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The Domain of Virtual Reality

Virtual technologies permeate our lives to near ubiquity, mediating our careers, social lives, finances, shopping habits and leisure activities to name a few. This is as much a result of our changing attitudes and understanding of the virtual as it is due to technological developments. This chapter introduces some of the philosophical foundations of the virtual and VR. What these terms mean and how that meaning has shifted over the years are discussed, and we explore the differences between the virtual as a technology and as a broader theory of organisation. There are two primary assertions made within this chapter. Firstly, that our perception of the virtual and VR is changing, not solely because of the technology (which is too often incorrectly positioned as the dominant aspect of VR), but because of a much wider web of interrelating factors all centred around us as perceivers of the virtual. The second position is that existing definitions and explanations of the virtual and VR are limited, but that each has value as a piece of the larger puzzle. It is bringing these pieces together that will help to create a more holistic understanding and support better VR design and implementation.

As a first step towards mapping out an emergent framework of VR sound, this chapter commences with some wider context regarding how

our relationship with virtual technology has paved the way for contemporary VR by steadily and subtly introducing us to both its conceptual and technological aspects. Following from this is a look at the technological perspective of the virtual, including an introduction to the various forms of virtual technologies. An additional, wider question is then asked relating to the global changes affecting contemporary VR and how things have changed (and how they've remained the same) since the 1990s. This chapter then closes with an exploration into the concept of the virtual from an organisational perspective, introducing the literature that has inspired the central position of this book—that both VR and sound are best understood as emergent phenomena.

Global Context

Typically referred to as '1990s VR', the period that commenced in the late 1980s and petered out towards the millennium represents the first generation of consumer VR. As described in greater detail later within this book, disappointment with the actual hardware and software of this generation caused great disillusionment with VR as a mainstream product and preceded something of a dark age. Subsequently, the historical timeline of consumer VR then begins to document the activity of note from roughly 2012 onwards, as an unknown start-up company, Oculus, looked to crowdsourcing to fund the development of their *Rift* HMD. Their initial designs ended the consumer VR dark age and sparked a resurgence of interest that marks the second generation of consumer VR. This section begins our exploration into the wider issues that contribute to VR as an emergent phenomenon, with a look at how our perspectives and priorities compare between the two generations of mainstream VR. Additionally, we consider some of the global changes that have been instrumental in repositioning VR in its contemporary form, as a serious contender for being one of the most widely accepted and ubiquitous technologies of the modern age.

Then and Now

How we define VR has certainly changed since its first consumer generation. For a fundamental example, we can consult the Merriam-Webster dictionary which, as of 2017, defined the term as: '[A]n artificial environment which is experienced through sensory stimuli [...] provided by a computer and in which one's actions partially determine what happens in the environment'.¹ Whilst this definition contains some issues, we can compare it to an earlier dictionary definition as a simple means of examining change in thought across the VR generations. In 1994, Heim (p. 109) quoted Merriam-Webster's dictionary definitions of both *virtual* and *reality* (the combination of these words apparently not yet accepted in dictionary lexicon). The former was defined as 'being in essence or effect though not formally recognized or admitted' and the latter 'a real event, entity or state of affairs'. There is no technological aspect to the definition, with virtual used in much more of an organisational sense. Heim interprets the two together as something that is real only in effect, it is not real, but merely appears to be so. What this reveals to us most prominently is the difference between the generations in terms of general acceptance.

For researchers throughout the 1990s, VR was largely defined by the technological hardware that facilitated it. However, the literature of the time was already raising concerns (see Steuer 1992) regarding this definition, specifically that such a perspective limits conceptual understanding and analysis, making it difficult for us to compare VR with non-VR beyond a basic dichotomy. It was also asserted that this perspective restricted the potential to comparatively examine multiple instances of VR (e.g. VR against AR or augmented virtuality, etc.). Steuer's counter to the hardware definition of VR is decidedly more phenomenological, positioning VR as an experience. Within this definition, Steuer identifies presence and, by extension, telepresence as key components of conceptualising the virtual. Comparing this to the second generation, a significant degree of similarity can be observed. VR remains a predominant technology/hardware-focussed concept but with pockets of thought describing VR as an experience. Unlike the 1990s, however, the

prevalence of the technological perspective is beginning to wane, presenting us with one noteworthy example of changes in contemporary VR. Perspectives focussing upon user experience have become progressively more pronounced, and the number of publications advocating this understanding continues to increase (see Jerald 2015).

In 1990, the Special Interest Group on Computer Graphics and Interactive Technologies held a panel session with speakers from the Human Interface Technology Laboratory on the anticipated future directions of VR (Bricken 1990). Some of the notes taken from that discussion reveal that many of the research and development themes of VR in the early 1990s are strikingly similar to their contemporary counterparts. Examples of this similarity include: a research focus upon bi-directional behaviour transducers (approaches to mapping natural motions/gestures into VR systems and creating VR content that can influence user physiology and behaviour); increasing sensory immersion (virtual environments that surround the user); and forming a detailed psychological understanding of the user (user experience: cognition, emotion, meaning, etc.) to inform design of virtual environments and interfaces. A search of VR applications (see Chap. 9) also reveals that prominent ideas pertaining to how VR can be practically utilised are comparable between then and now. Prime examples include teleoperation/telepresence, physical and psychological rehabilitation therapies and military training simulations. Research focus upon multi-modal feedback in VR is also comparable across the generations; 1990s research closely mirrors its contemporary cousins with much emphasis on visual feedback, a second-place position for auditory content and distinctly smaller pockets of research exploring further modalities that include haptic/tactile (Iwata 1990), olfactory (Krueger 1995) and gustatory sensations (Robinett 1994).

The hardware that facilitates VR has been refined over the generations and arguably still has great distance yet to travel in terms of further improvement. That said, the principle designs have changed relatively little over the decades. For example, HMDs of the 1990s may have been heavily criticised, but contemporary VR still positions them as *the* interface for VR experience. What is even more notable is that the appearance and quality of 1990s HMDs were dictated not

by design, but by limitations in the materials, computing components and other technologies of the day. Despite this, the foundational aesthetic of contemporary HMDs is largely unchanged, with design simply smaller and more ergonomic. Watching science fiction cinema from that period, in films such as *Back to the Future Part II* (Zemeckis 1989) and *Johnny Mnemonic* (Longo 1995)—and for a further all the more surreal example, an episode from *Murder, She Wrote (A Virtual Murder*, Smith 1993)—we can see that the concept designs for HMDs in this generation are strikingly similar to some of the actual systems being released at present. A comparable finding is also revealed in CAVE (Cave Automatic Virtual Environment) VR—a physical cubic space onto which between three and six of the walls are projections of a virtual environment. CAVE systems began to appear in the early 1990s (Cruz-Neira et al. 1992) and remain the subject of considerable academic and professional interest (Ritz and Buss 2016; Ronchi et al. 2016); their overall contemporary designs almost identical to 1990s precursors.

At this point, readers would be forgiven for presuming that very little difference exists between the VR generations and feel the urge to skip to the next chapter section. For the intrepid reader staying the course, however, there is one substantial difference in emergent VR between the early 1990s and more recent times. This difference is not VR itself as an isolated technological entity, but rather changes in the global state of things that have shifted what VR means to the population. What we are specifically referring to here are five discrete phenomena: advanced production, application, corporatisation, integration and acceptance.

Advanced Production

In statements made in 2016 relating to their *Daydream VR* project, Google expressed their intention not to simply create cutting-edge pieces of technology, but rather a global technological ubiquity driven by products could reduce the so-called barriers to VR. These barriers include attenuating motion-sickness, reducing HMD weight and increasing the longevity of use by the way of enhanced power efficiency, greater battery capacity and faster charging mechanisms.² How

confident they are in their ability to realise these ambitions has largely originated from their power to implement advanced production methods. In terms of manufacturing, the VR industry, like most commercial bodies, has changed due to the impact of technology and contemporary manufacturing practices. Advances in robotics have meant that many aspects of VR hardware production can be fully automated (Brookings 2016). This not only increases productivity, enabling more devices to reach the market, but also supports adaptive manufacturing (see Nielsen et al. 2015), in which companies can respond more quickly to changes in consumer expectations and demands. Adaptive manufacturing creates a sizeable difference when comparing VR of the 1990s against modern systems. Whilst the former was unwieldy and incapable of timely response to user feedback, the latter could be regularly upgraded and refined based directly upon the opinions and demands of the consumer. This ability to quickly evolve had a substantial effect upon VR. Specifically, it enabled the industry to resist gimmickry and work towards mainstream status. First-generation VR by contrast struggled to shrug its public perception as little more than a novel prototype, a technological curiosity worth experiencing only a handful of times before exposing its core limitations; its hardware then forsaken to collecting dust atop shelves or underneath beds.

Application

Though still labouring under popular perception as a games technology, VR has numerous diverse applications beyond such recreational use. To preface this point, technology cannot exist within a vacuum (speaking metaphorically—for a literal vacuum see Samsung's endeavour to test mobile phones in outer space³). Its design, construction, marketing and reception are significantly affected by the associated technology of the day, essentially a form of technological ecology. Possibly, one of the most significant components of VR's technological ecology is computing power. According to a 1990s edition of the magazine *InfoWorld*,⁴ £3400 (roughly £7000 as a 2017 equivalent value) would enable a consumer to purchase a 33MHz processor, 4MB of RAM and a 200MB

hard drive. An equivalently priced system as of 2017 would afford the buyer a 10-core 3.1 GHz processor, 32GB of RAM, 12GB proprietary graphics memory and 12TB of hard disk space. Calculating Moore's Law between 1991 and 2017 puts a rough exponential power increase at 2 to the power 13 (a multiplied increase of 8192). Whilst in terms of processing power the huge increase between the generations is not quite 2 to the power 13 and the consensus is now that Moore's Law is no longer applicable for processors (see Waldrop 2016), the increase in RAM is almost spot on and the disk space increase is actually closer to 2 to the power 16 (a multiplied increase of 65,000). However, computing power is not just about the numbers. In practical terms, these advances have dramatically increased the range of functions, in both VR and computing in general, that simply could not have existed in the previous VR generation. Discussed directly in Chap. 9, it is this array of new applications that has markedly contributed to our changing perceptions towards VR. Increased graphical capabilities now enable detailed and interactive three-dimensional models of human organs for the purpose of training surgeons (see Vosburgh et al. 2013). More powerful processors enable complex data sets to be visualised in real time, creating powerful tools that can analyse the human genome (Pavlopoulos et al. 2015). These are only two of many examples that illustrate how contemporary computing technology has facilitated a substantial widening of VR's perceived value, moving away from something only good for playing games and towards acknowledgement as a multi-faceted technology with diverse function and purpose.

Of course, the technological ecology is not limited to the effects of computing power. Advances in hardware, not initially developed for the purposes of VR, have had significant impacts. Prominent examples include digital photography (the essential underlying technology that facilitates most of what we commonly describe as AR), networking technologies and the Internet (facilitating numerous VR functions that include telepresence, teleoperation and shared/multi-user VR experience), human-computer interface technology (including biometric control devices and multisensory feedback systems that yield significant accessibility advantages for VR, can contribute hugely to evoking user presence and also have wide applications for pain distraction and limb rehabilitation)

and mobile/smartphone technology (building upon the advantages of networking to create a significantly different approach to VR experience). By the way of increased computing power and integration (see below), these technologies have all contributed to a huge expansion of both what VR can do and how well it can do it. Second-generation VR is no longer just a game or a novel experience, it is also a serious device for learning, building, designing, communicating and more.

Corporatisation

In a technological context, corporatisation describes another significant change to the modern meaning of VR. Whilst the term traditionally refers to transforming ownership products or services from the public state to corporations, here it refers to the way in which VR technology has transitioned from being developed and manufactured by a fledgling company built solely around that product, to but one branch of a much larger, typically multinational, corporation. From the *Stuntmaster* HMD by Future Vision Technologies to the *VFX-1* by Forte, first-generation VR systems were largely (but not entirely—see Nintendo's *Virtual Boy*) the products of smaller companies that dealt exclusively in VR technology. Comparing this against the second-generation VR and most devices, from Microsoft's *HoloLens* to Facebook's *Oculus Rift* and HTC's *VIVE*, evidences how VR technology is now firmly in the hands of corporations with exceedingly deep pockets, generating worldwide revenues of £67.5 billion, £14.2 billion and £3.3 billion, respectively.⁵ This influences our perceptions of VR both directly and indirectly. The direct effect is an improvement to the profile of VR. This is due to consumers associating it with a well-known multinational corporation, thereby raising connotations of prestige and higher quality. The indirect impact relates to the earlier discussion on advanced production. With great monetary resources available for investment in VR, the hardware can benefit from the common ability large organisations have to keep costs down through mass production and bulk deals that enable the hardware to be significantly more affordable and more widely available.

Integration

With this aspect of global change, we are discussing ways in which second-generation VR has become more diverse in terms of its hardware platforms by integrating with more established technologies. Noteworthy examples of integration include smartphone-mediated VR, 3D televisions and console game controller compatibility. As we shall discuss further in Chap. 8, integration also incorporates changes for VR developers; 1990s development required those producing the software to either code everything from the ground up or navigate their way around highly complex and inaccessible development environments. Contemporary pipelines, however, integrate VR development with a wide array of toolsets and prebuilt components, from game engines for building the virtual environment to audio source development kits for quickly creating detailed soundscapes. This integration enables VR projects to be exponentially more ambitious, both in scale and in quality. For the wider applications of VR, integrations with numerous physical interfaces and multisensory feedback devices also demonstrate ways in which VR has become substantially more connected to associated technologies. The effect of this in terms of VR's perceived status is that it is no longer an isolated product, but rather a way of interacting with the world by the way of a diverse range of hardware interfaces and software environments. The consequence of this great increase in VR integration transitions us into the final global change: increased acceptance of VR technology within our everyday lives.

Acceptance

This leads us neatly into the next section of this chapter, in which we explore some of the ways in which the virtual has become the everyday. Arguably, all the preceding points (production, application, corporatisation and integration) ultimately feed into acceptance; as VR spreads in its application, the hardware becomes more affordable, the quality reflects user demands, corporate marketing and branding increases desirability, and VR features become embedded in numerous hardware

products. This presents us with the most significant difference between the generations of VR. This time, we're ready for it.

How the Virtual Has Become the Everyday

Contemporary VR technology is evolving. As observed in the previous section, its development is benefitting from advances in various associated technologies and it is addressing many past mistakes to acquire worldwide acceptance and join the landmark technologies that have preceded it. We previously noted how various global changes have contributed to increasing public acceptance of the new technology, strengthening VR's bid for ubiquity as consumers are now, more than ever, well positioned to appreciate its value. This section looks to unpack the matter of acceptance a little further, by observing how, through various technological developments, the virtual as a concept has been steadily creeping into our collective consciousness. Over decades, perhaps even centuries, these technologies have been slowly managing our expectations and our values, to normalise the virtual into something we expect, take for granted and consider part of our everyday lives.

The Telephone

Whilst the history of the virtual certainly predates it, one of the first significant instances of virtual technology just so happens to be an auditory example. A story littered with debate and controversy, the origins of the telephone appear to revolve around Mr. John Philip Reis: 'the discoverer, some say, of the art of electrically transmitting speech' (Evenson 2000, p. 209). From tumultuous beginnings during which time multiple individuals laid claim to its discovery, the humble telephone presented substantial appeal by offering adopters the ability to converse with others across great distances with immediacy and clarity, as if that person was actually in the room. With the exception of some rather crude and unsubstantiated comments regarding women's addiction to the telephone (discussed in Rakow 1988), very little academic

research exists concerning the societal effects of the fixed-line telephone. That said, the proportion of fixed telephone lines across the developed world peaked at 57% between 2000 and 2001.⁶ Looking to their childhoods, many readers will remember their landline home telephone, usually perched upon a telephone table no less, aside a little notepad full of handwritten contacts and a bright yellow directory book. The fixed-line telephone was a massively popular technology that virtualised person-to-person communication, bypassing the requirement for physical proximity. It was utilised so extensively that it caused many to worry that the frequency and volume of person-to-person conversations were dropping because of the telephone. As such, the telephone meets the three requirements that we shall also observe in the subsequent technologies discussed within this chapter that provide further examples of the virtual becoming the everyday. Firstly, it virtualised an existing notion, object or process in a way that overcomes physical limitations. Secondly, it became ubiquitous, a commonplace entity that proliferated society and was utilised across the globe. Lastly, the technology brought with it some form of displacement (i.e. it is used regularly and to the extent that it reduces people's engagement with its 'actual' counterpart).

The Television

Although we may have begun with an auditory example, the visual modality is most certainly not without representation and possesses a powerful exemplifier in the television. An argument could be made that this discussion is failing to acknowledge the photographic camera. However, whilst it certainly meets our three requirements, the television does so to a somewhat greater extent, particularly in terms of ubiquity, and we shall be returning to virtuality and the camera at later points within this book. Beginning in the nineteenth century, the history of television is a complex blend of technological, sociological, cultural and economic narratives that cannot be done justice within a brief couple of paragraphs (for a comprehensive account see Hilmes 2003). In the UK, for the week beginning 25 July 2016, an average of 42 million people (roughly 71% of the population) watched television each day, with

an average weekly viewing of 22 hours and 34 minutes watched per person⁷—almost an entire day per week spent in front of the television. Across the world, approximately 1.57 billion households currently possess a television, with projections for 2021 increasing to 1.68 billion.⁸

As human technology develops overall, one noteworthy trend is the substantial increase in the diversity of virtual functions a single new product can present consumers with. This is particularly apparent when considering television which, due to its diverse programming, can present viewers with virtual alternatives to a range of activities, from accessing current events information from television news rather than a print newspaper to satisfying their need for escapist fiction by the way of the drama series instead of the novel. As far back as the 1960s, researchers were addressing widespread concerns that the television was replacing printed media. However, analysis at the time largely reflects the current state of affairs in which people are generally eschewing print in favour of television specifically for the headlines and surface details whilst still relying on text-based outlets for deeper analysis and editorial opinion (Belson 1961). A study by Pommerehne and Kirchgässner (1986) posited that television had contributed to the decline of conventional culture, one specific form of which was a significant reduction in audience attendance at live theatre. Similarly, a review article into the impact of television in the Netherlands has argued that reading has been significantly reduced as a result of increased television watching (van der Voort 1991). As with the telephone, the television transcended the physical limitations of a physical counterpart, including the theatre and the printed newspaper. The benefits of its virtual nature were powerful enough to make the technology an item that sits in almost every living room, and it has raised concerns of displacement that we shall all become slaves to the box.

Network Technology & Social Media

Like the telephone and television before it, the Internet represents possibly the most significant landmark in wider virtual technology. Much contemporary research has been carried out examining individual

applications of network technology and their displacement impact. With roughly 2.6 billion users, 205 billion messages sent daily⁹ and a capacity for outright replacing letter writing in most contexts, e-mail arguably meets the criteria for virtual technology as part of our everyday. Network technology is also now an established and powerful platform for buying and selling. A study by Shim and colleagues (2000) examined the impact of e-commerce on high street retail. They concluded that Internet-based shopping was a substantial competitor but specifically in cognitive rather than experiential sense. Items that did not require direct sensory evaluation and could be readily assessed by the way of quantitative information (specifications, user reviews, etc.), such as personal computers, were where online shopping was shown to be most disruptive. More recent studies implicitly testify to the impact of Internet shopping by exploring the effect that opening a physical outlet will have on a previously web-only company (see Pauwels and Neslin 2015), reversing the focus and bringing us to a time where e-commerce has become so popular, and opening a physical location has now become something of a curiosity.

Possibly, the most striking example of how the Internet has facilitated the virtual in our everyday is in its effects upon our relationships, both in physical and in psychological terms. With regard to the former, Carl Carlson and Lenny Leonardson once told Homer: 'You're the internet's number one non-pornographic site, which makes you ten trillionth overall'.¹⁰ The figures from this quote may not be particularly accurate, but the sentiment is something that clearly resonates with the truth. Research studies have described the exposure of young people to pornography on the internet 'as a normative experience' (Sabina et al. 2008, p. 691). A 2013 report conducted by the BBC¹¹ stated that there is much in the way of sensationalism, exaggeration and false claim regarding Internet pornography statistics. That said, their own findings reveal more considered ratios for pornography-related web searches, and sites delivering pornographic content were still notably high, at 14 and 4%, respectively. A review article by Short and colleagues (2012) analyses numerous papers to reveal noteworthy inconsistencies between studies in terms of how Internet pornography was defined and measured, and how conclusions were drawn. Alongside

Short and Colleagues, numerous research studies argue that the impact of Internet pornography is widespread, but it includes both positive and negative effects (see Hald and Malamuth 2008). Whilst the literature largely rejects the demonisation of Internet pornography in favour of a more balanced conclusion, it does not ignore the negative effects, some of which match our displacement criteria for normalising the virtual. Whilst predating Internet-mediated consumption, Zillman and Bryant (1988) conducted a study testing for the effects of pornography upon sexual satisfaction, their results presenting significantly lower ratings for actual sexual experience for the group regularly viewing pornography. An article in *New York Magazine* (Wolf 2013) voiced the displacement concern directly, arguing that the Internet was responsible for creating a scenario in which women's inability to match unrealistic 'porn-worthy' male expectation was causing men to lose sexual interest in actual women. Whilst this claim of displacement is treated with more caution within academia, its persistence in mainstream media^{12, 13} supports the assertion that Internet pornography is potentially another powerful instance of the virtual becoming normalised.

Whilst the Internet presents several other avenues for the normalisation of the virtual in a psychological relationship context, from dating apps to instant messaging, it is social media that arguably presents us with the most prominent example. In the UK, 73% of adults with access to the Internet also use social networking sites.¹⁴ According to Statista,¹⁵ the number of social media users globally stands at roughly 2.34 billion with the Facebook platform topping the rankings with approximately 1.59 billion 'active users' (a term that, according to Facebook, only accounts for those visiting the site directly and excludes individuals who interact with it via third-party applications¹⁶). Facebook is first and foremost a tool for social interaction, but has been shown to provide additional functions such as entertainment, self-status seeking and information (Park et al. 2009). Of course, such benefits are present in direct person-to-person contact but arguably not to the same extent and not without requiring greater effort. Should you wish to find out what a previous acquaintance from school was up to, you could give them a call and then meet with them in person, but then of course you might actually have to talk to them. Instead, social media offers us the

opportunity to discover contacts' information, compare their network personas against our own (facilitating hierarchical positioning of our own self-status) and be entertained by their recent cat pictures, all with the minimal investment of time and effort.

Social media does of course have a fair share of detractors, and research has raised genuine concerns to try and inform the public as to best use of the technology with regard to health and well-being. Recently, the term 'Facebook depression' has emerged in research papers. In most cases, links between clinical depression and social networking activity have not yielded significant connections (Datu et al. 2012; Jelenchick et al. 2013). That said, a more recent article featured in the *Review of General Psychology* argues that research up to 2015 may have examined social media users too broadly and that, were we to filter users (by concentrating only on those who have a proportionately large number of friends, frequently and for long period of time read posts from these friends, and these posts are largely of a bragging nature), then hypothetically, a clearer association between social media and depression would emerge (Blease 2015). Of course, correlations with depression are not necessarily direct indicators of virtual normalisation but another issue concerning social media is its effect upon actual person-to-person interactions. As with many of the above technologies, mainstream media is the prevalent source of this issue with headlines implying social media is the 'the death of real-world interaction', 'sabotaging real communication' and 'destroying our social skills'. When read in context, these three quotes are all posed as questions rather than statements and, whilst the headlines heavily imply that the impact of social media face-to-face interaction is both negative and a genuine problem, the articles themselves rarely take a conclusive position. Academic literature does attempt to address the issue, but only a few studies appear to have been conducted and largely reach conflicting conclusions. A paper by Kujath (2011) evidences the argument that social networking provides an enhancement to in-person interaction. Respondents to this study self-reported that they utilised Facebook primarily to maintain existing relationships and form new ones. Very few felt that they had a tendency to communicate with their friends more online than in-person. Conversely, Grieve and colleagues (2013)

posit that social media and in-person connectedness did not conclusively correlate and were arguably independent of one another, thereby questioning the assertion that social media either enhances or detracts from real-world socialising. Whether social media actually displaces face-to-face communication is unclear, but the belief that it does is itself very powerful with regard to normalisation of the virtual. Demonstrated by the way that it is being presented in mainstream media, there is a commonly held belief, whether truth or myth, that social media is taking over from in-person communications. It is this belief, first raising objection but slowly becoming accepted, that enables the virtual normalisation to creep in.

Mobile Technology

The mobile (cellular) telephone as a basic communications device offers relatively little in the way of product-unique access to the virtual (telephone calls, texts and e-mails are all functions that are available by other means). Mobile technology does, however, provide two relevant and highly substantial facilities. Firstly, it presents a single interface that houses (potentially) every single one of the above virtual technologies. Telephony, television, digital games, the Internet and social media are all accessible from a single device, and the accessibility and efficiency of this dramatically increase the potential for ubiquity across all sources of virtual. Secondly, the capacity to provide the virtual content without the restriction of physical location (typically the home) provides consumers access from a much wider range of locales and at more times throughout the day (such as when at work or during a commute), thereby also increasing the amount of time spent consuming the virtual content (and conversely, decreasing time spent doing anything else).

Sarwar and Soomro (2013) trace the history of the smartphone back to 1993 and its first incarnation: IBM's 'The Simon', which integrated fax, email and cellular paging functionality (plus personal digital assistant tools and a touchscreen interface) into a mobile phone. Various additions and refinements to both smartphone hardware and software have accompanied the dramatic increases in their commercial success.

The first-quarter UK statistics for 2016 reveal that 71% of adults now own a smartphone. This figure has risen consistently by 5% every year since 2014. As of 2016, roughly 2.1 billion individuals use a smartphone across the world.¹⁷

Whilst social media is a prominent specific example of how virtual systems have infiltrated the everyday, the smartphone represents a great leap in access to an array of virtual functions and content, arguably transforming the landscape by normalising the virtual in a much more general sense. ‘There’s an app for that’ has become something of a catchphrase and one perfectly summing up the diversity of virtual function that the smartphone offers. Type the phrase into your search engine and articles appear that describe a seemingly infinite number of possibilities. Want to translate language in real time? There’s an app for that.¹⁸ Need to find the nearest yoga class to your location from almost anywhere on earth? There’s an app for that too.¹⁹ Want to send automated message to your significant other rather because even texting has become too taxing? The list goes on.

Holding the Door Open for VR

The recent publicity and marketing that has encompassed modern VR presents us with various taglines, each promising numerous ways in which the technology will revolutionise our lives. Following Facebook’s acquisition of the Oculus Rift in March 2014, Mark Zuckerberg’s strategic plan for the technology prioritises VR ubiquity as a primary ambition. This is in terms of both its availability to the masses and its consistent use throughout an individual’s typical day. Whilst consumer VR headsets are being marketed predominantly as digital game peripherals, it’s difficult not to notice that much of the future-facing ambitions for the technology exist outside the application of digital games and are further examples of displacement. They are not offering entirely new experiences or interactions. Instead, they propose new ways of experiencing and interacting with that which already exists (and most largely that which is commonplace), essentially a virtual means of interfacing with the everyday or alternatively, a means of interfacing with the virtual

everyday. Were it presented to us fifty years ago, VR would have been met with an aggressive Luddite rejection and the technology branded as ‘unnatural’ and ‘unreal’. This all emphasises the emergent nature of VR, which exists not in a vacuum, but in our collective consciousness and wider culture. How it is produced, why it exists, what it can do, what came before it and how we believe it will add value to our lives, all contribute to the emergent picture and our understanding of precisely what VR is.

What Is Virtual? Positioning the Virtual, the Actual and the Real

The virtual is everywhere, both in space and in across time. It permeates every facet of our daily lives. As a technology, VR has accumulated a substantial degree of trust as we engage with it under the assumption

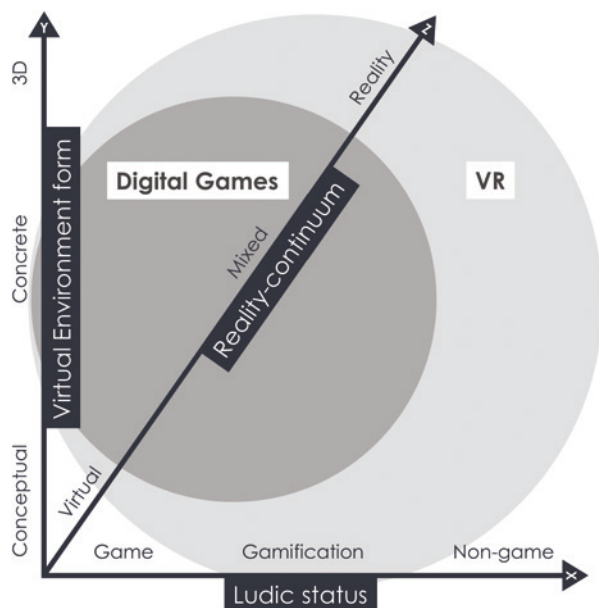


Fig. 2.1 A three-dimensional conceptual framework for VR and digital games

that the virtual is safe and of benefit to us. Despite this trust, what is meant by the virtual, virtuality and VR is something that we still struggle to define and explain. Are these terms descriptive of the same thing? If not, how are they different? Are their definitions stable or constantly changing as both our technology and understanding of the world develop at an ever-quickenning pace? This section examines these terms (and a few more besides) to provide a general overview of contemporary thought, primarily describing and contrasting the virtual from technological and organisational positions. The intention is to add another vital component of the emergent framework of VR and to help us better contextualise our subsequent discussion on the role of sound in VR.

The Virtual as Technology

As a fledgling research field, the very definition of VR is a noteworthy point for ongoing debate. Existing definitions range from broad and encompassing to highly specific. They typically centre on experience, with examples including VR as a synthetic experience (Kim 2005), an immersive, interactive experience generated by a computer (Pimentel and Teixeira 1993) and an experience in which the user is immersed in a responsive virtual world (Brooks 1999). A review article by Muhanna (2015) gives us a concise overview of contemporary theorists' definitions by presenting us with five elements that they argue are essential for something to be classified as VR: (1) a virtual world—a medium presenting non-physical space by the way of graphical representations and a set of governing rules and relationships; (2) immersion—qualitative experience denoting attraction to, engagement with, the virtual world; (3) feedback—information received by the user who can interpret the input as response to their own actions within the virtual world; (4) interactivity—primarily the ability to dynamically manipulate and modify elements within the virtual world; (5) participants—the presence of an actual person experiencing the VR. Are these the essential technological characteristics of VR and how do we confidently draw the line between what is VR and what is not? Across many definitions, one feature perceived to be particularly fundamental

is digital content, generated by way of a computer. To a lesser extent, three-dimensional objects/environments and user interaction also reliably feature in descriptions of VR (Dioniso and Gilbert 2013). Where we find less consistency is with regard to display type and sensory modality. Whether a true VR system has to provide visual feedback (rather than auditory, olfactory, haptic, etc.) is unclear. That said, reviewing the several definitions of VR presented above, not a single one directly mentions graphics or visual content. Equally ambiguous is whether a HMD or multi-screen display is essential to 'being VR', or whether a single flat-screen display can also be worthy of inclusion. Whilst it is difficult to get a conclusive answer regarding these questions, it is possible to make inferences by examining what technologies various literature sources identify as VR. For example, 'Audio-only VR' identifies a VR system not dependent upon any visual material (e.g. Patterson et al. 2004), whilst 'flat-screen VR' presents VR without head-mounted or multi-screen setups (e.g. Sveistrup 2004). Of course, such instances very much represent the minority and the likely reason that few people go on record to argue that graphical content delivered by the way of a HMD is fundamental to VR, is because such an assertion is quite simply taken for granted.

To complicate things a little further, the virtual as technology extends to incorporate further virtual forms. Alongside his colleague Fumio Kishino in the early 1990s, Paul Milgram (1994) put his name to the reality–virtuality continuum, distinguishing several discrete terms within. Going from left to right, reality describes the natural world, with no virtual content. Augmented reality (AR) blends natural with virtual content, overlaying the physical environment with digital content. Augmented virtuality (AV) is essentially the reverse, a virtual environment that integrates some physical content. Finally, virtuality refers to an entirely virtual environment and is closest to what a popular audience will most commonly interpret as VR. A paper by Koleva and colleagues (1999) posits that the difference between AR and AV is something of a 'whoever comes first takes precedence', meaning an environment that is founded in elements from the 'real world' and has virtual elements superimposed over it would be classified as AR. Conversely, AV begins with a virtual world and then embeds representations of physical

objects within it. What counts as an embedded representation is less clearly defined, and there is a possible paradox created when we consider the presence of a human user as an essential component of any VR experience. As the user is a natural component that influences the nature of a virtual world, pure virtuality is impossible and what we traditionally think of as VR would be more correctly identified as AV.

The terms above collectively sit underneath the umbrella term ‘mixed reality’, with the obvious exception of reality. Differentiating various classes of mixed reality appears throughout academic literature for multiple purposes. Milgram and Kishino (1994) utilised the continuum to categorise different types of visual display in tandem with alternative approaches to interfacing, whilst Billinghurst and Kato (1999) use it to explore the effects of shared experience in network-mediated collaborative work (e.g. a virtual world becomes increasingly mixed reality when the individual interacts within it alongside more and more human players). What is consistent across most of the relevant literature is the position that the virtual is separate and distinct from the real. Any computer-generated content, even if it is overlaying an otherwise physical environment, transforms that environment overall into something that is no longer real.

Another difficulty of definition with regard to VR concerns digital games. The question is raised regarding whether digital games inherently qualify as VR by design and does the ‘gamification effect’ dictate that VR is inexorably tied to games? Depending on genre, and considering recent developments in motion/gesture-control games interfaces, digital games can be 3D, interactive, responsive to player movement/position and evoke feelings of immersion and presence, matching several of Muhanna’s (2015) requirements for VR. Games cannot function without a player to play. They also provide multisensory feedback in both direct and indirect responses to player actions. Consequently, if we do not require HMDs in our qualification, then digital games arguably *are* instances of VR. This should not be extrapolated to assert that VR is equal to digital games, with the truth hidden in the finer details as part of a more complex idea. Figure 2.1 illustrates a broad framework for both differentiating the two terms and part-describing their relationship. The three dimensions of this model reflect

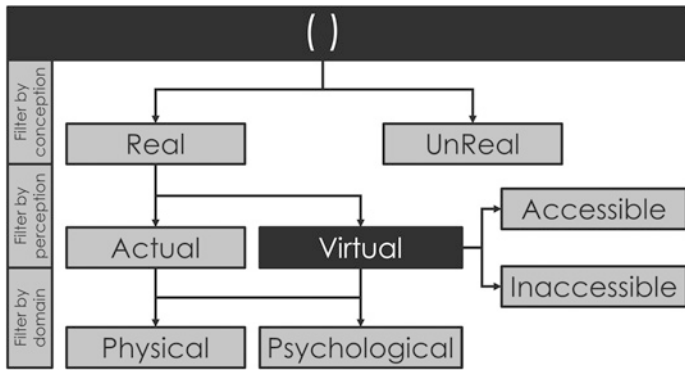


Fig. 2.2 A taxonomical perspective for the virtual based on organisational-virtual theory

the broad means by which we can consider both digital games and VR. ‘Ludic status’ refers to the extent to which something embodies traditional gameplay properties. ‘Virtual environment form’ denotes how the content of the virtual world is conceptual (an idea) and concrete (represented in some tangible digital form or a fully three-dimensional rendered environment). Finally, ‘reality continuum’ (which was described in more detail a few paragraphs prior) describes the degree to which various characteristics of the subject reflect either the natural world or the virtual world. In this framework, VR encapsulates digital games but also extends beyond them, in non-gaming applications and also in terms of environment form, as technical elements such as HMD-based head tracking, and stereoscopes differentiate things which are presented on semi-immersive (single flat screens) and those that are fully immersive (HMD, CAVE, multi-screen display, etc.). This framework is useful in that it helps delineate some of the key factors that contribute to our understanding of VR from a technological perspective. Whilst certainly not the whole story, these points still form a significant part of the emergent puzzle.

Overall, the virtual from a technological perspective offers us value in several notable ways. Firstly, it gives us an appreciation of how popular culture views the virtual (even if this understanding is flawed) and,

by proxy, helps us to elucidate some of the consumer expectations and preconceptions, arguably an important asset for anyone wanting to understand user experience in VR or those working to develop VR applications. Secondly, these perspectives bring together the key elements of VR as an object and help us to compartmentalise some of the VR variables that pertain to VR hardware and software. Whether visual feedback is or is not essential for a system to be classified as VR may not be an important question, but it is one that indirectly highlights the notion of VR systems built around alternative sensory modalities. As a result, such a question still manages to offer us a highly interesting avenue for further investigation. To summarise, the virtual from a technological position revolves around the contemporary computer technology commonly referred to as VR. It is a system-side focus. It gives us a sense of VR as an object or a system, with empirical qualities that can be measured and manipulated. It includes the display, forms of feedback, objective aspects of immersion, controller, tracking methods and interface hardware. What it does not do is describe the phenomenological (i.e. user experience) relationship between the system and the user. The virtual is an opportunity, afforded to us by technology, to experience other worlds. These worlds may be entirely virtual or they may be mixed with elements of the physical world. Lastly, the virtual from this perspective is in opposition to reality, a key point that the following discussion presents an alternative to.

The Virtual as Organisational Theory (Virtuality)

In most books that explore VR, the perspectives under discussion tend to fit within the technological perspectives outlined above. The organisational position, however, encapsulates additional and, crucially, broader thought on the virtual that is partially, but not entirely, oppositional to the technological perspective. Some of the most prominent examples of the organisational position can be found within the works of Gilles Deleuze and his exploration of virtuality. Deleuze's virtuality is markedly unattached to technology and is instead a part of broader philosophical thought. In an article by Linstead and Thanem (2007),

the virtual, as understood by Deleuze, is succinctly described as an integral piece of reality, *not* an opposition to it: '[...] the virtual *is* everything and [...] *is in* everything—a principle of connectedness' (p. 1492). VR is therefore encompassed within the virtual. Although the virtual is a component of reality, it is not equal to reality and sits alongside its counterpart, 'actuality'. For something to be actual, it must be consciously attended to by a perceiver in the precise here and now, what the individual perceives to be the present moment in both space and time. The virtual is everything else. It is everything that contributes to the present actualisation and every actualisation of the past and future. This goes against two significant assertions of the technological perspective: that the virtual and the real are distinct and separate entities, and that the virtual is born from (and inherently tied to) computer technology.

The explanation for the virtual as part of reality centres around two primary arguments. Firstly, in our experience of the world, immediate sensory input is inseparable from 'projection'—'a throwing of existence ahead of itself' (Roe 2003). In simple terms, we cannot at any point or circumstance help but consider (be it conscious or subconscious) the future. This is because without such consideration, any action within the world becomes impossible. How can you reach out to grasp an object with no concept of the outcome of your action? How can a writer type any text without some concept of the completed script as it is being written? Our actions and our being are inseparable from our perception of them, and they are also rooted in space and time. The actual can only exist in association with the virtual, making both equal partners in propagating reality.

The second argument posits that virtuality is real because of its observable (and often quantifiable) impact upon our existence. As Ramiller states: '[t]he virtual [...] is not simply anticipatory and prescient, but also generative' (2007, p. 355). This idea is reflected upon in popular culture, in *Imagination Land* (Parker 2007) an episode of satirical cartoon *South Park*, where the protagonists reflect on the powerful impact that characters and themes from fiction can have upon their daily lives. Although this is not a perfectly accurate depiction because the virtual is not limited to the imagination, a similar sentiment is presented nevertheless. An imaginary entity that inspires change in the

physical environment is powerfully real. Equally so, the virtual does not merely accompany the actual, it determines its precise form and launches it into actuality. It is also, powerfully real.

Understanding the virtual from an organisational position becomes even more complex when we consider that to do so additionally requires us to make sense of nothingness and existence, alongside reality, virtuality and actuality. Embodying the emergent perspective, these additional entities all intertwine with the virtual as it is positioned within a form of existential ecology that we can use to better explain virtual itself.

If there was a grand structure for *everything* that could be exhibited in a framework (leaving aside the point that does so is a rather arrogant thing to do... see Fig. 2.2), the uppermost level of the structure would, theoretically, need to be entirely undefinable as any descriptor would inescapably generate a conceptual space outside itself. If we were to entitle it as 'existence', then it follows that something could somehow be positioned outside existence; if we were to call it 'reality'... and so on. Taking a step down the hierarchy, we can position the 'real' (existence) and the 'unreal' (nothingness), the distinction between the two being quite simply that the former can be conceived of whilst the latter escapes from physicality and contemplation (at any time and by any being, not just humans). The unreal is not comparable to the unknown (referred to in the taxonomy as 'inaccessible') because the latter refers to entities that defy conception by the individual at the present, but that nevertheless have the potential to be conceived of by someone or something at some point in time. For example, the Internet would have been inconceivable in the nineteenth century and, during its first conception circa 1960, remained inaccessible to all but a few. Today, it can be conceived of by almost every human on the planet.

Whilst the unreal is not subject to further subdivision, reality constitutes the virtual and the actual, two terms that are differentiated in relation to perception. To be classified as actual, an entity must be being perceived within the here and now—as determined by the attendance of at least one perceiver. By contrast, the virtual is that which exists outside immediate perceptual space. Both the actual and the virtual can be subdivided into physical (embodies matter or energy) and conceptual (non-physical) variants. A physical entity is not automatically actual; without

attendance/perception, it is virtual. In terms of movement between these states, transition between the real and the unreal is essentially inconceivable because the unreal is itself inconceivable, and therefore, we cannot comprehend any entity transitioning between the two. We can, however, regard movement within the lower levels of the hierarchy. Something that was once virtual may become actual, subject to being consciously perceived, and then return to being virtual post-perception.

Virtuality theory, much like its technological counterpart, presents us with value when applied to VR design. Firstly, the notion of projection raises important considerations relevant to user experience in VR, specifically that users will not (and cannot) experience VR stimuli in isolation and that whatever is presented to them comes tethered to their prior experience and future expectation in addition to all connected aspects of space and time. By presenting human experience as a complex interaction of vast numbers of variables that are unique to the individual, it also highlights the inevitable limitations of homogenous design practices and assumptions that designer intent will automatically match user experience. Thirdly, the organisational perspective encourages us to consider more ecological approaches to design. It encourages us to more consciously attend to the background elements of our design. For example, the increase in body temperature we experience when wearing a HMD, or the subtle ambient soundscape in the background of a VR application, may not seem important at first thought, but addressing such points within the overall craft of VR design has great potential to dramatically improve the overall experience.

Virtuality is the underlying theory that leads to the conception of sound as an emergent perception (Grimshaw and Garner 2015), and it is now the foundation upon which this book is built. The collection of components presented in the emergent frameworks at the end of this book represents the individual pieces of the virtual as it pertains to the emergent actualisation of VR sound. When many of us consider VR sound, it is likely that the actualisation is formed of a relatively small collection of virtual components, as many others are presently inaccessible (i.e. they are simply not known to that individual). This book is itself, a means of helping the reader to enhance their actualisation of VR sound by making accessible some that which was once inaccessible.

The (hopefully not too arrogant) intention is that the reader, upon completion of this book, will actualise a renewed concept of VR sound. Possibly one that is very different to that which emerged prior to reading. Ideally one that is richer yields greater understanding and can facilitate better design in both VR and VR sound.

To summarise, the virtual can be thought of as a technological concept, built of objective and tangible elements to facilitate experiences beyond that of the physical world. From broader organisational perspective, the virtual is a fundamental underpinning of perception. It is the mechanism by which our unique experiences of the world come forth and cycle in an endless, infinitely complex, loop of sentient existence. Ultimately, both perspectives reveal significant value, both regarding our conceptual understanding of VR and as sources of practical design guidance. To acknowledge both is to position VR across the virtual, the actual, the physical and the psychological. All at once, VR encapsulates a physical component in its hardware and radiating stimuli, a psychological presence in our individual conceptualisation of VR, a virtual aspect incorporating every relatable unit of physical and psychological content that shapes experience and an actuality—our felt experience of VR within the here and now. We certainly have much to consider.

Chapter Summary and References

This chapter has begun our exploration of VR and VR sound as emergent concepts by reviewing different ways in which it can be defined and understood, but also how perspectives are rapidly changing. Two alternative perspectives are discussed, one asserting the virtual as technology and the other as an organisational theory. The central argument here is that what we understand as virtual should not be solely restricted to an experience of technology but rather a component of all experience. We can observe the broader applications of VR are revealing hundreds of new functions, whilst powerful corporatisation is enabling adaptive design and manufacturing. Better integration is contributing also, as VR reaps the benefits of advances in various technologies and our perception of VR is consequently becoming increasingly positive.

This positivity has fuelled production and implementation of VR on a trajectory that arguably is moving the technology towards ubiquity. When we consider this alongside how the virtual as both concept and an experience has permeated so many facets of our everyday lives, from the telephone to social media, the forthcoming acceptance of VR as a permanent mainstay technology is a pretty safe conclusion.

Whilst the discussion so far has admittedly focussed upon VR, this is of course relevant and leading into VR sound. Within an emergent framework of VR sound, all the above points are still of significant relevance. How we interpret and attach meaning to auditory content in a virtual environment is inexorably connected to VR and the broader issues that contribute to its nature. The organisational theory with which this chapter closed has particular relevance by the way of it covering some of the foundational concepts from which a framework of sound as an emergent perception is constructed. This framework is addressed in the following chapter as we explore the notion of Sonic Virtuality, the emergent understanding of auditory perception that was the main influence of the theoretical positions that are presented throughout this book.

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Echoes of Other Worlds: Sound in Virtual Reality

Past, Present and Future

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