk around in virtual space. Similarly, the hand controllers on these basic devices offered only limited movement tracking, which meant much less capacity to interact physically with the VR environment via hand movements. These technological considerations can shape what is and is not possible in different research projects, depending on the equipment used. That being said, as devices improve these constraints are being overcome.

Figure 1.3: Basic HMDs only track head movement via pitch, roll and yaw. More sophisticated VR equipment tracks users' movements across six degrees of freedom by adding strafe, elevation and thrust across the x, y and z axes



Source: Chantal Jackson

Structure of this book

The purpose of this book is to set out the different ways in which VR can be employed within research projects. It is important to emphasise that VR research does not have to be limited to specialists and technical experts, and we have structured the book to reflect this. The remaining chapters progress through approaches to VR research, starting with the most straightforward and moving through increasing levels of complexity. The book thus progresses from different kinds of projects that can be conducted using *existing* VR content, with the final chapters examining how to develop *original* materials that can be explored in VR.

Each of the chapters that follow examines a different approach to VR, critically reviewing the kinds of projects that have been undertaken in these areas. Each chapter also contains a case study from project work undertaken within the Playful Methods Lab to explore how these approaches can be implemented.

Chapter 2 examines perhaps the most straightforward approach to operationalise, where the researcher's own consumption of VR materials becomes the basis for content analysis. Commercial VR content, both games and other experiences, have been subjected to relatively little analysis by critical scholars. There is great potential, therefore, to adapt some of the interpretative tools from other disciplines, particularly game studies, in order to undertake analysis of these materials. Game studies put an emphasis on *playing* the text, rather than simply examining the story; autoethnography sits at the heart of this approach. This chapter reflects on the advantages and limitations of autoethnographic approaches for examining VR content as interactive texts. As a worked example of this approach, we reflect on our analysis of *Half-Life: Alyx* (Valve, 2020), the first big-budget ('triple-A') franchise game to be released exclusively for VR.

Chapter 3 moves beyond the researcher's own perspectives to examine how larger groups of participants can be enrolled in VR studies. The focus is on how existing VR materials might be used in projects with participants as a simpler and lower-cost alternative to building original VR content. We explore the ethics of working with human subjects in VR and the problems of cybersickness, as well as reflecting on the predominance of quantitative methods in projects that analyse participant response. The worked example, conversely, presents a qualitative analysis of a project where 33 regular gamers played the zombie shooter *Arizona Sunshine* (Vertigo Games, 2016). The exercise revealed a powerful affectual connection to the virtual space, creating a considerably more physically and emotionally intense gaming experience than participants were used to, even as experienced players.

As discussed, definitions of presence within VR lean heavily on questions of social engagement. Chapter 4, therefore, explores the opportunities presented when multiple users interact within the same virtual environment, particularly through social VR platforms. Mechanisms for collaboration within virtual space are examined alongside the critical role that avatar design plays in these interactions. While the nature of the HMD is to cut users off from the world around them, it does allow them to form communities within the virtual spaces they visit. We reflect on some of these issues through a case study of VR Church, where worshippers come together for virtual church services within the social VR platform *AltspaceVR* (Microsoft, 2015). This provides an opportunity to reflect on the challenges of undertaking ethnographic research with communities in VR.

Chapter 5 moves to look at the most basic form of content creation for VR, producing 360° photos and video. Images from two or more cameras with fish-eye lenses are stitched together to make a photo sphere. When viewed through a HMD, users can turn their heads and look around these images as if from a fixed point at the centre of the scene. As a tool, it has become popular for virtual field tours, journalism and tourism, allowing users to explore a site in the round. Existing 360° content like this can be reused within research projects, but it is also relatively cost effective and straightforward for researchers to generate their own materials for use within specific projects. The chapter focuses particularly on therapeutic landscapes and how 360° content can be considered as part of wider sensory stimulation in VR. This is followed by a worked example of a pilot project examining how the well-being effects of exposure to nature might be reproduced and interrogated through 360° video and audio.

Chapter 6 explores more complex forms of VR content creation, by using games engines to program original materials. Rather than covering the specifics of coding, the chapter reflects on different approaches to building original content, including opportunities for collaboration with skilled practitioners. In exploring why researchers may wish to develop original VR materials, the chapter reflects on two overlapping types of projects: those testing specific scenarios with participants, and those exposing users to novel environments. In the book's final worked example we reflect on a project where we created VR models of two historic landscapes for use in a workshop examining memory and memorialisation.

Chapter 7 concludes the book, examining what the next steps might be for research by social scientists and humanities scholars interested in using VR within projects.

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TWO

Working with existing VR material: content analysis

Introduction

One of our aims with this book is to move beyond the idea that research with VR can only take place via a complex process of content creation. This and the following chapter, therefore, focus on commercially available, ready-made materials. The use of existing materials lowers the barrier of entry for researchers wanting to work with VR, and there are significant research gaps that can be addressed through engaging with this content.

There are, of course, non-commercial existing VR experiences that can be reused in research projects as well. These can, however, sometimes need a bit of detective work in order to track down the owner of the material, find out whether they are willing to share it and, crucially for older content, whether it can still be made to function on available hardware. Permissions would also be needed for it to be employed in a different context from its design purpose, which may require careful consideration. The reconstruction of the Auschwitz concentration camp that we highlight in Chapter 6, for example, might potentially form the basis of a new project with a carefully framed educational remit, but the copyright owners would, quite rightly, be very unlikely to approve more insensitive uses.

Commercially available VR materials, meanwhile, can generally be reused more freely in a variety of different research contexts, though may need to be purchased before use. Such products can also suffer the same technical obsolescence that we see in non-commercial VR content, with the risk of becoming abandonware, where the developer sees no value in maintaining the material. Commercially produced material does, however, often have the advantages of scale and quality control that comes through professional development, as well as being relatively simple to find and install via online platforms such as Steam and the Oculus store.

Games are the most common form of commercial VR content, but there is also edutainment material and productivity and well-being apps, as well as more specialised industrial and medical software. In this chapter, we examine ways to undertake content analysis with existing VR materials; this represents quite an important research gap within the field. While a solo researcher undertaking a close textual analysis is a bread-and-butter approach in the humanities and has been widely employed within game studies, VR materials have largely escaped this kind of critical lens. Another significant research gap is in undertaking a broad survey of a particular VR genre – well-being apps or medical trainers for example – to examine the kinds of discourses being employed by developers and how these have changed over time.

There are challenges when employing a content-analysis type of approach to VR materials. Many of the analysis techniques employed within game studies and other disciplines are directly transferable, but need to be augmented with techniques for examining bodily movement. We will consider some of these issues in turn before moving on to a worked example where we examine the practicalities of undertaking an analysis of the VR game *Half-Life: Alyx* (Valve, 2020).

The absence of content analysis

Much of the work around existing VR materials focuses on the user experience and how *participants* respond to the content – issues that we will explore in Chapter 3. There has, however, been relatively little use of *content analysis* approaches by scholars working on VR. Where it does exist, these studies primarily take the form of content analysis of materials about VR rather than of the VR experiences themselves. Nevertheless, the second approach has produced some very interesting work. Keller et al (2017), for example, examined how a video about the use of VR in healthcare was received by social media users. Here, a quantitative analysis of 2,401 Facebook posts demonstrated a generally positive perception of the technology, with women slightly more favourable than men. This kind of study is useful for assessing public concerns about the use of VR technology and how these might be overcome, which is particularly significant in a healthcare context. Johnston et al (2017), meanwhile, note that, while VR has created a great deal of excitement within the education sector, the pedagogies underlying its use are not clearly articulated. They used a purposive sampling technique to examine publicly available websites and video material promoting and discussing educational VR content, alongside a systematic review of relevant academic literature. Of the 35 pieces of educational software they examined, the overwhelming majority (24) focused on *experiential learning* approaches. This is perhaps unsurprising given that experiential learning theory emphasises experience and interaction as key modes of learning, which has obvious resonances with the immersive and embodied qualities of VR.

Studies of these kinds operate at one remove from the actual VR experience itself, however. Johnston et al (2017) were investigating published material about different pieces of educational VR software, rather than examining that software directly and attempting to code its content. There is a notable lack of studies directly examining the discourses embedded within VR content itself, meaning that there is a great deal of potential for research in this area. An interesting example is the subgenre of well-being and personal development VR apps that emphasise the importance of the individual's control over their everyday life. Non-VR apps promoting similar things have been subject to different studies using content analysis. Mani et al (2015), for example, reviewed mindfulness apps for the iPhone, with the authors spending at least 30 minutes engaging with 23 apps in their sample. Apps were ranked for their functionality, with the authors drily concluding that, 'The lack of evidence for the effectiveness of mindfulness apps needs to be addressed' (Mani et al, 2015: 7).

Mindfulness discourses tend to position the individual as being responsible for their own self-improvement, rather than acknowledging the structural issues within a neoliberal economy that act as a barrier to this (Pykett and Enright, 2015). Given the emphasis on experiential learning approaches within VR, examining how these discourses of self-improvement are actualised by VR apps would be a very interesting research project. There is, however, a bit of a ticking clock here, as some of the apps developed during the initial excitement around the third wave of VR from around 2012 are themselves starting to become obsolete and may soon become inaccessible. An example of this is the range of *#befearless* apps developed by Samsung for its phone-based Gear VR headset. These apps were designed to provide users with virtual experiences, such as giving practice presentations in front of an avatar audience or 'walking' across high bridges, suggesting these could help people conquer their fears. Support for the Gear VR headset was, however, withdrawn by Samsung and the device rendered non-functional by software updates in 2020. At the time of writing, the *#befearless* apps are still available for the Oculus Go headset, but this device is itself due to have its support removed, meaning that these apps may become permanently inaccessible.

Lessons from gaming literature

There is merit to researchers simply *documenting* those VR experiences that are at risk of becoming abandonware. This would provide material for subsequent content analysis of how different VR genres evolve over time and the kinds of discourse embedded within them. Such an approach has commonalities with Miller and Garcia's (2019) work on 'digital ruins'. They examined online 3D worlds that, having fallen out of fashion, no longer had a significant user base to animate their virtual spaces. Methodologically, this project employed an autoethnographic approach, with the researchers visiting these semi-abandoned worlds and documenting their experiences. Again, this process of documentation is significant not least because *Blue Mars*, one of the three sites they investigated, has since been shut down. The relatively straightforward processes of capturing stills and videos from the researchers' interactions alongside taking notes of thoughts and reflections are key to documenting this kind of content.

Different forms of content analysis are commonly used within the field of game studies and allied research. As a result, work in this area offers useful methodological insights for approaching VR material. Game studies as a discipline owes some of its origins to media studies and although it takes an interdisciplinary and integrative approach, many of its methods and techniques are familiar to scholars within the broader humanities. Lankoski and Björk (2015) have compiled a useful collection that explores how conventional methods from the humanities and social sciences can be adapted to meet the specific challenges of working with games, from qualitative content analysis to much more complex modelling approaches. A key reason why conventional methods need to be adapted is that, unlike other forms of media, such as books or photographs, one of the unique qualities of games is their interactivity. This issue was codified at an early point in the development of game studies as a tension between *narratology*, the examination of story, and *ludology*, the examination of gameplay (Frasca, 2003). Both elements inform each other and need to be considered together. This raises important questions for work on VR because its interactive/ludic qualities operate somewhat differently from a conventional game where one manipulates images on a screen via a controller. VR gives the impression of placing the user's physical body *within* the virtual space, a highly embodied interaction that leads to a much more intense affective engagement with the content.

Although game studies is a methodologically diverse field, approaches to content analysis here tend to fall into one of two camps: reviewing multiple games to analyse a particular subgenre or theme (for example gaming nostalgia explored by Sloan, 2016), or close textual analysis of a single or small number of games (such as discourses of disability in *Mass Effect*, Jerreat-Poole, 2020). Both approaches have relevance to scholars interested in working with existing VR content. A review at the subgenre scale can be used to explore how discourses shift over time (such as the evolution of first-person shooters (FPSs), Hitchens, 2011). This can be particularly valuable when examining eras with the kind of rapid development we are seeing in the third wave of VR. Close textual analysis, meanwhile, is very familiar among literary scholars and others in the humanities and social sciences, with a variety of approaches taken. Felczak (2020), for example, offers a nice illustration of the specific challenges faced when undertaking this type of analysis within games. This paper undertakes a postcolonial examination of *Pillars of Eternity 2: Deadfire* (Obsidian Entertainment, 2018), noting that the designers were clearly telling a story that highlighted the exploitations and violence of the colonial period. The implicit decolonial critique of the game's story, however, can be seen as coming into tension with the gameplay and its 'heroic, power fantasy tropes' (Felczak, 2020) typical of role-playing games. The value of Felczak's analysis is in exploring how these elements are enmeshed in producing the gaming text.

Within academic literature, there are very few examples of scholars undertaking a close textual analysis of existing VR content. One important exception is the work of Vicki Williams (2018), who has examined how horror tropes translate into a VR experience through examining the 2016 game *A Chair in a Room* (Wolf & Wood Interactive, 2016). Williams' analysis is grounded in the embodied, drawing on Heidegger's ideas around 'enframing' as a means through which technologies and bodies come together to reveal truths about the world. Thus, her examination of the VR game examines how a story about someone confined to a mental institution contains slippages between the physical and the imagined – a discomforting uncanny that the horror genre deals with particularly well. In order to undertake the analysis of the game, Williams has to relate both the story and the player's physical movements, given how closely the two are aligned when considering the experience as a whole.

Analysing embodied engagement

In studying games, one cannot meaningfully separate story and gameplay. The immersive quality generated by HMDs make this interplay of content and interaction even more acute by generating the sense that the user is *inside* the virtual environment. Any content analysis of VR materials therefore needs also to consider the *body* of the user. Questions around embodiment have been of particular interest to geographers over the last two decades, with many projects examining bodily interactions with different spaces partly in response to an influential canon of theoretical work around the performative and non-representational (for example Thrift and Dewsbury, 2000). While these theoretical positions can seem somewhat opaque and insular to outsiders, they have helped to stimulate some really interesting practical development of methodologies for exploring how our bodies shape an understanding of the world around us. Wylie (2005), for example, has used autoethnographic approaches to examining landscape through walking. There has also been a very large amount of work by geographers and others using video to examine everyday embodied experiences, from Laurier and Philo's (2006) work on cafés to Bates' (2013) work using video diaries to explore health and illness.

Although the body plays a less prominent role in the experience of conventional gaming, considerations of the bodily are not absent from conventional game studies, with useful methodological lessons to draw upon. There has been a great deal of interest in how game designers attempt to maximise players' 'flow', drawing on Csikszentmihalyi's (1990) ideas of creating a psychological state where the individual has an optimised experience. Flow has been used to think about the ways in which games seek to maintain player engagement and enjoyment so that they play for longer and are more willing to buy new gaming products. The maintenance of flow requires a consideration of the bodily, from controllers that players can use to seamlessly control the on-screen action (Schmalzer, 2020) to sound design that creates affective responses in players (Oldenburg, 2013).

Considerations of the bodily are very significant within VR research, but primarily from the perspective of examining the physical effects of using these systems. We will explore the problem of cybersickness in more detail in the next chapter, but, at a basic level, it partly comes from the mismatch between bodily movement and position on screen. Indeed, it can even occur where expensive systems of treadmills and specialist footwear are employed to create a sense of physical movement within a constrained space (Wehden et al, 2021). Beyond cybersickness, however, as we go on to explore, physical considerations can have a major impact on the practicalities of undertaking research in this area.

Case study: approaching a content analysis of *Half-Life: Alyx*

In order to examine how these more abstract considerations play out in practice, we turn now to consider a worked example based on a project undertaken within the Playful Methods Lab. This project was designed as an attempt to think through the practicalities of adapting content analysis to the specific challenges of working with VR material. As such, we chose one of the richest and most detailed VR texts currently available, Valve's (2020) horror-themed FPS, *Half Life: Alyx* (hereafter *Alyx*), to examine the opportunities that content analysis presents when engaging with complex virtual environments and narrative arcs. We have broken the case study down into the different steps that need to be considered when undertaking an analysis of this kind.

Situating the content

In writing up any content analysis, there is a balance to strike between being overly descriptive and giving the reader sufficient contextual material that they can understand the point being made without having directly engaged with the text themselves. This is a particular issue within game studies, where some game texts are part of a long-running series with a sprawling and complex lore. As such, there can be a tension between situating a game within a wider narrative arc or treating it independently, both in terms of writing it up, but also in approaching the text in the first place.

Although *Alyx* is part of a long-running franchise, we chose to treat it independently and deliberately did not play the earlier games or read up on the wider story of which it is a part, as we wanted to approach it with a clean slate. There are disadvantages to this approach in that many references to parts of the wider story may be lost, but the advantage is in exploring the text without preconceptions. A good compromise between these positions is subsequently to learn more about the wider story and play the other games in the series before undertaking a second documented playthrough of the main text being studied.

Alyx's developers have also produced the Valve Index, a high-quality HMD set-up; one reading of the game could therefore be as a marketing vehicle attempting to increase public interest in the potential for VR. The game is much more than a simple technical showcase, however. *Alyx* is unusual in that it represents the first 'triple-A' (high budget) franchise game to be released exclusively for VR. The development costs of triple-A games are such that it is high risk to design for the niche audience of gamers with expensive high-power VR set-ups, but it has allowed the developers to design an experience that was predicated on players physically moving around (ducking, crawling, dodging, reaching). The developers, Valve, also own Steam, a multibillion-dollar distribution platform for video games, which gave them the financial muscle to produce the game without the risk of bankrupting the studio – a real concern for major developers if a game is a commercial flop.

In terms of the story, the wider *Half-Life* franchise imagines a post-apocalyptic future following an alien invasion. Players in the earlier games inhabit the main protagonist, physicist Gordon Freeman, from a first-person perspective and have to solve various puzzles, run around, drive different vehicles and shoot seemingly endless waves of different aliens and soldiers in a quest to liberate humanity. Highly innovative when the original game was released in 1998, *Half-Life* and its sequels have been imitated to the point of seeming not just technically dated but also somewhat derivative. Valve have publicly stated that they only wanted to return to the franchise once they could create something as technically innovative as the first game, and they saw VR as the opportunity to do this (Wilde, 2020).

Alyx takes place in the same world as the earlier games, but the player inhabits Alyx Vance, a young woman of Afro-Asian descent who previously appeared in the franchise as a non-playable minor character. The basic storyline of *Alyx* is not dissimilar to the earlier games, with players tasked with surviving attacks, exploring and solving puzzles alongside rescuing other characters (notably Alyx's father) and attempting to drive back the invading alien forces. The major difference between *Alyx* and earlier entries in the franchise is a clear switch in genre from action to horror. While the earlier games had horror elements, not least with the shock of alien 'headcrabs' jumping at the player, this element is much more viscerally intense in *Alyx*.

An advantage of researching a major game such as *Alyx* is that developers are often interviewed by journalists about the kinds of choices they made in putting the game together, which can add value to the content analysis. Because *Alyx* is so innovative and unusual, there is a wealth of secondary material that can be consulted in which the developers have reflected on the process of game design, particularly in the pacing of the story so as not to overwhelm the player with too many stimuli before they are used to being in the virtual environment. Indeed, some of the intended gameplay had to be slowed down to take account of how intense the VR experience is: during testing, some of the faster-moving creatures from the earlier games were removed because players found that they simply could not cope (Rad, 2020). Beyond secondary sources, developers are often open to being interviewed directly by researchers seeking more specific information about design decisions and, again, this is a well-established technique within game studies (for instance Haylot and Wesp, 2009) that could also be applied to VR content.

Documenting the experience

At its simplest, content analysis of games requires the researcher to play through the material – potentially multiple times – while taking notes about plot and gameplay alongside the visual and auditory stimulation and researchers' reflections upon the experience (Jones and Osborne, 2021). Given that the main story arc of a triple-A title can take upwards of 20 hours to complete, this is not an insignificant investment in time for the researcher. A non-gaming VR experience might be smaller in scale but, given the importance of the user's embodied engagement, can still be a major undertaking because of the added complexity of needing to capture and analyse bodily movement.

For the *Alyx* project, we set up a play space of approximately 2m by 3m and positioned a video camera on the edge of this area, capturing not only the player's movement but also a large TV screen mirroring the output from the HMD. One of the most powerful qualities of VR is in making imagery that looks unremarkable on a conventional monitor feel incredibly compelling in an HMD, even where the graphics are not particularly sophisticated. *Alyx*, with its triple-A production values, feels shockingly *real* in VR, though when looking at footage captured via a mirrored output, it appears to be simply a good-quality modern game. This emphasises the importance of considering the captured video material purely as a set of notes or aides-memoires for the researcher, given how different this imagery is to the VR experience itself. The game itself was played using a Razer Blade Pro laptop (7th gen Core i7, GTX1060 graphics card) in combination with a tethered Samsung Odyssey HMD.

The first phase of data collection was a collaboration between Phil and Tess, with one person playing and the other asking the player questions to prompt reflections on what was being experienced at different moments. The person not wearing the HMD also played a practical role of making sure that the player did not trip up or accidentally collide with objects in the physical world, given how quickly someone in VR loses any sense of having a body that exists outside the virtual space. This also had the unanticipated advantage of providing an anchor into a safe space, which proved highly valuable given the horrifying nature of much of the experience within *Alyx*.

The horror elements of the game proved particularly challenging, both emotionally and physically. Oozing slime on walls, which looks unremarkable when seen on a TV screen, is viscerally disgusting when viewed through the headset. Dark

Figure 2.1: Peering down into a dark sewer tunnel in *Half-Life: Alyx*

Source: Phil Jones and Tess Osborne

passages seem horrifyingly ominous as you move your hand to point a virtual torch that barely illuminates pitch-black spaces filled with unknown dangers. On multiple occasions, both of us stopped playing not because of cybersickness but because we needed a break from being frightened, such as this exchange, while stood on a ledge overlooking a dark sewer tunnel (Figure 2.1):

Tess: I'm not going down there. I can't.
Phil: OK.
Tess: I physically can't. I feel sick *thinking* of going down there.
Phil: OK.
Tess: That scares me far too much. … Oh, look at how nasty that looks. I'm sorry I'm so pathetic, but every inch of me is saying, 'No, do not go down there.'

(Extract from video recording, 22 July 2020)

Of course, this highlights questions about the extent to which VR experiences can exceed the player's embodied, affectual limit, with implications both for *who* is able to undertake content analysis research on such experiences and also the ethics of asking participants to be immersed in such content (discussed further in Chapter 3).

In conventional games, the player needs a period of adjustment, learning how different buttons on the controller relate to different actions on screen. The same is true in *Alyx*, but with an added layer of complexity because there are specific bodily movements to learn in order to accomplish particular tasks. Reloading a weapon, for example, requires a combination of button presses on the hand-tracking controller and physical movements – reaching over the shoulder to collect a magazine from a virtual backpack, bringing hands together in a particular way to put that magazine into the gun. Some of the weapons also need a two-handed manoeuvre to cock the gun. The video footage captures some of the learning process of becoming more practised and smoother at reloading weapons during – often quite hectic – combat sequences. Indeed, in notes recorded later in the playthrough, Phil talked about this becoming quite a physically satisfying process. To begin with, however, the unfamiliar set of motions created moments of abject panic, with a scurrying headcrab jumping at his face while he screamed, struggling to remember how to reload the weapon that he had emptied by firing wildly, desperate to stop the alien attack. We did not monitor heart rate or electrodermal activation as we have on other gaming projects (Osborne and Jones, 2017), but it is clear that both would have seen a dramatic spike in these moments. Indeed, the horror combat sequences fighting in the dark left both of us physically and emotionally drained and needing a break from being inside the game.

The data collection took place in the summer of 2020, which was unusually hot for the UK. Wearing a heavy, sweaty HMD while moving around, with game sequences creating a very high heart rate, the VR activity was simply *tiring* and we tended to play in 20–30-minute bursts. The combination of the heat and the stress left both of us feeling headachy and nauseated when coming out of the game. At the end of each sequence of play, we recorded a conversation to camera, effectively as a form of note-taking for our immediate reflections of the experience. The footage from many of these sequences shows us looking exhausted and unhappy, particularly in the early phases as we were getting to grips with the physicality of the gameplay, giving quite raw insights into our emotional state. As the data collection went on, the physical experience became easier and the horror elements more manageable as they became more familiar. The second phase of the data collection saw Phil completing the game alone, attempting to maintain a commentary for the camera during the gameplay, which was easier than in the initial phase where there were simply too many stimuli to remember to record these reflections without a prompt from another person in the room – the sense of immersion was so great to begin with that it was difficult to remember to be a researcher rather than a person trying desperately to survive an alien assault.

Analysing the materials

At the end of the data collection with a full playthrough completed, we had recorded approximately 21 hours of footage over 13 days spread across two months. Audio from the video recordings was transcribed using an automated process with manual correction, dividing between commentary made during the gameplay itself and our more reflective discussions delivered to camera immediately after coming out of VR. These recordings also captured the gameplay and story elements that were displayed via the secondary TV output, though these were not transcribed. The more narrative elements could have potentially been captured to a higher quality by using screen recording, but we avoided this for technical reasons, concerned that *Alyx* was already pushing the limits of a laptop at the bottom of the specification needed for the game. Thus, while the basics of the story were captured as a background element, a forensic analysis of the narrative would need a more detailed approach.

With transcribed notes of conversations, responses during gameplay and immediate reflections alongside footage of player movement and on-screen action, we had a wealth of material to examine. Different disciplines have different preferred approaches to content analysis, with different levels of complexity, depending on what the researcher wants to achieve. Because we were simply exploring the practicalities of how a VR experience might be examined through this lens, we have not as yet undertaken a major analysis of this dataset beyond some simple thematic coding. Even with a relatively superficial examination of the dataset, however, the importance of physicality to the experience came through very strongly: if we had examined the transcript data in isolation, some quite significant elements about this would have been missed. Thus, there is an imperative to draw on some of the techniques developed for analysing video footage within research projects to situate and make sense of some of the comments captured in the transcripts.

There are a number of useful techniques here. The transcripts acted as a jog to the memory, to recall particularly significant sequences that could then be examined in more detail via the video material. This allowed for descriptions of sets of movements to sit alongside the transcript material. There have been some interesting projects for analysing video that have made use of a kind of comic-strip approach to capturing a sequence of events through a series of stills and which could be useful when considering how to represent this kind of material for publication (Lloyd, 2019). We have also experimented with making animated gifs for key sequences to use in presentations, capturing five- or ten-second moments that illustrate a particular point. While the gifs are of limited use for conventional publication, they can form useful supplementary material where publishers offer this, or can be embedded within articles where publishers operate an online-only model.

A weakness of a content analysis approach is that it represents the perspective of a single researcher or small team. One means to counter this is to look for other accounts of the VR experience being examined. Although there are few academic pieces reflecting on VR materials, particularly when it comes to games there are often very interesting accounts of players' experiences. Because *Alyx* is unusual in its richness as a game, there are multiple blog posts, recorded livestreams and 'let's plays'[1] available online from which to examine other players' perspectives. While these may lack the rigour of an academic account, they can bring additional perspectives and insights that a lone scholar might miss. There are, of course, issues to consider in terms of the demographic representativeness of those who make such recordings, but, nonetheless, they can form a useful source to feed into an analysis.

Conclusion

The horror genre is built around unsettling and discomforting its audience, while maintaining a safe distance from the events being depicted. The sense of dislocation within horror works well for VR experiences, although being placed *within* the events can be quite distressing despite the knowledge that all one has to do to escape is remove the HMD. This highlights how VR experiences are qualitatively *different* from conventional media such as films, TV and games. Thus, while we can draw on approaches to content analysis from media or game studies, any examination of VR content needs to go further to bring questions of embodiment to the fore. As we have illustrated, this can be quite an intense and complex process that asks questions of how the material body intersects with the virtual space.

As we will see throughout the rest of this book, much of the work on VR comes from an explicitly scientific position where there is not the disciplinary tradition of using content analysis. When combined with the complex practicalities of subjecting VR texts to content analysis, it is perhaps not so surprising that examples of scholars taking this approach are few and far between. This is an important research gap to consider, not least because the intense embodied engagement with a virtual space within an HMD means that the discourses embedded in those virtual spaces can have significant effects on the people using them. It is no coincidence that Meta (owner of Facebook) is investing so heavily in VR, given that it is a company whose business model is finding out information about people in order to better manipulate them.

From a scholarly point of view, there is also a risk that parts of the history about the developing discourses embedded in VR experiences are going to be lost as earlier pieces of software and hardware become obsolete and non-functional. As a result, there is real value to applying content analysis approaches to these materials. *Alyx* is an unusual piece of software because of its scale and ambition, but many VR experiences are considerably smaller and would not require such a large commitment of time to examine. Thus, for example, an examination of VR well-being experiences as a parallel to Mani et al's (2015) work with iPhone apps could be fairly straightforward to undertake and would give some very interesting insights into the difference that being embodied *within* the experience makes to the way these discourses are shaped.

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THREE

Working with existing VR material: activities with participants

Introduction

One of the key selling points of VR is that it allows us to explore environments and scenarios without the need for travel and with limited physical risk. This means that there are tremendous opportunities for working with participants to examine how people react to different places and circumstances in ways that would simply be impractical if attempted in the real world. As we will explore in Chapter 6, however, much of this work with participants has taken place within environments that have been specifically built for a particular project – this approach can be quite expensive and requires considerable expertise. Our concern in this chapter, therefore, is the ways in which commercially available VR content can be cheaply redeployed within research projects to explore some of these same questions. This immediately lowers the barrier of entry into this kind of research.

Work with participants in VR has been dominated by researchers in psychology and human-computer interaction, leading to a particular skew in the topics and approaches considered. Projects employing standardised questionnaires form the majority of work in this area and, while this is highly valuable, it does create a research gap around more qualitative and creative work with participants. Likewise, as an emerging technology, more of the work with participants in VR has focused on questions of user experience than the new opportunities for research that are opened up when participants visit virtual environments.

This chapter is in four parts. First, we examine the ethical considerations that need to be made when designing VR research projects for participants. We highlight some of the emotional and physiological pressures posed by VR and how these can be mitigated in order to ensure that research is undertaken in an ethical and responsible manner. Next, we consider some of the practical issues around user experience within VR, particularly questions around cybersickness and physicality. We then explore how VR has been used for therapeutic and training applications, highlighting the power of VR to help participants overcome real-world constraints. Finally, in order to highlight the potential for qualitative research with participant groups, we present a case study of an exploratory project we undertook where participants had to fend off invading hordes of zombies.

Ethical considerations

Despite users not being in any real danger, VR still has major effects, both psychologically and physically. As a result, the ethical review process before commencing research with participants using VR requires more than a simple tick-box exercise. Part of the reason for this stems from the fact that the illusion of being *in* a particular situation is very compelling in VR. Slater (2009) has helpfully broken this down into two elements: Place Illusion, the sense of 'being there', and Plausibility Illusion, the feeling that the events being depicted are actually happening. Taken together, Slater argues, they create the sense for the participant that the scenario being depicted is actually happening – thus they will respond as if it were real even if they objectively know that it is not.

As noted when discussing *Half-Life: Alyx* in the previous chapter, this sense of being in a *real* situation means that users physically and emotionally respond to the scenarios being depicted in VR. From the standpoint of ethical review, therefore, the question is whether high-stress scenarios depicted in VR are measurably more impactful than experiencing something similar in a less-immersive medium. Many ethical review panels will have limited expertise in the effects of VR when making judgements as to whether a project should proceed, though they will likely have experience of comparable conventional scenarios, such as asking participants to watch a scary movie or play a stress-inducing game on a monitor. The relative affectual, embodied response of VR compared with non-VR scenarios has therefore been a crucial issue to test because it has consequences for whether and how we undertake ethically responsible research with participants in VR.

Wilson and McGill (2018) have raised this question by asking whether the intensity of fear response in VR means that games should be given a different age rating when played in VR compared with a conventional screen. As with many of the studies that we discuss in this chapter, Wilson and McGill used a standardised questionnaire (in their case the State-Trait Anxiety Inventory) to capture their participants' emotional state. A degree of caution should be noted here, particularly given that there have been concerns over whether the results from this type of research design are reproducible (Baker, 2015). Regardless, Wilson and McGill quantified the difference between participants playing *Resident Evil 7* (Capcom, 2017) on a screen compared with an HMD. This was triangulated with a set of qualitative interviews exploring the drivers of players' physical responses. Overall, they found a slightly higher fear response from the VR experience, though not strongly different from conventional screen-based gameplay.

Fear response therefore needs to be considered carefully when reviewing the ethics of research within VR. Developing on Slater's ideas of place and plausibility illusions, Lin (2017) examined player reaction to VR horror game *The Brookhaven Experiment* (Phosphor Games, 2016). Only a small minority of the 144 participants reported strongly negative responses to the experience. Likewise, the day after exposure, very few recalled nightmares or any dreams about the game, nor any sense of the 'Tetris effect', where one perceives elements of the game bleeding into everyday life. Lin's study is especially interesting because it highlights Slater's plausibility illusion having a particularly strong effect on players' fear response: they reacted because of the feeling that the events were *actually happening*, even if that illusion was broken once the HMD was removed. Similarly, Lin observed that differences in participants' coping strategies to manage their fear were in line with what one would expect in a real-world scenario, reproducing common responses that reflected, for example, gender and sensation-seeking traits.

All the participants in Lin's study were students, and a more diverse group might have responded somewhat differently to the material. Indeed, reliance on students to generate larger samples is quite common in studies of this type. Nonetheless, the qualities highlighted by Lin indicate that VR is quite a good tool for assessing response to different fear-based scenarios without necessarily creating negative psychological responses that still affect participants the following day. Thus, from a research ethics point of view, this suggests that, while participant activities exploring fear in VR should be carefully designed, they do not need to be ruled out altogether.

Fear is, of course, only one emotional response that one might look to explore via a VR intervention. Nonetheless, in terms of ready-made VR materials, the horror genre does seem to be particularly attractive to VR developers and this brings a temptation to focus research projects more in this area. One interesting potential way around this is to use tools such as VorpX, which are designed to let a range of different games be experienced in VR even if they were not originally designed for this. Tate (2016), for example, has demonstrated how VorpX can be used to access the social virtual world *Second Life* (Linden Lab, 2003) in VR (social VR is discussed in more detail in the next chapter). In terms of more conventional games, VorpX could be used with something like *Mirror's Edge* (DICE, 2008) a game that involves parkour across the rooftops of a future cityscape – this can be quite vertiginous in an HMD and would be an interesting tool for exploring anxiety about heights. Again, however, going beyond *fear* as the primary emotional response, one could also use these VR conversion tools with a range of games to explore different scenarios. Walking simulators would be interesting in this regard as they are designed to be more contemplative and rooted in expansive environments rather than more traditional gameplay tropes. Participants could be given the opportunity to explore and derive aesthetic and sensory pleasure from, for example, the landscape of the imagined Scottish island in *Dear Esther* (The Chinese Room, 2016) or the forests of *Firewatch* (Campo Santo, 2016). With some careful thought around matching games to the aims of a research project, therefore, tools like VorpX can be an inexpensive way to access commercially produced, high-quality virtual environments that can generate convincing plausibility illusions via an HMD.

A note of caution is necessary here since these games were not designed for use in VR. As a result, when 'hacking' them into an HMD, they bring a higher risk of cybersickness. The problem of cybersickness, which we discuss in more detail later, needs to be actively considered when reviewing the ethics of potential harms in VR studies with participants. Szpak et al (2020), for example, argue that, although most of their participants showed no symptoms of cybersickness 40 minutes after an extended period playing in VR, around one in seven still had a relatively high score on the standardised Simulator Sickness Questionnaire. Indeed, they explicitly caution against assuming that participants do not suffer longer term physical effects from VR – not least because their study examined a predominantly younger cohort where one would expect a faster recovery rate. Their key recommendation, which is a sensible one, is to ask participants to trial exposure before the main study to assess whether they are particularly vulnerable to cybersickness. Likewise, they suggest including recovery time in any study and insisting that participants agree to a waiting period at the end of the exposure to VR.

Another key consideration for undertaking ethical research in this area is highlighted by the periodically recurring moral panic about video games encouraging violent and addictive behaviours. The myth of video games creating real-world violence is routinely debunked, but frequently resurfaces, particularly following incidents of US school shootings (Gallar and Ferguson, 2020). Again, however, it is important to consider whether the immersive qualities of VR lead to a greater propensity for violent thoughts and actions among participants following exposure. There has not been a great deal of research around this, although an early study by Arriaga et al (2008) attempted to explore whether VR created an increased aggression response in participants. This relatively small study could not find any significant increase in self-reported hostility for those playing within an HMD. Likewise, a more recent study failed to find any major effect in terms of aggression response when playing a violent game in an HMD (Ferguson et al, 2021). The absence of evidence does not completely rule out the potential for VR experiences of violence to trigger aggressive behaviours, but it does suggest that a short exposure as part of a research intervention is unlikely to cause long-term harm.

Addiction is the other well-known bogeyman in popular discourses about gaming. There is well-established evidence that small numbers of users struggle with addiction to video games, to the point that, in 2018, 'Gaming disorder' was included for the first time in the World Health Organization's

International Classification of Diseases (World Health Organization, 2018). Although for the individuals affected this is a serious issue, the numbers of people involved appear to be relatively small, with a *Guardian* investigation (Thomas, 2021) revealing just 56 referrals to a specialist clinic dealing with gaming and technology addictions in the UK from January to May 2021. There have, however, been relatively few studies looking at the addictive qualities of VR specifically. Zhai et al (2020) found some limited connection between the increased sense of presence generated by VR and a tendency toward addictive patterns of behaviour. Nonetheless, there is not a great deal of evidence that VR users are at a markedly higher risk of addiction than the wider population of gamers. When undertaking an ethical review, therefore, it is unlikely that limited exposure as part of a research project offers a particular point of concern around addiction risk.

So, we can reflect that while VR does have distinctly different qualities from non-immersive forms of media, the risk to participants does not appear to be substantially greater. Clearly, however, there are some sensible safeguards to build into projects where researchers are working with participants, particularly in terms of trial exposures and cool-down periods. In summary, there *are* specific concerns that researchers and ethical review panellists should consider in applications for studies utilising VR, but these should prove relatively straightforward to manage and mitigate.

User experience

Beyond reviewing the ethical implications of working with participants in VR, there are also practical issues around user experience to consider when designing research projects. Fortunately, there has been a wealth of studies in this area. As an emerging technology, much of the research around VR has been around how users interact with it, with implications for how these systems are designed and developed.

Cybersickness is an absolutely crucial issue here and, beyond the ethical concerns about making research participants ill, there are also considerable practical issues to consider in terms of generating a usable dataset. Cybersickness can affect participant drop-out rates and can overwhelm other aspects of the emotional and affectual experience for participants that the researcher might want to examine – hence finding ways to mitigate this is important for the data collection process. The impact on sampling is a particular concern because women have been consistently shown to be more susceptible to cybersickness than men (MacArthur et al, 2021). As a result, considerable energy has gone into examining how cybersickness might be tackled, though we should note that it is a somewhat catch-all phrase, with a number of different drivers (Rebenitsch and Owen, 2016).

The main issue is a mismatch between perceived and actual movement. Recent research has examined drivers of the cybersickness gender divide, noting that interpupillary distance between the lenses on many HMDs defaults to a larger size, assuming a male bodily norm. As a result, women are much more prone to ill effects because, in many common headset designs, the lenses cannot be properly aligned for typically smaller female bodies (Stanney et al, 2020). Beyond this, there are also problems caused by maintaining focus on a screen just a short distance from the eyes, incorrect adjustment of the interpupillary distance on the HMD, the fact that the field of view within HMDs is less than humans naturally experience and the 'screen door' effect of being able to see individual pixels on older, lower-resolution displays. At a simpler level, the weight of the headset, how it is balanced and the heat generated when it is clamped across the face can all lead to problematic levels of discomfort and nausea.

Research around some of these issues has driven changes to the technology, with manufacturers creating lighter, higher-resolution HMDs with much wider fields of view and made of breathable materials. Nonetheless, cybersickness persists as an issue and it is important to consider this when designing research projects. The problem is sufficiently serious that a number of standardised tools have been developed for assessing the degree to which participants are made ill by different scenarios. These include variants on the Simulator Sickness Questionnaire, although there has been some debate about how appropriate they are for examining user response specifically within HMDs (Sevinc and Berkman, 2020).

There is some evidence that the *type* of gameplay affects rates of cybersickness. The majority of VR content is designed from a first-person perspective, meaning that the body of the user is mapped onto an avatar of the protagonist within the virtual environment. There is some evidence, however, that cybersickness can be reduced when using VR content based around a third-person perspective, with users seeing the environment from the view of a game camera that follows the protagonist. Monteiro et al (2018) compared third- and first-person perspectives for participants playing *Mario Kart Wii* (Nintendo, 2008). They used Dolphin VR – a system similar to VorpX described earlier – both to transfer the game into VR and to allow it to be flipped between first and third person perspectives. This allowed a direct comparison between the two states in the same gaming environment. While participants reported feeling less immersed in the third-person perspective, they also reported lower levels of cybersickness, with no apparent impact on levels of enjoyment.

In virtual environments specifically designed for VR, there are now a number of standard design techniques used to mitigate the mismatch between bodily and perceived movement. In non-VR gaming, camera movements usually track smoothly the position of the virtual protagonist. In VR this visual flow can be quite nauseating, as the perceived movement does not align with the player's stationary body position. Many VR games therefore adopt a 'teleport' approach, where the virtual body is moved in a series of non-contiguous jumps. Alternatively, some games have a 'comfort' mode that narrows the field of view when the virtual body is moving quickly as this reduces the effects of nausea.

Omnidirectional treadmills are sometimes presented as a silver bullet to solve the mismatch between perceived and actual movement. These treadmills allow the player to walk or run in any direction while remaining in a fixed position. When synced to a VR system, they can give a convincing impression of being able to walk endlessly in virtual space without ever leaving the physical room. Wehden et al (2021) have undertaken a really interesting study of how an omnidirectional treadmill affects user experience in VR. In a rather neat move to make good use of an existing, high-quality virtual environment, the research team built a unique quest within *The Elder Scrolls V: Skyrim* (Bethesda Game Studios, 2011: remastered 2016, VR version 2017) creating a custom hunting task using a bow and arrow. The fact that some games allow this type of customisation is worth bearing in mind when considering the design of an intervention because it may be possible to reuse and adapt an existing commercial product rather than having to go to the expense of designing something from scratch.

In some ways, the results from Wehden et al's study were a little disappointing. Comparing treadmill VR, standard VR and non-VR gaming, with a sample of 203 students, they did not find a reduction in cybersickness from using the treadmill. While participants reported enhanced presence and awe in both VR scenarios, the overall gameplay experience did not appear to be significantly improved when using the treadmill. Interestingly, however, using the treadmill for more natural locomotion around the game space did result in higher levels of physical exertion, and the authors suggest that this might be of value in the field of exergames. An omnidirectional treadmill is a relatively expensive additional piece of equipment for a VR lab. Nonetheless, where projects are interested in exploring participants' *physical* activity, it might be a worthwhile investment, even if it does not apparently help to combat cybersickness.

Wehden et al reported unambiguous findings that VR produced an enhanced participant enjoyment of the game. This conclusion is, perhaps surprisingly, not shared by all studies in this area. Player enjoyment is a crucial issue in commercial gaming and, as a result, there has been a fair amount of research exploring how it can be maximised. A number of papers have attempted to reproduce the findings from a study by Shelstad et al (2017), which found a clear enhancement of user satisfaction when playing in VR compared with conventional gaming. Shelstad et al employed the Game User Experience Satisfaction Scale, another of the standardised tools developed within psychology. Yildirim et al (2018) attempted to replicate these findings and found little difference in enjoyment between the VR and non-VR parts of their experiment. Indeed, in a subsequent paper, Yildirim (2019) hypothesised that the higher levels of cybersickness reported in an HMD might be a key barrier to VR systems outperforming non-VR when it comes to player enjoyment. The fact that Yildrim's team were unable to reproduce Shelstad et al's findings again highlights some of the concerns around reproducibility when using this type of research design.

There are a couple of things to reflect on here. The first is that, while standardised questionnaire tools exist for studying VR and are valuable research methods, they do not necessarily give unambiguous and reproducible findings. The second is the sheer number of potential confounding factors that could explain the differences in findings derived from apparently similar experiments, from the type of game used, to the participant sample, even down to the controllers that participants used. Following up on Yildrim et al (2018), Carroll et al (2019) attempted to compare game types (a racing game with a first-person perspective versus a strategy game using a third-person perspective) while using the same type of controller to try to rule that out as affecting the player experience. Again, they found no significant difference in player enjoyment between the VR and non-VR.

An interesting element in Carroll et al was that participants consistently enjoyed the strategy game more than the racing game, regardless of whether it was played in VR or not. One potential reason for this is that a standard gamepad controller does not accurately reproduce the experience of driving, thereby creating a mismatch between virtual- and real-world experience. This suggests that there might be more research to be done around the effects of the controller interface on VR participant experience. We have done some exploratory work in this area, having visitors to a university open day engage with *Assetto Corsa* (Kunos Simulazioni, 2014), the same driving simulator used by Carroll et al, but using a steering wheel and pedal set-up to more accurately reflect the experience of real-world driving. Older participants (parents and grandparents of applicants) tended to be more comfortable with this because it was a familiar experience and user interface. Some of the younger participants struggled simply because many of them had not yet learned to drive a car so the controls for the virtual simulation were much less familiar than if we had given them a standard gamepad. Clearly, this is not much more than anecdotal evidence, but indicates that there is still work to be done in thinking specifically about the effect of participant's prior real-world experience when considering which controllers they could use to interact with these virtual environments.

Beyond the use of standardised questionnaires, there are interesting possibilities for using more direct physiological measures to assess participant response to VR. In recent years, tools for measuring heart rate, electrodermal activation, brainwaves and other physiological responses have started to be used more widely by researchers beyond medicine and psychology (Osborne and Jones, 2017). These measures can be ambiguous and require a fair degree of expertise to interpret meaningfully. Nonetheless, falling costs and increased ease of application means that they can potentially add an interesting element to projects examining how participants respond to different VR scenarios. Heo and Yoon (2020), for example, explored the potential for using an EEG device measuring brainwave activity in order to examine participant comfort while playing a basic fantasy combat maze game. They found activity in the occipital and temporal lobes stimulated by exposure to VR led to nausea among their participants. Further, they suggested that real-time monitoring of EEG during gaming could be built into systems that encourage players to take breaks or even to increase the difficulty of the game where players were not physically discomforted. While EEG monitoring is not straightforward to operationalise, these kinds of studies indicate that there might be potential for scholars interested in VR to collaborate with those more familiar with physiological monitoring in order to devise cross-cutting research projects.

Therapeutic and training applications

Many projects with an explicit therapeutic or training element use bespoke software and set-ups that we discuss in Chapter 6, but there are also examples of these kinds of issues being explored much less expensively, through off-the-shelf approaches. Dahlquist et al (2007), for example, chose to use the Jellyfish Race sequence of *Finding Nemo* (Traveller's Tales, 2003) in a study on pain distraction in children. The children had one of their hands placed in water at 5°C and either played the game or watched previously recorded footage of the game being played. The participant group wearing an HMD had a significantly increased pain threshold compared with the control group and it was higher still among the group who were actively playing rather than simply watching gameplay footage.

This kind of project demonstrates that the immersion effects of VR operate not merely in the visual and auditory registers but can also make us less aware of external physical stimuli. It also shows how existing materials can be usefully employed within a careful research design. Here, the use of a commercial product potentially *enhanced* the research findings because *Finding Nemo* would be much more familiar – and thereby distracting – to that cohort of children compared with a bespoke virtual environment designed for the project. Of course, many researchers in the social sciences and humanities would not wish to be involved with projects that deliberately caused participants pain, even in the highly controlled manner employed by Dahlquist et al. Knowing that VR is an effective distraction from pain, however, could prove useful in projects working with the elderly and groups suffering from chronic conditions.

There have been a number of review papers within medical literature looking at the potential applications of VR and gaming technology, though in practice some of the older sources in this area relate to virtual environments as experienced through a conventional monitor rather than via an HMD (for example Ferguson et al, 2015 and Yates et al, 2016). Nonetheless, a meta review of projects employing HMDs in VR exposure therapy for trauma patients has found this to be an effective technique for combating anxiety disorders (Carl et al, 2019). Even widely available commercial products can be seen to be effective here, such as Lindner et al's (2019) study which used the off-the-shelf app *VirtualSpeech* (2016) to examine VR exposure therapy to tackle a fear of public speaking.

The powerful physical effects that we see in explicitly medicalised applications of VR indicate that there is interesting potential for research that takes a more interventionist approach, attempting to alter participants' lives. Unsurprisingly, therefore, there has been considerable excitement about the role of VR within training and education research. Aebersold et al (2020), for example, explored whether a conventional team-building simulation app was enhanced if participants had first engaged in a VR simulation of the same environment. The group who had explored the *Everest VR* (Sólfar Studios, 2016) app on the Oculus Rift subsequently performed better in the Everest-themed 2D team-building simulation than a control group. The research team hypothesised that a VR experience might be useful to provide context to students who did not have real-world experience to draw on during a team-building exercise.

The importance of previous experience fits within constructivist theories of education that emphasise sensory stimulation as a learning tool. These ideas have been discussed in a review paper by Oyelere et al (2020), which examines how educational materials have been deployed on the major commercial VR platforms. From an educational and training point of view, the primary advantage of VR is in being able to virtually visit sites that would be too expensive, inaccessible or dangerous to experience in person. In a classroom setting, however, this can be quite challenging because the experience within HMDs is often quite solitary, even before one considers the expense and logistical difficulties of working with multiple VR set-ups with larger groups. As a result, teacher and classmates are not usually sharing the experience *inside* VR with a participant; it is more common for large classes to follow one person's exploration of VR content via a mirrored-screen set-up, which, of course, lacks the immersion and sense of control over the environment.

The use of 'serious gaming' VR in educational settings positions the technology as having social value. Another potential benefit is in encouraging greater exercise in an increasingly sedentary population. Because VR can distract from physical pain or discomfort, exergames can encourage participants to exercise harder and for longer than they might otherwise do. McMichael et al (2020) noted, however, that using such games to encourage exercise in adolescents ran into parental concerns around addiction and violence related to gaming. While the parents in this study were grateful that their teenage children were taking *any* form of exercise, the researchers concluded that educating the parents about this new and unfamiliar technology was a crucial step to it being more widely adopted as a way to encourage exercise.

There is an interesting contrast between the kind of physical training in VR represented by exergames and the use of VR in training scenarios where participant mobility is restricted. This restricted mobility might be as simple as the cost of taking a class to a distant field site. There are also physical mobility issues to consider. Coldham and Cook (2017) give a nice example of whether commercial VR could be used to help older people learn to navigate real-world environments. This study used Google Earth VR, an incredibly compelling, freely available tool, which reproduces topography and buildings rendered in 3D combined with the option to enter Streetview images as 360° immersive photographs. While many participants saw the technology as somewhat frivolous, the virtual environment was not seen as jarringly unrealistic and there was a general acceptance by participants of its potential value for older people to safely explore different navigation scenarios.

It is important, however, to reflect that older people are not a singular cohort, and clichés about them being reluctant adopters of technology are far from universally the case. Indeed, the popular *Elders React to Technology* YouTube series plays with this idea, with one episode specifically examining the responses of older people using an Oculus Rift HMD (REACT, 2014). We have undertaken a tentative initial exploration along similar lines, asking Phil's parents to try Google Earth VR, with both reacting very differently to the experience. Val, now too unsteady on her feet to climb the hills she loved to walk when she was younger, was somewhat underwhelmed by a virtual climb up the Old Man of Coniston, a mountain in the English Lake District. Although the view of the wider landscape from the top of the hill is quite convincing, when looking around at ground level, it is clear that one is standing on a highly pixelated aerial photograph. Val commented that her primary reason for enjoying walking was to see the plants and flowers around her on the hillside, so this was a poor substitute. She also struggled a little with controlling her virtual movement. Ian, meanwhile, rapidly got to grips with the hand controller and was soon zipping across the skyline of Liverpool as if flying a virtual aeroplane, diving under Runcorn Bridge and attempting a 'landing' at John Lennon airport, just around the corner from where he grew up. In part, this returns to the issue of control mechanisms needing to feel familiar. Google Earth VR asks the user to tilt and pitch the hand controller in order to set the direction of movement – Ian had been a gliding instructor and found the controls entirely logical because they mirrored an aeroplane's control stick. A standard gamepad controller would have been much more of a struggle because of its unfamiliarity.

Case study: surviving the zombie apocalypse

We turn now to reflect on one of our projects, led by Calla, which asked participants to play the FPS, *Arizona Sunshine* (Vertigo Games, 2016). The game takes some of the familiar elements of VR survivalist horror, but, unlike the dark and grimy realism of *Half-Life: Alyx*, transfers these tropes to the bright daylight and wide-open spaces of a cartoonish Arizona desert. The setting alters the deliberately unsettling atmosphere favoured by many zombie games, although there is an interesting contrast narratively between the attractive landscape and the horrifying creatures that populate it.

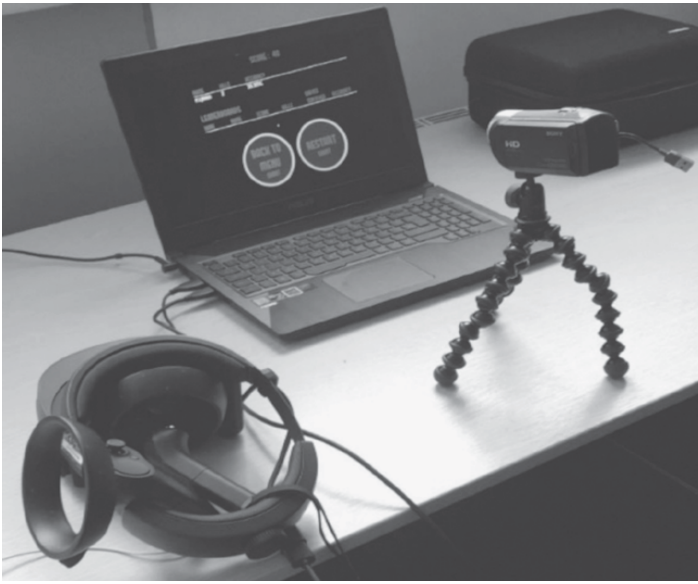
Arizona Sunshine was a finalist for 2017 VR game of the year, reflecting the fact that it is a well-made game, though it lacks the depth and scale of a triple-A offering. Nonetheless, the shooting mechanics within the game are highly intuitive, with weapon aiming controlled by pointing the hand controllers rather than using a gamepad, as would be the case in non-VR. The participant sample for the research was a group of 33 experienced FPS gamers (aged 18–32), meaning that they could reflect on the VR versus non-VR experience. The participant group was all-male, to isolate gender effects for this initial study. Only 30 per cent (10 participants) had previously experienced VR.

The project used a large classroom, with the play space cleared of furniture to remove trip hazards. One of the major safety concerns when using tethered VR is of tripping over the cable. At the time of undertaking the study, wire-free, streaming VR was prohibitively expensive. We thus attempted a relatively simple mitigation placing the gaming laptop (Asus FX503, 7th gen Core i5, GTX 1060) into a rucksack worn by the participants during play so that there were no trailing wires. This proved to be impractical, as VR runs the battery down very quickly and it was too time consuming to recharge between participant sessions. In addition, because the rucksack was not ventilated, the laptop could easily overheat and shut down mid-session.

Following these practical tests, we pragmatically decided to give participants a play area restricted by the length of the HMD tether. The Windows Mixed Reality system allows users to set up a warning boundary that appears in the field of view when getting too close to the edge of the safe area. In addition, the researcher remained in the room to ensure that participants were safe during gameplay and was ready to intervene where there was a risk of tripping over the cable. Unlike participants in Coldham and Cook's (2017) study with the elderly, the relatively young sample group were less anxious about tripping and therefore more confident in their movements. Participants' physical movements were not recorded, but a camera was mounted in front of the laptop screen to record the gameplay (Figure 3.1). As with the *Half-Life: Alyx* study in the previous chapter, screen recording was not attempted on the gaming laptop to avoid placing additional load on a system that was at the bottom of the required specification for running the game.

Participants were given a ten-minute orientation period both to become familiar with the hand controllers and to become acclimatised to VR. None dropped out at this stage with cybersickness symptoms. All participants were then asked to play a 20-minute session of the game in 'hoard mode', where continual waves of zombies attack. The 'Canyon' map was

Figure 3.1: Recording set-up for the *Arizona Sunshine* project



Source: Calla Sullivan-Drage

utilised because it confines participants to the centre of a small tarpaulined area, thus avoiding the temptation to make larger physical movements that might have drawn the user outside the designated safe play area.

After the 20-minute period of gameplay, participants removed the HMD and sat down to undertake a video-stimulated recall interview, which allows participants to reflect on their actions that have been captured in a recording (Nguyen et al, 2013). Adapting this approach for use with VR gameplay, we drew on a technique previously employed with non-VR games (Jones and Osborne, 2020), with participants watching footage of their gameplay while the interviewer asked questions about the experience and the choices being made. These qualitative interviews were subsequently transcribed and underwent thematic coding in NVivo. It was possible to use time codes on the audio to track back to the specific action being discussed within the participant videos, although this was not felt to add much value in this specific use case since most of the recorded gameplay action is fairly repetitive.

Reflecting on the general theme of comparing VR and non-VR FPS, much of the participant commentary concerned itself with ideas of presence, for example: "like you're in the action – you're like a hero, aren't you? You're actually more immersed in it because it feels like the gun's in your hand" (Participant 22, 18 March 2019). This does not necessarily translate to a greater *enjoyment* of the gameplay compared with non-VR, but indicates that the sense of presence adds *value* to the experience. Given that the participant sample was of keen gamers, there was an unsurprising theme around being impressed by the technology and its effects: "It was really intense. My heart was racing and I felt quite hot and sweaty at points because it felt so much more realistic. I didn't think that games could get this sort of reaction out of you" (Participant 33, 7 March 2019). Nonetheless, there was no sense that participants were going to rush out and buy a VR system after this experience. Even though they responded positively to it, this was not going to replace *Call of Duty* and similar non-VR FPS as their primary choice of games.

Methodologically, the project highlights the potential for undertaking rich, qualitative studies with participants using VR. Much of the existing work with participants using VR concentrates on standardised questionnaires, with qualitative material either missing or a second-order method. The participant interviews in the *Arizona Sunshine* study gave more reflective context to some of the well-worn debates around player enjoyment in the fields of computer science and psychology. The caveat, of course, is that VR remains a very niche concern, with many potential participants either not having experienced it at all or only very briefly. Thus the 'wow' factor of being immersed in a rich VR landscape for the first time can overwhelm the participant experience.

In turn, this can narrow the focus of research projects more toward the VR user experience and less on what it can mean for projects working with participants in being able to virtually visit otherwise inaccessible environments and scenarios.

Of course, the *Arizona Sunshine* project is equally guilty of focusing on the experience of being in VR rather than what VR allows us to do with participants. Likewise, many scholars working in the sciences would be unconvinced by what conclusions one can draw from a small qualitative project. This flags up philosophical differences between disciplines, particularly on the use of qualitative datasets. Nonetheless, given that most VR research to date has focused on quantitative approaches, there is quite a large gap for qualitative research in this area.

Conclusions

This chapter has explored the challenges and opportunities presented by working with participants immersed in VR. Environments and scenarios can be created in VR that would be simply impractical to explore with participants in the real world. As a medium, however, VR still raises unique questions for how we undertake ethical research, but there are sufficient studies demonstrating that these ethical concerns are not unsurmountable. The great strength of VR is that it can feel surprisingly plausible, even though you know it is a simulation. Exposing participants to virtual danger, for example, can thus have a physical and emotional impact even if this does not last much beyond the point where the headset is taken off.

Modern VR is still a fairly new technology, so a great deal of research has focused on player experience – not least with the commercial aim of finding ways to encourage more people to buy equipment and software. Cybersickness remains a considerable barrier for many participants being able to engage with VR, which can narrow the sample of participants for research seeking to immerse people in different environments.

Likewise, because VR remains unfamiliar to many potential participants, the 'wow' effect of using it for the first time can overwhelm other emotional and affectual responses to virtual environments that a researcher might be keen to explore.

In this chapter, we have been specifically considering work with existing, commercial VR content. There are significant disadvantages to this compared with custom designing content that specifically meets the needs of the research project. But there are valuable advantages to finding existing content through which a project's research questions can be explored: removing the cost of custom development; using globally familiar characters which can ground participants in the otherwise unfamiliar world; and providing robust and high-quality virtual experiences built and tested by large teams of experts.

As a medium, VR works very well for the horror genre. A selling point of VR is that one can try activities that would be too dangerous in the real world, meaning that reusing commercial content risks nudging research projects more toward topics considering fear and anxiety. As we have seen, however, there are ways around this, from employing tools that allow a wider range of games to be experienced in VR, to using games that allow for unique quests and experiences to be built. While *Half Life: Alyx* is a horror game, for example, the developers have released modding tools that allow users to easily customise the game environment and experience. Researchers can browse a catalogue of other users' designs or create their own to simulate the type of environment and scenario that they want their participants to experience.

As with any project, careful research design is therefore essential when considering how to utilise VR with participants. Suitable virtual environments need to be chosen and participant groups appropriately selected, carefully briefed and looked after while in VR. There are important considerations about the types of tools (quantitative, qualitative, creative, mixed) that might be applied to collect the data and materials that will address the research questions. Nonetheless, VR offers significant opportunities for research with participants. There are major research gaps around: investigating *positive* emotional experiences; considering how participants can themselves engage more creatively with VR environments; and, more generally, undertaking in-depth, qualitative projects with research subjects. In short, when focusing on commercially available software environments, there is no shortage of work to be undertaken with participants in VR.

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FOUR

Working with social VR

Introduction

One of the criticisms of VR is that it can be a rather solitary experience. Users are cut off from the physical world, seeing and hearing different things from those around them. Most of the projects we have discussed thus far have focused on a single user experience. We turn now to reflect on the research potential offered by social VR systems, which allow multiple users, normally not in the same physical location, to come together in a shared virtual environment.

Writing about potential future applications of VR in the early 1990s, Valerie Stone (1993), argued that collaborative and creative experiences would be of much greater value than the kind of solitary and non-creative interactions that she associated with the video games of the time. The European Commission-funded *COVEN* (Collaborative Virtual ENvironments) project, which ran from 1995 to 1999, was a pioneering attempt to create a networked VR infrastructure to produce these kinds of group experiences, with projects such as Slater et al (2000) examining the potential social effects of these shared virtual spaces. The dream of VR becoming a collaborative platform has, however, only really become possible since the third wave of VR from the early 2010s, thanks to dramatically improved technology, commercial interest and a much larger consumer audience. Indeed, Perry (2016) optimistically described social VR as the 'killer app' that would allow the new generation of VR to break into the mainstream.

Online collaborative social experiences in virtual environments have been around for some time, though they were at first available only via desktop interfaces. In the early 2000s, VR developer Bernie Roehl (2019) was involved as a beta tester on the development of *Second Life* (Linden Lab, 2003), the best-known and most successful of these desktop-based collaborative environments. He recalls how difficult it was to explain to friends at the time that, while *Second Life* *looked* somewhat like a game, it did not function as such because there were no particular goals to meet. Instead, platforms like *Second Life* act as spaces for *socialising*, allowing synchronous engagement with real people from around the world meeting in virtual locations. Newer platforms, such as *AltspaceVR* (Microsoft, 2015), *Hubs* (Mozilla, 2018) and *Facebook Horizon* (Facebook, 2019) take this model one step further by allowing users to immerse themselves in these social worlds via an HMD.

Roehl (2019: 291) identifies four key qualities underpinning social VR platforms: multiple users are present and represented by avatars; users can navigate the virtual environment; users can communicate with each other; and users are able to tell which of the avatars is communicating with them. With desktop platforms such as *Second Life* and its VR successors, however, there are significant technical constraints that shape their design and interactive qualities. Users' avatars are generally graphically simple because of issues around latency when the software is trying to draw multiple people interacting in the same space. Nonetheless, these constraints create opportunities for creating new ways to interact socially. Mcveigh-Shultz and Ibister (2021) even go so far as to describe these limitations as creating new forms of 'weird social', allowing for experimentation with new modes of social interaction. In *AltspaceVR*, for example, you can see multiple emojis floating above a user's avatar to express their feelings in a given moment.

In this chapter, we explore the different ways in which collaborative virtual experiences can be used within research projects. In some cases, this involves researchers building custom software for their experiments – something we will return to in Chapter 6. For those lacking this kind of technical expertise, however, there are many opportunities to employ commercial social VR platforms within projects, many of which are free to use. These commercial platforms benefit from being well designed and robust, with an established user base, and having some capacity for customising environments and avatars and opportunities for interaction around the needs of a research project. Beyond these advantages, as Maloney et al (2021) point out, the large numbers of commercial social VR users interact with these platforms in ways that their designers never anticipated – sleeping in VR for example. As such, the communities and modes of socialisation enabled by commercial social VR platforms become fascinating objects of study.

The chapter starts by exploring the opportunities for collaboration between participants and researchers presented by social VR. Next, we explore the role of the avatar in shaping interactions between social VR users, looking in particular at questions around social cues and harassment. Finally, we report on a case study from our own work examining the communities that have grown up around a virtual church within *AltspaceVR*.

Opportunities for collaboration

One of the traditional selling points of VR was a vision of people in different geographic locations being able to come together in the same virtual space for education, work and leisure. The reality certainly is not as seamless as the vision; social VR is yet to become the 'killer app' that Perry predicted. Nonetheless, the steady stream of work on social VR became a flood after 2020 as the COVID-19 pandemic trapped people in their homes, and tools for remote collaboration were suddenly in high demand. Rzeszewski and Evans (2020) undertook a review of how attitudes toward *VRChat* had changed since the beginning of the pandemic. Methodologically, this is an interesting use of content analysis, using the Steamworks application programming interface to scrape reviews of the software posted on Steam – the most widely used platform for purchasing and downloading PC games. The 28,334 reviews downloaded were split into pre- and post-March 2020 and subject to qualitative analysis using NVivo. The reviews posted after March 2020 contained fewer gripes about the glitchiness of *VRChat* and an increased sense of positivity toward the platform and its potential. This included reflections on how engaging with *VRChat* helped some users overcome wider social anxieties by creating a safe online space to socialise during a period when meeting friends in the physical world had become actively dangerous.

At the time of writing, there are a number of competing social VR platforms, which have a different appeal to different audiences; *Rec Room* (2016), for example, is targeted more toward children. Common features include opportunities to play games collaboratively, interact with objects and chat. These platforms have different limitations on interaction, which are useful to consider when designing a project employing one or more of them. Liu (2020) has produced a useful comparative overview, asking participants to reflect on the difficulties of attempting the same set of tasks in different platforms. Common issues included not being able to communicate with another user if they were not in the same virtual room – which made coordinating activities quite difficult. Indeed, in our own experiments with *AltspaceVR* we have found that getting people to understand how to navigate around and communicate with other users can be quite tricky, although the platform does have a useful onboarding process to train novices.

The uses to which people put these platforms varies considerably and there is clearly scope for projects that simply undertake ethnographic work about how social VR shapes forms of socialisation. Zamanifard and Freeman (2019), for example, searched for social media posts about using social VR in long-distance relationships, examining how users were able to create a sense of intimacy through the illusion of co-presence. There remain, however, real barriers to reproducing the conversational flow experienced when physically in the same space. Bleakley et al (2020), for example, highlight the need to develop technical systems that more consistently create a feeling of social presence, such as being able to understand the role a given user is playing in a social interaction. They also identify practical issues that act as social barriers, such as not being able to see what other users are looking at in a virtual environment, thus reducing the illusion of sharing an experience.

We will return to the question of shared social cues when talking about avatar design. It is important to note, however, that the limitations of the platforms in reproducing non-verbal communication have a significant impact on how we are able to research topics around VR collaboration. Nonetheless, there has been some interesting work in recruiting existing social VR users as research participants. This has the advantage that they are already familiar with VR and have their own equipment and so can participate remotely – something which was very useful during the COVID-19 pandemic. Saffo et al (2021) recruited participants this way for a replication study employing bespoke VR environments that participants could access from home. That the researchers were able to replicate results from earlier work using both quantitative and qualitative approaches is quite encouraging. One possible reason why this worked effectively is that the recruits were familiar with VR and thus were not distracted by the technology when undertaking the study. Indeed, ethnographic work by McVeigh-Schultz et al (2018) highlights how social VR users have to learn a new set of social cues in order to successfully interact with those spaces. Again, this is significant when thinking about how to recruit participants into VR studies, particularly if placing novices into virtual settings with unfamiliar social protocols.

Industrial interest in VR products has often been in its use for training purposes, where shared and collaborative experiences can add real value. Employees can enter dangerous or potentially expensive scenarios and gain experience before undertaking these for real. Such training was initially intended for an individual working alone, but, as the technology is maturing, so more collaborative scenarios are starting to be produced. The ways in which industrial users are applying collaborative VR is an important topic of study in itself, which can be explored through a combination of discussions with designers and participants as well as ethnographic observations. In a review of industrial VR applications, Berg and Vance (2017) highlight the example of the firm Case New Holland, which brought together its engineering, design and marketing teams within a VR environment in order to work together on optimising new products. Indeed, this idea of collaborative design within VR is itself an interesting research technique to explore.

A fascinating, if somewhat quirky example of how co-design can be undertaken in VR is Mei et al's (2021) CakeVR tool. Here, the researchers prototyped a system to solve a common problem experienced by pastry chefs, where clients struggle to articulate precisely how they want their customised cake to look and, as a result, are not always happy with the final outcome. The researchers undertook a storyboarding exercise with pastry chefs and used this as the starting point for a basic VR platform that allowed chef and client to come together to build models of potential cakes and visualise them in the round. They then tested this in VR with a researcher role-playing with chefs and clients to explore the useability and usefulness of the system; each participant spent about an hour in VR co-designing a cake. Although only a pilot, with limited graphical sophistication and flexibility, both groups of participants were enthusiastic about the potential for collaborative cake design using this medium. Given the emphasis in a great deal of social sciences and humanities work on the importance of co-design with participants (Zamenopoulos and Alexiou, 2018), one can see a similar approach being taken in work with, say, residents and housing developers or creative practitioners and community groups. Although CakeVR was a custom-built tool, there is potential for a simpler approach where an existing social VR platform is used to undertake different kinds of co-design activities. Many of the commercial platforms allow varying degrees of creative work where users can come together to build and interact with shared objects and environments, meaning that there is real potential for rapidly prototyping ideas without the need for investing in custom software.

Collaborative and sharing experiences are central to some forms of educational pedagogy (Le et al, 2018). Undertaking this kind of work in VR can sometimes demand that a complex and expensive custom environment be constructed. The kind of 'flying classroom' described by Schulte et al (2018), for example, needs significant investment because of the way in which it meets highly specialised training needs. Here, they developed a system whereby a remote instructor could adopt the same point of view as a trainee and appear as a set of virtual hands, guiding the trainee through the correct actions to repair a piece of industrial machinery. This kind of approach can be incredibly valuable, particularly in allowing experts with highly specialised knowledge to be sent to remote sites. There are some limitations to it, however, beyond the simple cost of developing a custom environment for the specific training needs. One of the issues is where very accurate movements need to be replicated by the trainee. Xue et al (2020), for example, have piloted a system where patients with arthritis can be brought into a virtual surgical room to talk with a remote doctor about the process of injecting themselves as part of a treatment regime. Correctly using a hypodermic needle, however, requires fine motor skills, and a purely visual VR simulation would be less effective in this use case. Xue et al therefore combined their collaborative VR platform with a SenseGlove, a device that mechanically manipulates the movement of the fingers, looking a little like a nightmarish spider clamped around the hand. This gives haptic feedback to the user such that it gives the sensation of picking up a physical object. As a result, patients in this study were actually able to get a *feel* for giving themselves injections, with a remote medical professional being able to watch and give them feedback in real time.

Tools like the SenseGlove can seem quite magical, but are expensive, require custom software to be built for each application, and their appearance can be intimidating for the faint-hearted participant. Indeed, for many applications, the SenseGlove would be overkill, though there has been some really interesting work looking at object handling in a virtual museum using the system to simulate the feel of holding a piece of pottery (Senseglove, 2021).

Other researchers examining the educational potential of social VR take the more cost-effective approach of using existing platforms. Yoshimura and Borst (2021), for example, taught a course in Mozilla *Hubs* and then asked their students for feedback on how well it worked. They emphasise that those students who did not get simulator sickness found the sense of presence particularly useful, especially in the context of the COVID-19 pandemic prohibiting conventional face-to-face teaching. Students also reported feeling less nervous giving presentations as avatars than they would when using conventional video. Interestingly, the students noted the lack of visual cues from the teacher's avatar had an impact on their feeling of being properly engaged with. We will return to the issue of avatar design later.

Returning to Stone's (1993) original idea that VR should be both collaborative and creative, there have been some innovative projects attempting to engage with more arts-led approaches. Gochfeld et al's (2018) interactive theatre piece *Holojam in Wonderland* is a good example of this. They ask what added value can be brought to theatre by using VR, beyond the merely gimmicky. Drawing on the Alice in Wonderland stories, they built a virtual environment in which a live audience was present in the same virtual space as real actors controlling avatars in a short play. Using VR allows the actors and audience to change in size, reflecting the shrinking and growing tropes of the original stories, with Gochfeld et al reflecting that VR offers productive opportunities to set stories in magical and fantasy worlds. This is a nice example of where a bespoke virtual environment is more than just a necessary expense to test a particular hypothesis, and is itself a creative output underpinning the wider theatrical experience.

Engaging participants' own creative energies can also be quite productive. Baker et al (2021) have undertaken a large project examining how social VR can be used with older people. They used a participatory action research approach, working with older people to discuss the kinds of materials that they would like to experience within VR. The researchers then built a prototype environment, based on participants' interest in creating a tool for reminiscing. Their *School days* app allowed participants living in different parts of Victoria, Australia, to come together within a virtual classroom, to reminisce about their youth and to share experiences. By adopting a participatory approach, the team were able to explore how this kind of tool could be refined and made more useful for helping older people socialise and avoid becoming isolated even when living some distance apart.

Avatars, social cues and harassment

The *School days* app was developed as part of the *Ageing and Avatars* study funded by the Australian Research Council. Considerable effort went into testing different ways to reproduce participants' bodily movements within social VR in part to try to resolve some of the issues around ambiguous social cues and non-verbal communication highlighted earlier.

Some of their participants felt, however, that highly accurate body tracking might actually reproduce negative stereotypes of ageing in the virtual world, such as uncontrollable trembling (Baker et al, 2019). Again, this emphasises how participatory design work can be incredibly valuable in highlighting issues that might simply have never occurred to young, fit programmers.

Another issue raised by the *Ageing and Avatars* project was that participants found the avatars' lack of facial expressions somewhat disconcerting. This is a question that has generated considerable research interest, including a large project funded by the European Commission, *VR Together*.[1] One of the challenges that the *VR Together* project tackled was trying to find ways of creating more photorealistic avatars in VR (Gunkel et al, 2018). Participants were asked to watch a video together within a VR environment, simulating the effect of sitting with other people sharing a movie (Simone et al, 2019). The participants found that the experience was better where the avatar sitting next to them was a photorealistic representation created using Microsoft's Kinect sensor, which tracks body movement. It has to be said that looking at the project's promotional videos, the effect is somewhat rough around the edges, producing a low-resolution rendering of users wearing HMDs appearing as avatars in the virtual scene. Nonetheless, the project has examined some significant questions, such as how the lack of facial expressions on avatars acts as a barrier for more naturalistic social interaction, including examples of discussing shared photographs (Li et al, 2019), or understanding what another avatar is looking at in a virtual environment (Rothe et al, 2020).

While it may appear at first to be a somewhat niche concern, the way that participants are represented within a social VR environment can be quite significant for how projects can be undertaken. Indeed, the fact that most social VR platforms use rather cartoonish or abstract avatars has been seen as a barrier to business use, given the desire to project a more serious and professional appearance (Lee et al, 2021). Nonetheless, even with these somewhat abstract designs, avatars can create a reasonable sense of being socially present with other people. Yoon et al (2019) tested six different avatar types from live video and whole-body capture through to cartoonish virtual characters. They found that participants responded best to a whole-body avatar, though abstract representations of just the upper body or a cartoon style could also be effective in different types of collaborative activities. While it is now easier than ever to create photorealistic models of individual participants using technologies such as volumetric capture and photogrammetry, these remain fairly expensive and complex to operationalise. It is therefore reassuring to know that relying on the basic cartoon avatars of commercial social VR products can still be effective when researching virtual collaboration.

The presence of even a somewhat abstract avatar can be seen to create a much greater sense of collaboration within a virtual space. Herder et al (2019), for example, set up a task where participants had to operate virtual machinery. Participants found it easier to complete the task when the researcher appeared alongside them as an avatar compared with when they were merely talked through the exercise by a disembodied voice. The avatars used in this study were basic rather than fully photorealistic models, again giving reassurance that a sense of co-presence and collaboration can be generated in research studies with abstract representations of other users. This does not get away from the fact, however, that most non-verbal social cues are missing from these types of systems. There are potential technical fixes for this – Izzouzi and Steed (2021), for example, suggest that HMDs with built-in eye tracking could be used to reproduce a user's gaze through animating eyes of avatars, while prototypes have been built showing how a combination of cameras pointing at the mouth with artificial intelligence reconstruction could be used to create VR avatars that have more natural facial expressions (Olszewski et al, 2016). These kinds of technical solutions are just beginning to be seen in some commercial products. As a result, questions around non-verbal communication within social VR pose an interesting and rapidly evolving set of challenges to researchers. Maloney et al (2020b) highlight how the use of an HMD and the associated sense of physical presence give many more opportunities for creating non-verbal cues than in desktop platforms such as *Second Life*. Nodding, bodily position and the use of emojis are central to signposting emotional engagement with other social VR users, and there is further potential for improved hand and finger tracking to capture gestures.

Methodologically, Divine Maloney's work has relied on a mix of interviews and participant observation within social VR to explore the everyday use of these shared virtual spaces. One of the important issues that his work highlights is how users of social VR reveal and conceal personal information in order to protect their personal safety. Children in particular are at risk of intrusive questioning and even grooming within these spaces (Maloney et al, 2020a). This work highlights the significant ethical concerns around working with participants in social VR spaces, particularly for projects relying on ethnography. There have been quite a few studies looking at how social VR is used by vulnerable or marginalised groups to socialise and gain support from like-minded people. Acena and Freeman (2021), for example, have looked at the ways that LGBTQ users have built communities within social VR, undertaking a series of interviews and observations of online events. The ethical risks of this kind of work need careful consideration, particularly given that some participants may be living in real-world communities where their sexual and gender identities are seen as problematic or even illegal.

While some marginalised communities have attempted to carve out safe spaces within social VR, it is important to note that harassment and trolling are significant problems on these platforms. At its most benign, this might be a simple case of new users not really understanding the implicit rules of social interaction in an unfamiliar platform. This being said, in a study by Blackwell et al (2019), most participants who experienced harassment in social VR distinguished between a naïve violation of established mores and malicious intent. Within their interviews, participants recounted the kind of racist and sexist abuse that is familiar to anyone who has studied wider online and gaming cultures (Mantilla, 2013) but is no less depressing for its ubiquity. What VR brings to online harassment, however, is a sense of embodied *proximity*. Abusive users placing their avatar far too close to others, for example, can create real discomfort for those targeted (Sun et al, 2021). Teleporting into a virtual space to spew invective at people is also common: these types of abuses come without the risk of being subject to the kind of physical altercation that such behaviour might trigger in the real world.

Thus, when one is considering using a commercially available social VR platform for research, there is a risk of coming into contact with abusive activity. Developers are not unaware of this as a problem and many platforms include tools that allow users to mute abusers and even make them disappear from view. Indeed, some have specifically made choices around the avatar design options available to users, for example avoiding hyper-sexualised attributes in order to reduce sexist harassment (Kolesnichenko et al, 2019). When working with participants in social VR, therefore, there may have to be compromises in order to maximise participant safety, depending on the needs of the research project. Undertaking data collection within a social VR space brings the advantage of better understanding how participants interact with that environment, but it can bring the risk of trolling from random users unrelated to the project. Activities outside that space, such as interviews on Zoom, can risk the anonymity of participants from vulnerable groups, but allows for more in-depth conversations with lower risk of hostile interruption.

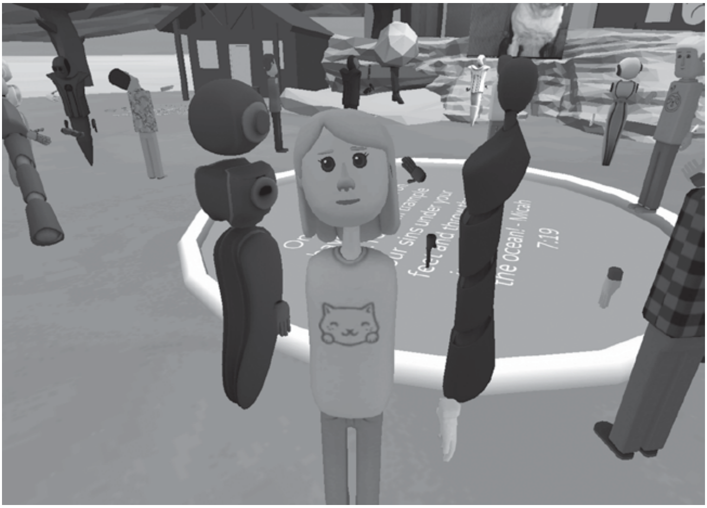
Case study: VR Church

We turn now to reflect on one of our projects, led by Natasha, undertaking an ethnographic investigation of the communities formed around church services that take place in VR. Religious groups have a long history of building communities in digital worlds, including *Second Life* (Radde-Antweiler, 2008) and on social media (Cheong, 2014). Yet VR potentially offers a more immersive religious experience and community. Founded in 2016 by DJ Soto, VR Church offers a new and innovative opportunity where people can use VR to develop real relationships across geographical boundaries (Round, 2019; Jun, 2020). The VR Church community is an extremely active group with weekly services in 'Church World' via *AltspaceVR* and various chat platforms including *Discord*.

Natasha attended European and US services in *AltspaceVR* using the now discontinued Oculus Go HMD. This was a stand-alone headset with a single hand controller and three degrees of freedom, meaning that it tracked head orientation but not body movement. The project took the form of an autoethnography, with the aim of exploring the practices and experiences of worship within social VR. This was supported by semi-structured interviews with members of the congregation, and content analysis of the group's *Discord* server. This combination of methods enabled a reflection upon the researcher's experiences as part of the VR community and the perspectives of the congregation.

The autoethnography was undertaken at weekly services between November 2018 and June 2019. Natasha entered the church community openly as a researcher and constructed her *AltSpaceVR* avatar to personify her identity as a young, white, middle-class, cis woman (Figure 4.1), but chose not to reveal her religious positionality in a deliberate effort to avoid religious debates. Some members of the congregation chose avatars that attempted to match their

Figure 4.1: Natasha's avatar in a VR Church service. Note the single floating hand giving away her use of a cheaper headset. This image was produced prior to a significant graphical upgrade to the platform in 2020



Source: Natasha Keen and *AltspaceVR* (2020)

physical appearance, while others preferred to construct their own visual identities, thus enabling a sense of anonymity in the virtual space (Galanxhi and Nah, 2007). Despite this ability to customise one's appearance, the HMD used by an individual shaped the capabilities of their avatar. Natasha was using the Oculus Go with a single controller, meaning that her avatar only had one hand, whereas those using more expensive devices with two controllers had two hands: "Like right now I'm using the Go which is obvious. I'm trying to upgrade to the Quest when it comes out, which is gonna be like $400, if I'm correct, so I'll have two hands" (Interview with David in VR).

Typically, autoethnography involves taking comprehensive field notes, yet the use of HMD restricted this possibility, so, in a similar vein to the *Alyx* project discussed in Chapter 2, Natasha recorded an oral commentary of her experiences. However, the extended periods of immersion led to practical and technological issues during the data collection, including running out of battery, motion sickness and issues linked with connectivity. At various points during the autoethnography, the audio would cut out or voices would be distorted, with a subsequent impact on the data collection. Audio and visual glitches were a common problem that hindered communication with others:

> 'It's really sad 'cause I can see the people dancing, and there's no music! It's really sad. Oh dear. Everyone's dancing!'
>
> 'This tech error keeps making it difficult to keep up with everything going on.' (Extracts from field diary)

In this example, Natasha was unable to hear the music alongside the video feed, so felt that she was missing out on a fun social experience. Regular members of the congregation were used to these technical glitches, but they clearly served as a barrier to engagement.

Another key problem that worshippers discussed was the impact of trolls coming into the service and yelling or making a nuisance of themselves. As a relatively high-profile event within *AltspaceVR*, these interruptions were not uncommon, meaning that the organisers had become well versed in muting and ejecting those trolls. The existence of trolling was significant particularly because some members of the group were active in VR Church precisely because they had issues around anxiety or other vulnerabilities that made it more difficult to access church spaces in the real world. The role of social VR as a safe space for vulnerable individuals again emphasises the importance of giving very careful ethical consideration to how an ethnography is undertaken with these groups.

Conclusions

The prevalence of glitchiness and trolling are just some of the factors that mean social VR remains an imperfect realisation of the promise to enable people to come together in a virtual space for creative socialisation. Nonetheless, what VR Church and other communities within social VR demonstrate is that VR cannot be considered a purely solitary experience. Many of the communities within social VR platforms are public and open to visitors. This creates a wealth of opportunities for data collection via ethnographic work within the platforms themselves and online interviewing, as well as content analysis of the chat logs and social media posts generated by these communities.

Because of technical constraints around processing power and bandwidth, the avatars used in most of the commercial products are rather abstract or cartoonish. They generally lack subtle ways to convey non-verbal communication and other social cues, which can act as a barrier to engagement. Nonetheless, various experiments have demonstrated that, while more realistic models do generate a greater sense of embodied presence, even abstract or cartoony avatars can effectively produce feelings of co-presence and a capacity for socialisation among users. This means researchers can be relatively confident that even the commercial social VR platforms offer good opportunities for exploring new forms of collaboration and socialisation within these virtual worlds.

Significant research projects have been undertaken where custom environments have been built that can be shared between two or more users. As we will discuss in Chapter 6, these offer excellent opportunities to examine participant response to specific scenarios when considering interactions with other people. The need to invest in creating a custom environment will, of course, depend on the demands of the research project and available budget. What we wish to emphasise here is that commercial social VR platforms can be a good vehicle with which to test ideas – and indeed to work with large numbers of potential participants – before going to the expense of developing custom software. Moreover, the huge expansion of interest in social VR sparked by the COVID-19 pandemic will inevitably drive further innovation in this area, meaning that collaboration within VR will remain a significant and rapidly evolving research topic for many years to come.

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FIVE

Creating 360° imagery

Introduction

Custom-made VR environments can be incredibly valuable for research, but as we discuss in Chapter 6 they can be time-consuming, complex and expensive to create. While the previous chapters have demonstrated that research with VR can be undertaken effectively using pre-existing materials, 360° photos and video can be a striking and straightforward way to get started with the process of creating original immersive experiences. These materials combine 2D images from cameras with two or more wide-angle lenses to create a photo sphere with the viewer at its centre (Figure 5.1). As a tool, it has become popular for virtual field tours (Kenna and Potter, 2018), journalism (Jones, 2017) and tourism (Wagler and Hanus, 2018), giving users the capacity to explore a distanced location in a more naturalistic manner than conventional monodirectional images. Unlike VR environments built with games engines, it is not possible to navigate around the virtual space because 360° environments are merely projections of flat images. Despite this, 360° photography can provide immersive experiences and a high degree of realism with fairly low effort and minimal cost.

Figure 5.1: 360° photograph of woodland in Rotterdam seen in a spherical projection

Source: Tess Osborne

The popularity of 360° photography stems from its simplicity and its relative affordability. In the previous chapters, we have spoken about HMDs that require a powerful gaming computer to operate. However, 360° imagery can be accessed on low-power HMDs (Hughes and Montagud, 2020). The now discontinued Google Cardboard and similar smartphone platforms provided an opportunity for immersive VR experiences to reach larger audiences. These 'dumb' HMDs comprise a simple headset with users looking through a pair of lenses to the screen of a smartphone. Gyroscopic tracking on the phone gives the user three degrees of movement, which is perfect for use with 360° imagery. Such devices do not give as smooth an experience as more powerful tethered HMDs, but can still give an impressive sense of immersion, benefiting from the fact that looking around photo spheres is not very computationally demanding.

The accessibility of 360° imagery, combined with easy creation, has resulted in an extensive collection of VR experiences. Websites, including YouTube, have produced 360° video content, as well as application developers creating games and other experiences. In this chapter, we reflect upon the strengths of 360° photography for experiencing real-world spaces in VR and the work done on therapeutic landscapes. We then turn to discuss the sensory qualities of VR as an ocularcentric experience. Finally, we reflect upon a pilot we undertook where participants were exposed to urban and natural stimuli through audio and 360° imagery.

Travelling through 360°

One of the main benefits of using 360° imagery, beyond the simplicity and easy access, is that it can provide a more realistic-looking virtual environment than those discussed in earlier chapters. 360° imagery is a visual copy of the real world rather than a computer-generated replication. It is, therefore, no surprise that 360° imagery has become increasingly popular in the tourism sector as a promotional and marketing tool (Guttentag, 2010), where it acts as a 'try-before-you-buy' option for potential tourists. Thus, 360° imagery has been a popular addition to the promotional activities of national tourist boards, hotels and travel agencies in recent years. For example, Visit Scotland developed a multimedia smartphone app called *ScotlandVR*,[1] which included animated maps, photos and 360° video to allow people to visit 26 attractions without leaving their homes (Gibson and O'Rawe, 2017). The app was seen as an excellent example of how VR is 'far from being a fad or gimmick, [but] revolutionising the way people choose the destinations they might visit … and learn more about the country in a unique and interactive way' (Chief Executive of Visit Scotland, cited in Gibson and O'Rawe, 2017: 97). There is a vast collection of touristic 360° imagery from all around the world and there has been, unsurprisingly, a good deal of research exploring people's experiences of VR tourism, which primarily uses interviews and questionnaires to unpack those narratives. The abundance of free and publicly available 360° content comprises a rich dataset for tourism scholars, but the sheer quantity of material is also incredibly useful for researchers more generally.

With this realistic quality in mind, 360° imagery also has the potential to enhance accessibility. Just as with the story of Val and Ian in Chapter 3, it can be used to immerse people in spaces that would be difficult, or even impossible, for them to access. Discover Cracow (2016), for example, produced a three-minute-long promotional 360° video called 'Auschwitz-Birkenau Walkthrough', which depicts the concentration camp's interior and exterior spaces. It is a powerful piece of media, combining emotive music with both mobile and stationary video footage; it is no surprise that people were leaving comments along the lines of, 'Even though I'm not there I can feel it,' (Discover Cracow, 2016) on the video's YouTube page. We used this 360° video in a methods workshop in Washington DC to allow participants to experience the various spaces of the camp and how these were subsequently reflected in the architectural design of the city's United States Holocaust Memorial Museum (Osborne and Jones, 2021). Many of the workshop attendees had only ever seen Auschwitz-Birkenau through 2D photographs and videos. Yet, immersion in the 360° video helped the attendees feel that they had a presence in the environment, as if they were actually visiting the site. This transcendent quality of 360° video makes it an effective tool for researchers: it can create a greater connection to a location compared with 2D imagery and prompt more nuanced reflections from users.

Using 360° photography or video, whether that is existing footage or materials specifically captured for a project, solves many practical issues in fieldwork. For example, Mathysen and Glorieux (2021) used 360° photography to conduct 73 user surveys of five public libraries in Flanders and Brussels to understand class-based dispositions in relation to the 'invitingness' and/or 'attractiveness' of the libraries. The use of 360° imagery allowed Mathysen and Glorieux to study multiple spaces in a relatively short amount of time and without taking people on field trips to libraries across Flanders, a region covering nearly the whole northern half of Belgium. At first, some of the respondents had doubts about whether they could engage with the virtual environments in the same way as real life, but once immersed in the environment, nearly all the respondents started evaluating the libraries without noticing that they were in an HMD. This study demonstrates the effectiveness of using 360° imagery to create an efficient and straightforward fieldwork process with participants and invoke a realistic experience of actual locations.

360° therapeutic landscapes

Aside from the fantastic work undertaken in tourism studies, 360° imagery has been used to great effect in research around therapeutic landscapes. The term 'therapeutic landscapes' was first coined by Wilbert Gesler in 1992 to explore why certain places seem to have healing qualities, such as green and blue spaces, spas and religious spaces. Since then, the concept and its applications have evolved and expanded with new foci, spaces, methods, and approaches being evaluated, including digital and virtual places (Bell et al, 2018). It is frequently argued that green and blue spaces have a restorative effect (Bell et al, 2018), however, some groups of people, such as poorer communities and the less mobile, may have worse or limited access to these spaces. Therefore, it is no surprise that a growing body of research has focused on understanding the restorative experiences of natural environments encountered via VR to explore whether this can act as a substitute for real environments. This type of research has used various VR formats to explore therapeutic effects, including pre-made gaming landscapes, purpose-built computer-generated environments and 360° photography.

This body of work has shown how being immersed in 360° nature videos can lead to a therapeutic effect and improved mood (White et al, 2018). Browning et al (2020), for example, studied exposure on mood and restorativeness in three settings: (a) an outdoor forest setting, (b) an indoor setting with no visual or auditory stimulation, and (c) a 360° video of the same forest with noise-cancelling headphones. Using skin conductance and self-reported survey measures, Browning et al were able to show how nature exposure outdoors boosted a positive mood, while VR preserved a good mood compared with sitting indoors with no nature exposure, which diminished the person's mood. The study shows the promise of 360° imagery for mental-health promotion, which is coupled with its easy accessibility and affordability, and how research with VR can be applied in and outside a lab setting.

Although this book focuses on the methodological approaches of VR, the work of these various scholars and charitable foundations, such as Virtual Dream, demonstrate the ways in which VR can provide relief and encourage well-being. With the affordability of using 360° imagery, easy distribution, and accessibility, it is no surprise that many therapeutic experiences have been developed – especially during the COVID-19 pandemic. Covid Feel Good, for example, is a weekly social self-help virtual therapeutic experience using a 360° video of a 'Secret Garden'. Riva et al (2020) were able to demonstrate that repeated ten-minute immersions in the Secret Garden led to a statistically significant reduction in anxiety, depression and perceived stress, as measured by the Depression Anxiety Stress Scale and Perceived Stress Scale. This therapeutic-focused work demonstrates the methodological possibilities of 360° imagery in psychology, geography and the wider social sciences, and how 360° imagery can contribute positively to society.

Sensory VR

Notwithstanding the excellent research possibilities arising from the accessibility of 360° photography, it is crucial to consider the whole range of sensory stimuli. We have already shown that there can be sensory mismatches when in VR, such as cybersickness occurring where the visual and the haptic experiences do not align (see Chapter 3). 360° imagery, by its very nature, is a visual experience. Yet, touch, smell, hearing and sight combined are all relevant to how we understand our surroundings. The multisensory has been shown to play a crucial role in our emotional and embodied experiences of place (Rodaway, 2002). Thus, it is fair to assume that VR immersion can be significantly enhanced by engaging senses beyond the visual (Dinh et al, 1999).

Audio is easily incorporated into the VR experience using headphones or located speakers. Hearing is one of the key senses for creating immersive experiences and directly contributes to the sense of presence and therapeutic responses discussed. Annerstedt et al (2013), for example, found that stress recovery can be advanced by adding sounds of nature to a virtual green environment in a laboratory setting. We will elaborate on audiovisual stimuli in the case study later in this chapter. It is important to stress that the audio used in a 360° video can significantly enhance emotional responses. Indeed, the emotive music overlayed on the Auschwitz-Birkenau video reinforces the eeriness and numbness that can occur when watching the video. Thus, using an overlaid audio track can be a handy tool for developing those emotional connections while immersed.

While using an audio track may stimulate an emotional connection, it may also create a disconnect in relation to presence. While the user may be *seeing* Auschwitz-Birkenau, the real matching audio would likely be the mumbled chatter of tourists, rather than emotionally stirring classical music. However, 360° imagery lets us create tailor-made virtual environments with selected or emphasised audio. A nice example of this is the Oscar-winning VR film *Carne y Arena* [*Flesh and Sand*] (Iñárritu, 2017), which allows audiences to experience a fragment of refugees' personal journeys crossing the United States–Mexico border. Once the HMD goes on, the user is placed in the vast, baking scrubland of the Californian Sonoran Desert, with many tired and thirsty migrants looking at the border in the distance. Suddenly, there is the deafening and belligerent noise of the border patrol helicopters, which hammers the user's eardrums while powerful spotlights blind them. This careful construction of audiovisual stimuli makes this VR experience all-encompassing and profoundly moving. That visceral response is narratively and artistically purposeful. Iñárritu, the director, stated that he wanted to find a personal and emotive way to present the stories of the refugees. While *Carne y Arena* is an art piece, it demonstrates how important the combination of audio and visual is essential in a VR experience. It also highlights the methodological potential for participatory work within VR film-making; Iñárritu used VR to portray the emotional stories from refugees, 'After many years, their memories finally have a public face' (Iñárritu cited in Medrano, 2020: np).

Incorporating audio is essential, and is also relatively easy to do compared with the other major senses, namely smell and touch. These are much more challenging to simulate, yet also very important to create a well-rounded and fully immersive experience. In a visit to the Human Interface Technologies Team at the University of Birmingham in 2018, Phil and Tess spoke with Bob Stone and his research group about the various ways they create realistic immersion in the VR environments they create for military training and healthcare. The set-up in their facility was exceedingly impressive, with all the latest hardware and a reproduction of the interior of a

Chinook helicopter taking up an entire training room. Still, they commented that they struggled to get the matching smells for their simulations, such as the pervasive odour of aviation fuel in the helicopter. This can be crucial, since smell is a very complex sense that triggers many subconscious registers in the body, including memories, emotions and physiological responses (Osborne, 2021). During the visit, the team opened an abattoir ambient scent pot, which they were thinking of using to simulate the smell of blood in their medical training simulations. Unfortunately, the artificial smell of warm blood overpowered the whole room, making it quite difficult to continue working in.

There are both high- and low-tech ways to employ smell when working with HMDs beyond simply filling a whole room with an odour. The FeelReal Sensory Mask, as an example of a high-tech solution, is a newly developed multisensory mask that can stimulate water mist, wind, heat, vibration and over 250 different aromas. It is certainly an impressive piece of kit with its own desktop app for adding scent to video files. Still, it is an extra cost on top of the HMD. Additionally, each bespoke aroma set (such as one for *Arizona Sunshine*) costs $50, and learning is needed on how to operate a new piece of software. Based on our experience of artificial aromas in Bob Stone's lab, it is hard to gauge how realistic these artificial smells are. Nonetheless, it is promising that these technologies are being developed and can add new nuances to VR research. We look forward to seeing the sensory masks make progress in the future and possibly become a staple in VR research.

Until then, and for those who prefer to work with a low-tech solution, a sensory tray is a simple but very effective solution. The *Living Environments for Healthy Ageing* project used a combination of 360° imagery and multisensory simulation experiences, using a sensory tray to explore the benefits of bringing natural environments into the physical space of residential care homes (Scarles et al, 2020). Rather than using artificial smells exclusively, the team created trays filled with objects from which their participants could experience different smells and haptic textures. For example, in their coastal stimulation, the tray included sand, shells, pebbles and seaside sweets (such as candy rock). The combination of 360° video and the associated auditory, tactile and olfactory senses created a more embodied connection to the virtual place, with the smells helping to trigger personal memories for the older adults. The use of a sensory tray in Scarles et al's work is a good example of a simple and effective way to move beyond the ocularcentric nature of 360° imagery to create a multisensory experience for participants.

Case study: mismatched sensory stimuli

The salutogenic effects of exposure to natural spaces to promote well-being is well established (Bell et al, 2018). Still, such spaces are unevenly distributed, with poorer communities and those who are less mobile having worse access. Exposure to 360° imagery can reproduce some of the sense of being in these spaces, but as we have reflected in this chapter, immersion in a virtual environment requires more than the visual alone, regardless of how realistic that visual environment is. The focus of this study was not to immerse people in a realistic environment, but to create a scenario where the visual stimuli mismatched with the auditory stimuli to explore which sensory stimuli (visual or audio) had the strongest effects on psychological and physiological response. Eleanor, who led this study, adopted a mixed methods approach with pre- and post-VR immersion questionnaires, using the Profile of Mood States (POMS) test alongside biosensing measures, closing the study with a brief semi-structured interview.

Creating the VR environments

Although there is an abundance of 360° imagery available online, we opted to create our own materials to ensure that the visual and audio elements of the immersion were an appropriate fit for the study. To do this, Eleanor visited places in Birmingham that epitomised urban and green spaces – including Colmore Plaza and Cannon Hill Park – capturing a five-minute video of the scene using an inexpensive Samsung Gear 360 camera. Audio of the park and an urban location were recorded with a Huawei Honor 7 phone. The Samsung Gear camera has two fish-eye lenses that can each film and photograph 180°. The outputs from these are subsequently stitched together in an app to make 360° imagery, either as an mp4 or jpg file. This simplicity in creating 360° imagery really showcases the accessibility of the format, and it is no surprise that it is increasingly used in tourism, journalism and real estate. However, when it comes to research, the researcher's presence in the captured footage is problematic since they can become a distraction in the virtual environment. Indeed, a vital element of generating therapeutic effects is creating the feeling of being alone in nature and the associated sensory quietness that comes with it (Osborne, 2021). The Gear 360 can be remotely operated and monitored through a smartphone, making it easier for the researcher to conceal themselves. Alternatively, the camera can be manually operated, and the researcher can attempt to disguise themselves in the shot. For this project, Eleanor hid behind a tree during the recording (Figure 5.2).

Following successful 360° imagery capture, the video and audio files were edited and combined using the Gear 360 Action Director software. Two five-minute videos were created that deliberately mismatched the audio and the video: an urban scene with green-space audio and a natural scene with the sounds of traffic noise. It is important to stress that more editing can be done to the footage should it fit with the study. For example, Zulkiewicz et al (2020) added visual effects to their 360° video to portray the sensory experience of a migraine. Indeed, just as with a 2D photograph or video, it is possible to tailor the experience to your needs, but, due to

Figure 5.2: Walking to hide behind a tree in Cannon Hill Park while recording a 360° video, seen in an equirectangular projection

Source: Phil Jones and Tess Osborne

the characteristics of 360° videos, the editing process can be labour-intensive and complex. Furthermore, there are various types of 360 camera with different price levels – more expensive (high-resolution, multi-lens) devices would benefit from using a more powerful computer to stitch together the different cameras and render the final video.

The study

In this study, we immersed the participants in mismatched sensory scenarios using a stand-alone HMD with three degrees of movement (Oculus Go) and headphones (Bose QuietComfort 25 Acoustic Noise Cancelling). The participants were immersed for five minutes in each scenario while seated in the researcher's house in Birmingham. Sitting down meant that participants were not exposed to most of the risks linked to trip hazards and the anxiety that can be associated with ambulatory VR (Coldham and Cook, 2017). This also meant that we could avoid bringing signal 'noise' from physical movement into the biosensing element of the project (see Osborne and Jones, 2017).

After the initial introduction to the study and the pre-immersion POMS questionnaire, the participants sat in the HMD with headphones/earphones without visual and audio input. This meant that participants were seated in darkness and that any background noises were somewhat muffled. This acted as a control scenario for the study and allowed the participants to get used to wearing the HMD. All participants were then asked to sit in the two sensorily mismatched scenarios for five minutes each while wearing a biosensing wristband (Empatica E4). We considered having scenarios where we tested the audio experience without visuals and vice versa but ruled this out because of time constraints. Furthermore, as we have shown in this chapter, immersion is a multisensory experience and there is the potential for the brain to 'fill in the gaps' by imagining visuals or audios that matched the stimuli presented (Moran, 2019). Following the immersion in each scenario (including the control), the participants were asked to repeat the POMS questionnaire.

Unlike the other case studies in this book, this took more of a quantitative approach to the experience, using biosensing and the POMS surveys as the primary methods. The POMS test is considered the standard method for studies concerned with assessing participants' subjective moods and involves asking the participants to indicate on a five-point scale how much they agree with the sentence, 'I am currently feeling …' and then a list of 40 moods. Biosensing, on the other hand, measures the automatic, or unconscious, physiological responses that can indicate emotions or stress response. For example, an increase in perspiration combined with a decline in skin temperature (a cold sweat) would indicate stress (Osborne and Jones, 2017).

The pilot study had a limited number of participants (three, all female, aged between 22 and 24) and unfortunately the larger planned campaign of data collection was not completed because of the interruption caused by the UK's first COVID-19 lockdown in March 2020. Still, the pilot data indicates that people expressed greater feelings of confusion, anger and depression in the green visuals with urban audio than they did for the urban visuals with green audio. This pattern in self-reported mood did not, however, correlate with the physiological measurements, where the stress response was more prominent in the urban visuals with green audio scenario. Of course, as a pandemic-interrupted pilot, it would be bad practice to give definitive conclusions here. Still, it does suggest that a more complete study could be undertaken to test a hypothesis emerging from the pilot data, whereby the auditory components of green environments may be better suited to managing psychological stress, while visual elements of the green environments may be better for alleviating physiological stress.

Despite its limitations, this pilot does demonstrate some of the methodological opportunities that come from working with 360° imagery. The ease of capturing these virtual environments and editing the footage allows the researcher to control the environment in ways that would not be possible in the real world, whether that is changing the sensory stimulation or visual tweaks such as removing litter from the images. Despite the benefits that this control gives the researcher, there is still some debate about the usefulness of VR within research into salutogenic environments. This is mainly due to uncertainty about the extent to which virtual environments can act as substitutes for real environments, with certain subtleties being lost (such as the movement of water in still photos of blue spaces – see Gao et al, 2019). Nonetheless, the adaptability of 360° photography creates an opportunity to explore different environments with participants. This gives us better understandings of people-environment relationships and of how we can modify real spaces to maximise beneficial well-being effects.

Conclusion

In this chapter, we have explored the challenges and opportunities presented when working with 360° photography, which offers an impressive experience yet is fairly straightforward to produce. Such imagery can be highly accessible to researchers since it does not require high-powered hardware to run, needing only a smartphone and a basic ‘dumb’ HMD which can cost just a few pounds. Since this kind of 360° imagery is simply a photographic representation of an environment, rather than being built in 3D-modelling software, it provides a realistic virtual environment for researchers to use that can be produced with minimal technical skill. However, it does come with the limitation that participants are unable to move around the environment, only look upon it from the point where it was photographed or filmed (three rather than six degrees of freedom). Nevertheless, 360° imagery offers excellent research opportunities both as a methodological tool and a research focus.

There is an abundance of 360° content online that can be reused to expand the locations and topics considered in our research projects, and which can also be an object of study in itself. Currently, the majority of research on 360° content has been undertaken in tourism studies, meaning that there are many opportunities to undertake analyses and projects from different disciplinary perspectives. Methods such as content analysis and participatory work can be employed with this material, benefiting from VR’s unique properties around embodiment and immersion.

Despite all these opportunities, the true strength of 360° photography lies in its ability to easily create virtual environments that can be tailored to whatever the research project needs, whether that is mixing up the audiovisuals (as in our case study) or editing the footage for creative or artistic effect (such as Iñárritu, 2017 and Zulkiewicz et al, 2020). Additionally, since 360° photography is a visual copy of the real world, it is more likely to induce a state of *presence* – the feeling that you are somewhere else. While this may feed into the ethical issues discussed in Chapter 3, if you think along the lines of spatial manipulation, it demonstrates the versatility and adaptability of 360°. Nonetheless, editing 360° videos can pose difficulties linked to the time required to make those edits, even with the relatively low-resolution footage produced by cheaper cameras. When working with super-high-definition outputs from better-quality cameras, a powerful computer will be needed to edit and render that footage.

A key point to note is that, while 360° photography may give a strong sense of presence, it still differs substantially from the real world. A big factor in this disconnect between the real and virtual is the privileging of vision over the wider senses. While sight may be our dominant sense as a species, we use smell, sound and touch to engage with the environment around us, whether in the real world or VR. The audio element is more straightforward to incorporate than smell and touch, but we have shown that there are various innovative ways to incorporate the olfactory and haptic, such as scent pots, masks and sensory trays. The case study demonstrates one of the ways researchers can explore the senses in VR, but there are many other opportunities to use 360° imagery to explore embodied experiences, using either pre-existing materials or creating our own.

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SIX

Creating original VR content

Introduction

We have structured this book so that the chapters move from simpler to more complex ways of using VR in research. This being said, perhaps the majority of projects using VR to date skew toward the more complicated end of this spectrum, with researchers building bespoke 3D environments for their work. This approach gives maximum flexibility to the design of specific worlds and scenarios that can be used in a variety of ways with participants. Developing custom 3D content requires significant expertise, however, and can be seen as a barrier to researchers beginning to employ VR within their own work. Hopefully, the earlier chapters of this book have demonstrated that one does not have to learn how to code or design 3D objects in order to undertake interesting projects using VR. Nonetheless, our concern in this chapter is to examine why and how we might create this kind of bespoke content.

We are not going to get into the details of programming here. There are a number of step-by-step guides available to get researchers started with coding for VR (for example Murray, 2020), as well as countless YouTube tutorials and blogs with handy hints and tips. Instead, we are going to focus here on *approaches* to developing original material and the kinds of research this enables. As discussed in Chapter 3, there are opportunities to customise existing materials, which can be a relatively straightforward way into testing specific scenarios. This can be as simple as finding a game that allows users to build specific quests or missions. Some of the commercial social VR platforms allow users to create buildings and spaces, decorating them and even importing photographs, video and 3D objects. At a more involved level, one can create 'mods' for existing games. Indeed, part of the reason why there are currently over one thousand community-created mods available on the Steam platform for *Half-Life: Alyx* is because its developers have created an incredibly flexible and sophisticated toolbox to allow fans to create and share their own variations on the core game.

For building VR content from scratch, the Unity and Unreal games engines have become default tools. Unity seems to be more commonly used by academic researchers, in part because it is a little more user-friendly for amateur programmers, whereas Unreal exchanges greater complexity for flexibility and sophistication. Both of these are free to use for non-commercial purposes and both have ready-made code packages and 3D assets available to import, which take much of the heavy lifting out of creating content. Games engines generally rely on 3D content being brought in from other platforms to integrate into a project, such as designing objects and avatars in Blender or importing landscape and terrain features from geographic information systems mapping software (Sermet and Demir, 2019).

For the beginner, with no coding experience, there is a very steep learning curve and many 'how-to' guides can assume knowledge that you simply do not possess. If you have no experience with programming, this can be very challenging and, again, the perception that you need to be able to program in order to undertake research using VR, acts as a barrier to more scholars working in this area. As a result, those researchers wanting to create a customised VR experience, but who have neither the time nor skill to learn basic coding, will need to work with an experienced programmer. If you want to create your own 3D assets rather than relying on ready-made materials, you may need to bring in expertise from the digital arts and animation. This might involve paying a commercial developer or collaborating with a specialist researcher. An alternative approach might be to contact one of the coding clubs organised in many universities where students produce games for fun, or recruit undergraduates studying programs in design or architecture who have experience in 3D modelling. This might offer the opportunity to hire student interns for less-demanding projects. Either way, having a basic understanding of how games engines and 3D design work can be invaluable when commissioning third parties to develop content for your research.

The very large number of studies that have created their own VR content means that we can only scratch the surface here rather than attempt a comprehensive review. Instead, the chapter explores the wider reasons why researchers build custom VR experiences, which can be crudely divided into two overlapping categories: testing different scenarios and creating novel environments. We examine each in turn before reflecting on a case study of a small project we undertook in which participants explored highly simplified reproductions that we created of two urban landscapes: the National Mall in Washington DC and an unbuilt Nazi project for the post-war reconstruction of Berlin.

Scenario testing

VR research in the social sciences has been most commonly undertaken by psychologists. As a result, there has been a great deal of work examining the extent to which participant reactions to situations depicted in VR are similar to those expected in real-world scenarios. This has been important to establish, as it means that VR can be used reliably to examine people's responses to situations that would otherwise be impractical or dangerous to test. An early example of this kind of work was a study by Pan and Slater (2007), which was undertaken prior to the third-wave of VR using a CAVE[1] system rather than an HMD. They compared the responses of socially anxious and more confident heterosexual men to the approach of an attractive woman at a virtual bar using measurements of EEG, electrodermal activity and post-experiment interviews. In short, they found that confident men responded confidently to the simulated interaction with the female avatar, while those with anxiety issues demonstrated the same signs of stress as if approached by a woman in the real world.

A host of studies since have demonstrated that the response of participants to scenarios tested in VR is a reasonable analogue for studies undertaken in the real world. This allows for otherwise impossibly dangerous scenarios to be explored. A recent study by Baker et al (2020), for example, sought to explore fear response and risk-taking behaviours. They used Unreal Engine to build a mountain environment where stepping on the wrong block of ice would lead to participants falling to their (virtual) death. Trackers were attached to participants' shoes so that the precise movements of their feet as well as head and hands could be reproduced in the game. They were also able to create a track log of players' movements – capturing hesitations and unsteadiness – effectively making more data available for subsequent analysis than would have been possible without a custom build. As a result, they were able to use an extreme scenario to induce emotional and physiological responses in their participants and then examine how those with different levels of neuroticism responded. Those with higher levels of neuroticism were shown to demonstrate much more risk-averse behaviours, being less willing to commit to standing on a block of ice that could collapse at any moment.

The fact that VR stimulates the same kind of emotional and affectual responses as people experience in real scenarios has been shown to have tremendous implications for medical and training uses. The kind of 'conquer your fears' apps that we discussed in Chapter 2, for example, thus do appear to have some kind of scientific validity. Bentz et al (2021) built their own smartphone-based VR app *Easy Heights* where they attempted to reproduce the kind of conventional but expensive in-vivo exposure therapy that has been demonstrated to be very effective for people with a fear of heights. Participants were exposed to different virtual scenarios and then subjected to a Behavioural Avoidance Test in the real world where they had to climb a lookout tower. The app was built around 360° images taken using drones at different heights, with audio layered in that matched the height at which the image was captured. The app asked participants to indicate their level of discomfort based on the Subjective Units of Distress ranking, not being allowed to progress to the next stage until they were able to give a low rating for the scene they were witnessing. The control group simply viewed ground-level Google Streetview images through the same HMD and without the test of distress. Participants who had used the app performed better in the subsequent test of climbing the real lookout tower compared with the control group.

The *Easy Heights* app is not especially technically complex and would have been relatively straightforward to design, commission and build, although it does have a fair degree of polish. What the app demonstrates is that even relatively basic VR experiences can be effective when carefully constructed to serve the needs of a wider research design. We see something similar in Salovaara-Hiltunen et al's (2019) work creating a simulation training app for healthcare workers. The app was built in Unity and designed for the now obsolete Samsung Gear VR smartphone platform. Although it is graphically quite sophisticated, with realistic renderings of patient avatars, medical equipment and so on, a key reason why the app worked well is that it was prototyped with the input of a series of specialist clinical staff. The app was designed to train medical practitioners in the latest European guidance for resuscitating critically ill patients. The main feedback received by the researchers was not about the quality of information that participants absorbed through the simulation but rather more mundane concerns about how to interact with the HMD.

Salovaara-Hiltunen et al's app was very much a prototype. Medical simulators in particular require considerable prototyping, user testing and refinement prior to deployment, given that this training might make the difference between a patient living and dying. Even in use cases where someone's life is not at risk, projects creating original VR content need to build in sufficient time and resources to pilot and refine the app with users to ensure it can deliver the needs of the research design. This is not necessarily about highly sophisticated visuals, however. Creating something graphically complex takes considerable time and skill and may not always be crucial to testing the scenario that is being investigated. The sense of immersion generated by wearing an HMD can often significantly offset the lack of realism from abstract or unsophisticated graphics. As Hupont et al (2015) point out, convincing simulation of movement can be more significant than convincing visuals. In their study, they built a forklift truck simulator and put considerable effort into reproducing the way the machine moves, as well as giving their participants a gaming steering wheel and foot pedals to use rather than a conventional controller. These helped to simulate the *feel* of driving the vehicle and thus enhance the immersion in the training scenario, even though the graphics used were a little underwhelming.

Reproducing environments

Sometimes a more visually sophisticated experience is important, however, and this in part comes down to the user group that the custom VR content is being created for. For prototyping purposes, or experiments in a lab, it is less of a problem that content is a little rough around the edges. Where content is being designed for use outside a research context, however, considerably more work needs to be undertaken to improve the visuals and functionality. Indeed, there is a good argument for using a specialist external developer when producing public-facing materials, rather than researchers cobbling something together with amateur-level design and programming. A really nice example of this more refined content is in a project undertaken by Ryu et al (2018) designed to help children who were being taken in for surgery. The research team worked with a VR games company to produce a sophisticated experience, with a Pixar-like cartoon feel designed to appeal to children. Participants were taken through a representation of being anaesthetised, so that it was less unfamiliar and frightening when subsequently experiencing this for real. Compared with a sample group who were given the hospital's conventional paediatric pre-surgery orientation exercise, the VR group reported lower pre-op anxiety and demonstrated greater compliance while being anaesthetised. Beyond simply creating a slick experience, another advantage of working with a commercial developer is in the longevity of a project like this. The hospital can commission updates depending on changing procedures and the developers can easily recompile the app for other platforms as the original technology becomes obsolete.

Longevity can be an issue with materials built for one-off projects, as specialist team members leave or the source code goes astray or becomes unusable. The National Holocaust Memorial Museum in Washington DC, for instance, has been sufficiently concerned by this to archive a number of different virtual reconstructions of wartime concentration camps that have been built over the years to ensure that these are not lost – including Ralph Breker's centimetre-accurate VR model that was used in a war crimes trial (Cieslak, 2016). Fortunately, in recent years it has become more of a standard procedure within research projects to make source code openly available, so that these materials are not lost and other researchers can check the validity of research findings derived from them (Easterbrook, 2014). Many funders now actively require this, though there can be issues around intellectual property rights to negotiate where external developers are commissioned to produce the software – this is something that ideally needs to be carefully thought about at the grant-writing stage.

Within archaeology there is a long-established tradition of creating reconstructions of what sites may have looked like in different periods of their history. Archaeologists in the 1990s were thus unsurprisingly quick to grasp the potential of using digital 3D modelling within their work. It is a small step from creating a 3D model to bringing that model into VR for an audience to explore as if they were present in the historic landscape. Ch'ng et al's (2020) model of Sanjiankou, an 800-year-old Yuan dynasty site in Ningbo, is a nice example of just how sophisticated these digital reconstructions have become, with highly realistic models made using photogrammetry and other techniques. The model was turned into a VR experience using Unreal Engine and was used to examine whether younger demographic groups could be made more receptive to consuming heritage experiences in VR as a way to encourage them to visit actual museums and historic sites. The researchers concluded that VR could help to create a more constructivist learning environment, which could allow museum visitors to engage more actively with the different aspects of heritage being presented.

The heritage sector is a good example of how carefully one needs to consider the design of VR experiences when designing for public audiences. A useful review of how this immersive material has been employed in heritage contexts has been undertaken as part of the AHRC-EPSRC-funded Scottish National Heritage Partnership project (Pittock, 2018). Here, the researchers examined both the current state of immersive experiences within Scottish museums and heritage sites and the potential for their wider use. Key findings were that immersive experiences needed to move beyond the gimmicky, to present meaningful educational experiences – indeed, to encourage the type of constructivist learning that Ch'ng et al highlighted. Particularly in heritage contexts, audiences wanted strong storylines and a blending of both virtual and physical content. This idea of integrating original VR content into a physical experience is something we will return to in the case study later. In short, however, it is not enough simply to put a pretty 3D model into an HMD and assume that this will add significant value to a heritage experience.

Thus far we have concentrated on talking about VR experiences that are led by visual materials, with audio playing more of a supporting role. As discussed in Chapter 5, VR offers considerable potential to explore the multisensory, which can be built into projects creating original content. A rather lovely example of this is an attempt to reconstruct the acoustics of King James IV's Chapel Royal at Linlithgow Palace. A 3D model of the now-ruined chapel was built and used as the basis for acoustic modelling. Andrew Kirkman's Binchois Consort recorded music that would have been heard in the chapel during the period and this was then acoustically manipulated to create a 3D audio reconstruction of how the music would have sounded in that space. HMD users can thus stand in a model of the chapel and hear the music accurately reproduced. The researchers used a collection of off-the-shelf tools to undertake the modelling, meaning that the same technique could be quickly and easily applied to other spaces and recordings (McAlpine et al, 2021).

The ways in which participants can move around a virtual environment is a key consideration when designing original content, not least because of the relationship between movement and cybersickness in VR. By building a basic game, Christensen et al (2018) were able to test how different control mechanisms for movement shaped a multiplayer VR experience. The code could be tweaked to create three different versions of the same game: desktop, seated VR and ambulatory VR. Players seemed most satisfied with the full-VR state, which integrated their body movements into the scene. It should be noted, however, that these kinds of projects assume an able-bodied participant. Indeed, this is true of most commercial VR games. In screen-based gaming, considerable effort has been made to create controllers that can be customised to allow players with disabilities to build a set of control mechanisms around their particular physical constraints – the Xbox Adaptive Controller being an important example of this (Stark and Sarkar, 2018). For VR, there have been some community-led projects, such as WalkinVR, which remaps the buttons on handheld controllers in order to replace body movement when using Steam VR games.

In order to explore how games might be better adapted for wheelchair users, Gerling et al (2020) built a series of game prototypes to test with disabled participants. This included integrating the GAMEWheels tool, which allows game input to be controlled by a wheelchair mounted on rollers. The GAMEWheels tool proved particularly popular because it very accurately reproduced participants' own bodily movements, which was seen as giving more agency to players than other prototype designs where button presses triggered pre-programmed automated moves. None of the prototype games were going to win any awards – indeed, this is a good example of where producing a highly sophisticated product was not really necessary for the research design. Nonetheless, the prototypes were effective in allowing different modes of navigation for wheelchair users around the virtual environments to be examined. This rigorous user testing simply would not have been possible without the research team being able to build their own software.

Case study: building urban landscapes

We turn now to consider a case study where we created two very basic VR experiences. There was a dual purpose to this.

First, we could undertake a small research project that blended virtual and material experiences of urban space and heritage (Osborne and Jones, 2020). Second, it gave Phil an opportunity to learn the basics of working with Unity. This is part of his wider practice of getting to grips with the fundamentals of a new technique in order to have more meaningful conversations and collaborations with experts in that field (an approach to research discussed further in Jones, 2020).

Germania was a Nazi-era plan for the wholesale reconstruction of Berlin intended to be completed shortly after a successful war against the Allied powers. Designed primarily by Albert Speer with direct input from Hitler, the designs envisaged a 3-mile north-south axis lined with neoclassical buildings. At the northern end was a vast public square and parade ground surrounded by giant buildings, including Hitler's personal palace and the Volkshalle, a 290m-tall domed building intended for public gatherings and rallies. The Reichstag was retained in the plans, which gives a useful sense of the location and scale of the planned design, given that this building still exists today (Scobie, 1990).

Several amateur historians have created 3D models of the proposed scheme, which can be downloaded for use in projects. We selected one of these that effectively reproduced the scale of the main buildings, although it was not a complete reconstruction as it lined the parade route with generic infill structures. This was then imported into Unity running on a Razer Blade Pro gaming laptop (7th gen Core i7, GTX 1060 graphics card). The research design for this project called for the model to be used by participants outdoors and in public spaces, so it was designed in Unity to be exported to the (now obsolete) Oculus Go standalone headset. The Go is a relatively underpowered HMD and there was a process of trial and error to balance the number of assets and detail used in the VR project against the capability of the device. Ultimately, we stripped out additional 3D assets, including models of the contemporaneous neue Reichskanzlei and

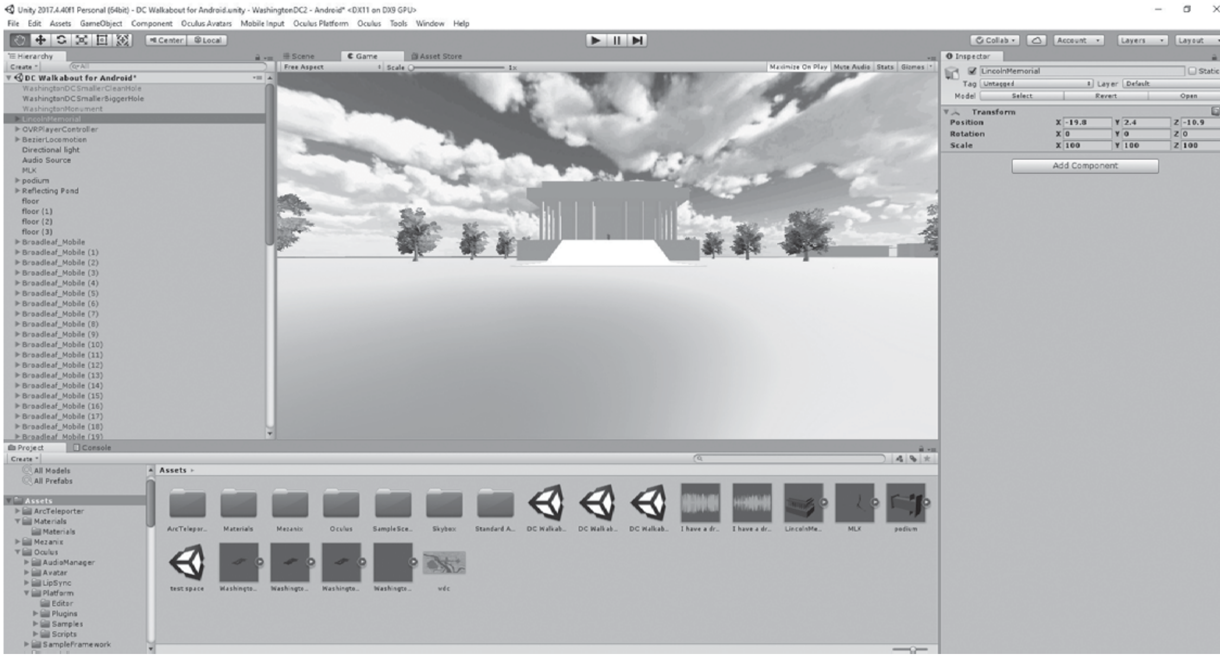
Tempelhof airport, which made the software run too slowly on the stand-alone HMD.

One of the advantages of working in Unity is that the major VR hardware developers have produced ready-made code packages that can be imported into projects to save on programming time. We used the locomotion assets provided by Oculus, which have a number of preset tools for VR navigation, including the standard 'point-and-teleport'. Again, there was a process of trial and error here in setting the teleport distance to give a sense of the scale of the simulated environment, while allowing users to move around a very large model in a reasonable time. We also set the height of the game camera to 1.8m so that users had a human-scale view of the environment, and imported a ready-made sky-box that created a sense of a sunny day with a blue sky and light clouds.

We used the same design approach for the second model, of the National Mall in Washington DC. An abstract model of the wider city was imported to Unity, derived from OpenStreetMap data – effectively plain boxes extruded to the correct height for the buildings. Ready-made tree models were imported and used to line the western end of the National Mall area, while the memorial reflecting pond was reproduced using one of Unity's standard water tools (Figure 6.1). This tool was not able to correctly produce reflections in stereoscopic VR and so these were turned off. (This problem could have been resolved by buying a higher-quality water asset, but this would have been computationally demanding and unlikely to run properly on the low-powered Oculus Go.)

Neither of these VR experiences would win any awards – indeed, they would not even meet the standard of undergraduate work in a cognate discipline. The point here was to explore principles and potential. Oculus allow users to develop and test their own software on its HMDs by setting the headsets to developer mode, rather than having to go through the challenging process of building software to a quality where it could be approved for formal distribution via the Oculus

Figure 6.1: Part of the Washington DC model as it appears in Unity



Source: Phil Jones and Unity

stores. Ten Oculus Go devices were loaded with the two Unity projects containing the city models. We took these to a conference in Washington DC in April 2019 and used them as part of a day of workshop activities around memory and memorialisation. Participants stood at the foot of the Lincoln memorial and put on the HMDs to run the Washington DC model, which we had set to start in the same location. Participants were able to explore the model while listening to extracts from Martin Luther King's 'I have a dream …' speech, which had been given from the steps of the Lincoln Memorial. This gave participants an opportunity to have a blended experience, blurring the boundaries between the virtual and material, somewhat in line with the recommendations of the Scottish National Heritage Partnership discussed earlier.

The second phase of the intervention was to ask participants, still standing in the National Mall, with a view of the domed Capitol building in the distance, to try the Germania model (Figure 6.2). The architectural historian Barbara Miller Lane (1986) noted that the kinds of neoclassical designs favoured by the National Socialists in Germany were not significantly

Figure 6.2: Workshop participants exploring the VR environments while standing in the National Mall

Source: Phil Jones

dissimilar to the state architecture of other nations. Indeed, she particularly singled out Paul Cret's design for the Federal Reserve Board Building, completed in 1937 and located just on the edge of the National Mall, as something that would not have looked out of place in Hitler's Berlin. Participants were thus able to reflect on the striking similarities between the triumphal axis and neoclassic architecture of the National Mall and that of Germania, giving an uncomfortable juxtaposition, particularly having just listened to part of a speech calling for racial equality in the United States.

This was only a small test project, and the VR simulations were of an exceedingly rudimentary quality. They were, however, appropriate for the limited aims of a research design examining how we might modify our perception of urban heritage. Creating the VR materials in Unity took a few hours for each project, but this followed on from about a week of getting to grips with how Unity works, how models and code assets can be imported and customised and how the final product could then be compiled and exported for use on a different device. We would not, therefore, want to underplay the difficulty of this, though for those with a technical mindset and enough time, it can be quite a fun exercise. Both Unity and Unreal can be used to do considerably more interesting things than simply letting users navigate a pre-existing 3D model, but this means going beyond simply bolting together existing pieces of code and beginning to learn the nuances of different programming languages. For most researchers, this will mean collaborating with a specialist. Similarly, while much can be done with inexpensive or free assets, for more complex projects consideration may need to be given to bringing in a designer to create realistic-looking 3D models.

Conclusion

Much of the existing research that uses VR is based around constructing custom pieces of software. While we have argued throughout this book that there is much potential for research using existing VR materials, there are situations where the only way to meet the needs of a research design is to create original content. In this chapter, we have considered two main reasons why this might be the case: where one wants to place participants into a specific scenario, and when asking them to explore a particular environment. Of course, in practice, these two can and do overlap in interesting ways. What we have not been able to do here is present a comprehensive survey of all the different types of projects that have been undertaken where researchers have produced their own VR experiences. This is now a very large field of work. Conferences dedicated to VR have proliferated in recent years – some sessions were even held in VR during the COVID-19 pandemic – with findings from hundreds of exciting projects being presented. Some of this material is highly technical, with a great deal of engineering detail that is entirely opaque to the outsider. Nonetheless, much of the work in this area shows just how innovative and dynamic the emerging field of VR research has become, with applications across a whole range of different disciplines.

As with any research project, it is important to start by thinking about what you want to achieve with work using VR. It might be that the research design can function more cheaply and easily by reusing or customising an existing piece of software. If original content is required, it does not necessarily need to be particularly graphically refined. A surprising number of pre-built 3D objects are available for free or at low cost, from plants and flowers through to vehicles and machinery. These can give a relatively sophisticated look and feel to a VR project without the cost of bringing in a specialist designer. For projects that test user responses to a particular situation, a graphically advanced environment may be surplus to requirements. In other applications, a more visually convincing design may well be needed. This is particularly the case where VR experiences are designed to be public facing rather than for simply testing an idea in a lab setting. Indeed, where a public audience is sought, much more thought needs to be given to how the VR content fits into a wider set of user experiences; blending the virtual and material, for example, can help to drive more active engagement.

Whatever the intended purpose of the project, building in enough time for prototyping is crucial. Working with a pilot group not only smooths out bugs, it can also highlight design issues that form a barrier to proper engagement by participants. Beyond mere user testing, co-design can be an incredibly useful approach, as we saw with the *School days* app discussed in Chapter 4. User groups are often much better able to identify their own needs and interests than a research team, which can lead to more effective VR experiences. Building rapid prototyping into the time frame (and budget!) of a project can take research in unexpected and productive directions. Co-design can also move us beyond the power-centric model of research *subjects* having no role in the design and outcome of projects.

We would encourage researchers to have a play with programming tools such as Unity, but not to feel that becoming a coder is an essential barrier to overcome. Similarly, getting a sense of what can be done with 3D-modelling tools such as Blender can be interesting, but will not turn researchers into skilled designers overnight. Trying these tools *might* spark a genuine enthusiasm for design and programming among some scholars, but, perhaps more prosaically, it opens up avenues for discussion with collaborators and a better sense of what might be possible in a research project. Thus, while we are keen to emphasise that one does not have to a technical expert to undertake research with VR, engaging with some of the possibilities offered by creating custom content can open the door to an incredibly wide range of potential projects.

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SEVEN

Conclusion: next steps in VR research

Throughout this book we have argued that VR offers a variety of interesting opportunities to scholars working in different areas. Nonetheless, published research in the field tends to be dominated by a small number of disciplines, not least human–computer interaction, psychology, medicine and archaeology. This is not to say that exciting work is absent outside these fields, just that perhaps it is not as widespread as it might be. In our own discipline of geography, for example, VR has drawn the attention of a surprisingly small number of researchers, despite its obvious power for exploring questions of space and place (Bos, 2021).

VR is an emerging technology; arguably it has been for over 40 years. Rapid advances in the last decade have seen plummeting costs alongside precipitous rises in graphical quality and useability. The result is that opportunities are opening up for a much wider range of researchers. There remain, however, significant barriers to use. Because VR remains a fairly niche pastime in wider society, many researchers have never had their own VR 'wow' moment of experiencing the technology for the first time. Looking at VR content on a conventional monitor is a qualitatively *different* and frequently unremarkable experience compared with the feeling of immersion generated by an HMD. To understand potential research applications, therefore, scholars first of all really need to try it for themselves.

Despite the advances in useability, there is no doubt that VR remains fiddly to set up and occasionally temperamental, which can be a barrier to the non-technically inclined. Newer stand-alone HMDs are helping to overcome this, but there is no getting around the fact that VR is a peculiar experience. The thing that makes it so compelling – being instantly transported somewhere else – is also the thing that can be so off-putting. VR makes you physically vulnerable to a material world you can no longer see or hear: you can trip over real objects that do not appear in the virtual world; you might fear ridicule or even assault from those sharing your physical space but not your virtual one. These issues raise very significant questions around gender, age, ability and a range of other embodied qualities that have historically garnered less attention from a tech sector dominated by young, white, cis men (Bergvall, 2020).

Even after trying VR, many people are left with the thought that it is impressive, but it is not clear what one might want to *do* with the technology. Hopefully, this book has gone some way to addressing that question when it comes to potential research applications. What we have emphasised, however, is that to get started with VR research, it is not necessary to learn 3D design and programming in order to build your own content. This may have been true prior to the third wave of VR from around 2012 but simply is not the case today. Indeed, focusing purely on creating your own VR content misses significant potential opportunities for research using existing materials.

In Chapter 2, we looked at existing VR content as a possible object of research. Content analysis is a well-established technique in the humanities and social sciences, though is less familiar to the more science-led disciplines that have hitherto dominated VR research. As such, there is a real lack of work examining the kinds of experiences that are being consumed by VR users today. This is in stark contrast to work applying this kind of approach to art, literature, music, film and TV, video games and a variety of other media. The tools and techniques developed to explore these art forms and media can also be applied to examining VR materials, but with the added complexity that the VR experience is a co-construction between the content and the body of the user. This embodied quality needs to be carefully integrated to make the analysis meaningful.

In Chapter 3, we examined the ways in which VR can be used with participants, focusing on how existing VR content can be reused rather than on the process of creating original materials. Commercial content has the advantages of being abundant, often of high quality and technically robust. The sheer quantity of such materials means that it is often possible to find content that aligns with a research design, or which can be adapted to fit. Because VR experiences generate a strong plausibility illusion, however, there are significant ethical concerns to reflect on when putting participants into highly convincing virtual situations. Our physiological and psychological responses to VR scenarios are similar to those we would experience in the real world, although the effects do not seem to linger for long after removing the HMD. In the moment, however, participants can be genuinely frightened and experience other negative emotions, meaning that a clear ethical rationale is required to undertake activities that generate such feelings. There are also important practical considerations when working with participants, including the need to keep them safe while they are cut off from the physical world around them. Cybersickness, where a mismatch of movement and visuals generates nausea, remains a significant problem with using VR. While there are techniques to mitigate this, a significant minority of participants can potentially suffer ill effects, and this needs to be considered in any research design.

In Chapter 4, we reflected on collaborative VR experiences, particularly social VR systems. This moves us past the idea that VR is a solitary practice by allowing people in different parts of the world to gather in the same virtual space. Many social VR systems are free to access, with users able to come together to socialise and work, even building their own environments in which to do this. There are fascinating possibilities for ethnographic work in these spaces, as new forms of community are beginning to develop among groups using these platforms. There are, of course, issues to consider, such as problems associated with trolling and the constraints caused by somewhat abstract avatar design, notwithstanding ongoing work to explore how non-verbal social cues can be integrated into these worlds. One key opportunity, however, is that the communities associated with these platforms can also form a pool of potential research participants. Recruits from these groups have the advantage of not being distracted by the novelty of being in VR as well as being able to use their own equipment for remote projects.

Chapter 5 turned to consider the simplest level of content creation for VR: using 360° photographs and video. A number of cameras have been developed that can create imagery that places the user in the middle of a scene, from very expensive multi-lens devices to simpler dual-lens gadgets and even software for creating panoramas from a basic smartphone. 360° photography can be viewed in the simplest of HMDs, even those that are little more than a box with two lenses and a mount for a smartphone. The key advantage of 360° imagery is how simple it is to create a convincing sense of being in a completely different location. This has great potential for remote site visits and tourism research as well as experiments that examine how people respond to being in different kinds of environments. Such imagery can be made even more compelling by considering the multisensory, adding audio to the visuals and even appropriate smells and haptic stimuli.

Finally, in Chapter 6, we reflected on the process of creating original VR content using games engines. Platforms such as Unity and Unreal Engine have become the de facto standard for VR researchers wanting to create bespoke experiences for participants. When testing participant response to a particular scenario or environment, creating project-specific VR materials may be the only option. Working with professional programmers and 3D designers may be necessary, especially when creating the kind of sophisticated experience needed with public-facing content. This level of refinement may not always be necessary to meet the needs of a project, however, and there is a wealth of ready-made 3D objects and pre-written code that can be employed when assembling your own 'rough and ready' VR materials. The advantage of creating bespoke content is that it can be built directly around the needs of the research design. Indeed, exciting possibilities open up for collaborative co-design with participants when programming and 3D design skills are added to a research team.

In making some final reflections, we have to note that nothing dates as quickly as a book about technology. As a result, we have tried to avoid, so far as possible, getting into the specifics of different VR products, as these will change rapidly. There is, however, one elephant in the room that is worth briefly acknowledging here. There is no avoiding the fact that VR technology has advanced rapidly in part because of investments from Meta (formerly Facebook). At the time of writing, nearly one fifth of Meta's global workforce is employed in VR-related development (Byford, 2021). Meta CEO Mark Zuckerberg has even outlined his long-term vision to create a 'metaverse' that seamlessly blends virtual and physical experiences in our everyday lives (Newton, 2021). For those of us interested in questions of technology and privacy, this is a truly horrifying prospect given Facebook's history (Losse, 2012; Spring, 2021). Meta's Oculus subsidiary has become the default option within consumer VR, offering easily the cheapest user experience. But Meta is also committed to placing advertising content into VR as well as introducing eye tracking and other biometric measures to its HMDs that can be used to quantify engagement with that content (Robertson, 2021). Researchers considering using VR therefore need to think carefully about the type of device that they employ, and the particular ethical concerns raised by using Meta's products.

We have written this book from the position of being academic geographers. Geography is a bit of a magpie discipline, encompassing the physical and social sciences as well as the humanities. Nonetheless, the ways that *we* would think to use VR in research are going to be very different from how scholars working in other disciplines might think to use this technology. What we hope to have achieved with this book is to highlight possibilities and spark ideas to take research in directions that simply would not have occurred to us from our disciplinary perspective. If there is just one message that we would like people to take away from this book, it is that one does not need to be a skilled programmer or have access to a large budget in order to seize these opportunities. Much like the hype about VR early in its life cycle, we would end with the rather hackneyed observation that the possibilities for research are limited only by our imaginations.

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Notes

two

[1] A *let's play* is a recording of a playthrough of a game. Usually taking the form of a video capture, though sometimes stills with text commentary, these are usually more curated and edited than a standard livestream, with hosts giving a detailed account of their perspectives of how to play the game.

four

[1] This is slightly unfortunate project branding as it is similar to the name of the Japanese anime girlfriend simulator *Together VR* (Aurora Games, 2018).

five

[1] The app has now been removed from the Google Play and iOS App stores, but elements can still be found here: https://youtu.be/h8OMpihZIhs.

six

[1] Common in VR research in the 1990s and 2000s, the CAVE system projected images of a 3D environment onto the walls of a cubic room in which participants stood. Real-time body tracking and 3D glasses helped to reinforce the illusion of standing *inside* a virtual environment. With the creation of higher-quality HMD devices from the 2010s, CAVEs have fallen out of favour for research purposes because of their expense, complexity and the need to maintain a dedicated room to house the facility.

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"This book is delightful, deeply informative and suitable for many audiences. It is an eye-opener for all who thought of doing research with virtual reality but did not know where to start."

Alexander Klippel, Wageningen University & Research

Phil Jones is Reader in Cultural Geography and runs the Playful Methods Lab at the University of Birmingham.

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Calla Sullivan-Drage, Natasha Keen and **Eleanor Gadsby** are independent scholars and former members of the Playful Methods Lab at the University of Birmingham.

Since the mid-2010s, virtual reality (VR) technology has advanced rapidly. This book explores the many opportunities that VR can offer for humanities and social science researchers.

The book provides a user-friendly, non-technical methods guide to using ready-made VR content and 360° video as well as creating custom materials. It examines the advantages and disadvantages of different approaches to using VR, providing helpful, real-world examples of how researchers have used the technology.

The insights drawn from this analysis will inspire scholars to explore the possibilities of using VR in their own research projects.

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