Coextensive space: virtual reality and the developing relationship between the body, the digital and physical space

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Abstract

Virtual Reality (VR) has traditionally required external sensors placed around a designated play space. In contrast, more recent wired and wireless systems, such as the Oculus Rift S (released in March 2019) and the Oculus Quest (released in May 2019) use cameras located on the outside of these devices to monitor their physical position. Users can now mark out a physical space that is then digitally tracked within their display. Once a play space has been established, users are alerted if they come close to breaching this boundary by the visual inclusion of a grid. Should this threshold be breached, the headset display shifts to an image of the surrounding concrete environment. We contend that physical space is increasingly being incorporated into the digital space of VR in a manner that meaningfully differs from older systems. We build our argument in the following way. First, the article explores how theories surrounding VR have implicated only a limited relationship with physical space. Second, the article introduces the concept of coextensive space as a way of understanding the developing relationship between the physical, digital and concrete reality enacted by current VR systems.

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Introduction

To understand recent advancements in Virtual Reality (VR) and their wider significance, it is important to first briefly reflect on the history of this technology because VR is a complicated technology to discuss. From one angle, it is the 'next big thing', an emergent media form supported by hundreds of millions of USD in investment from major tech companies like Facebook, Google and HTC, which has led to the release of more commercially orientated systems like Sony's PSVR. From another angle, it is much older than its veneer might imply, and has followed a circuitous path of hype, disappointment and revival (Jenkins, 2019). In fact, it was not until the 1980s and early 1990s that commercial VR actually began to gather pace. In 1984, for instance, Jaron Lanier – often considered the 'father of VR' – created VPL Research, and produced several industry-defining devices, including the DataGlove and AudioSphere. And while VR continued to grow in various ways throughout the 'halcyon days of VR culture' (Evans, 2018: 27), only a limited number of systems were publicly available, and these systems ranged from US$10,000 to US$50,000. For Evans (2018), a significant reason for VR's lack of progress is what he refers to as 'technological lag'.

Simply put, during the 1980s and early 1990s the cultural imaginary for VR exceeded the technical capability. Whereas, most technologies (e.g. the Internet or mobile phones) are shaped by some degree of 'cultural lag' (Brinkman and Brinkman, 1997), with cultures often taking many years to adapt to the impact of emerging media, VR is different. Influential novels, such as Neuromancer (Gibson, 1984) had already imagined people spending the majority of their time in virtual worlds, and by the early 1990s, *Computing Gaming World* predicted 'affordable VR by 1994'. Perhaps most famously, Nicholas Negroponte (1995), reasoned that '[we] will socialize in digital neighbourhoods in which physical space will be irrelevant' (p. 8). In stark contrast to this vision, early VR was disappointingly slow, had major lag times, and the few commercial sets on offer were exorbitantly priced and largely impractical (Burdea and Coiffet, 2003). The technology was just not ready.

In spite of the lack of adoption, the implicit promise of being able to inhabit a digital space distinct from our physical environment is precisely what made VR seem like such a radical technology. And as Evans (2018) explains, '[this] is still the potential of VR today, and in this potential the claims of revolutionary medium lie – a fully alternative, computer-generated reality that we can be fully immersed within' (p. 7). Significantly, the current generation of VR might finally be on the cusp of fulfilling some of this potential. In contrast to older VR technologies that require a multitude of external sensors, such as the HTC Vive, Oculus Rift and PSVR, more recent systems, such as the Oculus Rift S (released in March 2019) and the Oculus Quest (released in May 2019), have cameras located on the outside of the headset that monitor their physical position. Users can now mark out a physical space that is then tracked within their display. Once the 'Guardian System' has been implemented, as it is officially termed, users are instantly alerted if they come close to breaching this boundary by the visual inclusion of a red grid. Should this threshold be breached, users' display changes to a monoscopic and monochrome image of their concrete surroundings, which is powered through a system termed 'Passthrough'.

Regarding distinguishing characteristics between the Rift S and the Oculus Quest – which we are positioning here as exemplifying the current generation of VR – the Quest is the first commercially available VR system that allows users to experience six degrees of freedom (6DOF) without requiring the headset be connected to a separate and powerful personal computer. 'DOF, refers to the variation of movement that are available to any tracked object. A tracked object is one that moves in a physical space and reports its position and/or rotation information to the game engine' (Pangilinan et al., 2019: 140). 6DOF, then, mirrors the physical freedom of moving in three-dimensional space. In contrast to the Rift S, which requires tethering to a separate machine three a small wire, the computer system used – in this case a Snapdragon 835 – is built into the front of the Quest's display. Consequently, the Quest can be played anywhere that has enough open space because it does not require a room with a specialised attachment to a gaming computer (White, 2019). At the same time, and beyond its advanced graphical power, the Rift S also has features that the Quest currently does not. For example, Passthrough can be manually activated by users 'on-demand', while it can only be accessed on the Quest if the established play space is physically breached. Consequently, Rift S users can seamlessly shift their display between the digitality of VR and the concrete reality of their surroundings.[1]

In this article, we argue that the increasing incorporation of concrete reality through current VR systems and emerging design features presents a form of VR that conceptually differs from older systems. We build our argument in the following way. First, the article explores how theories surrounding VR – including virtuality, immersion, and presence – have only implicated a limited involvement of concrete space. Second, we argue the current generation of VR may partially alter primary relationships between digital information and physical space, which is an issue that has long been a focus of different strands of media research (Heim, 1994; Jensen et al., 2002; Manovich, 2001). To address this shift in direction, we introduce the concept of coextensive space as a way of understanding the developing relationship between the physical, digital and concrete reality that has been enacted by current VR systems. More precisely, coextensive space describes a symbiotic relationship between physical and digital that is increasingly proximate, extensive and transformative. And this relationship is twofold. First, movement within the digital realm of VR is mirrored in the physical, and vice versa, with actual space visually encroaching upon the digital display, should a threshold be reached. Second, concrete reality can be included in the mediated space of VR, either in the form of a relational grid or a monoscopic and monochrome image of the concrete surroundings outside of the headset. An important part of the development of VR, then, is specifically this visualised symbiosis between the physical and digital. In addition, it is also our contention that following the release of the Quest, VR may have reached a point of fairly widespread attention that necessitates new explorations of the theoretical and social importance of VR.

Virtuality and the reality of the virtual

Today, the word 'virtual' has moved beyond esoteric 'strategies for conveying what concepts cannot say' (Guerlac, 2006: 189) or unravelling the experience of time à la Bergson.

Instead, it is commonly employed to describe the effect of emerging digital technologies and the renaissance of VR as a realisable possibility (Evans, 2018). Nonetheless, it remains important to develop an appreciation of the virtual that engages with its chronological roots. In fact, discussions of the virtual stem back to the execution of Archbishop Thomas Cranmer for heresy in 1556 (Shields, 2005). At the heart of this event 'was a debate in the early reformation period of the Christian Eucharist, and specifically the transubstantiation of bread and wine into the blood and body of Christ during the performance of the sacrament of the Eucharist' (Miller, 2011: 32). For reformers and Protestants like Cranmer transubstantiation should not be understood as a literal process, but instead a *virtual* one. 'In 1556, that was enough to get one hanged' (Miller, 2011: 32). Deliberations, then, 'surrounding the virtual and practices of virtuality have a long history' (Shields, 2005: 1); one that extends beyond the digital. Yet, the virtual as a 'significant . . . cultural category' (p. 4) has been used to conceptualise digital technologies and developments, such as the Internet and the recurring metaphor of cyberspace, as well as VR (Saker and Frith, 2019).

Certainly, the rapid growth of the web made new forms of outwardly 'disembodied' social interactions possible. For much of the Internet's history as a popular technology, the term 'cyberspace' became the dominant metaphor for understanding this possibility. 'Portrayed as enabling a human virtuosity beyond the limits of the body or gravity' (Shields, 2003: 15), this cyber world effectively opposed the physical and the digital by imagining a 'cyber' space separate from the physical realm. Here, the idea of cyberspace moved the emphasis away from the physicality of location and the fleshly form underpinning embodied communication (Benedikt, 1991; Heim, 1994). As a response to this changing landscape, Nicholas Negroponte (1995) wrote about a 'world of bits' versus a 'world of atoms', telecommunication companies ran adverts about the circumvention of distance, and commentators belittled relationships maintained primarily online (Baym, 2015; No More There, 1994). From the 2000s forward, however, the suggested abstraction of the virtual and the real became less popular (though still commonplace), with scholarly interest turning to 'the very real (lives) lived in the idealized space of the virtual' (Schreibman et al., 2015: 111).

For Baym (2015), the 'myth of cyberspace' shaped how we talk about the Internet, but it was always just a myth. In reality, the Internet was increasingly woven into peoples' everyday lives, affecting both online and offline interactions. As a result, 'notions of the virtual now look like exaggerated representations of certain relational potentials of computer-mediated communication' (Mackenzie, 2006: 92). The solution, however, as Shields (2005) reasons, 'is not to debate the reality of the virtual, but to develop a more sophisticated theory of the real and the ways in which the *virtual* and the *concrete* are different really existing forms' (p. 21, italics in original). To do this, Shields follows Proust's account of involuntary memories as 'real but not actual, ideal but not abstract' – which Bergson latched onto (see De Zengotita, 2018: 259) – by making a distinction between 'the real', 'the actual' (or 'concrete'), and 'the virtual', which provides a more tempered appreciation of this latter category's potential. While the virtual might not be 'concrete', it can nonetheless still be 'real'. In other words, the 'real' should not be limited to something tangible. Take the example of a child playing make-believe (Miller, 2011). On the one hand, the world of make-believe clearly is not concrete. On the other

hand, it would be incorrect to suggest the reality of this world is not experienced as being real by the child at play. One only has to witness the seriousness of a child at play to appreciate the veracity of this point.

In a similar vein, it would be incorrect to suggest that an understanding of the virtual solely relates to the digital, which is what commonly occurs within current discourse. Yet, it would be inaccurate to suggest that VR does not – in part at least – problematise the relationship between 'the real', 'the actual' (or 'concrete'), and 'the virtual' in ways that exceed other media, and for the following reason:

> The physical space of VR is almost entirely (though never completely) superseded by the virtual world displayed through the headset . . . Symptomatic of this physical and digital rapport, and the ensuing regulation of space, the user is potentially more able to become myopically immersed in the digital space of VR. (Saker and Frith, 2019: 10)

Modern VR systems simulate a semblance of physicality that feigns the materiality of actual space, even though the spaces mediated through VR are not concrete *per se*. The ability to visually simulate something physical separates this technology from the virtual sensibility of a child at play. And the experience of being placed in a virtual space that ocularly appears disconnected from the physical environment is precisely the phenomenological effect of this technology, and what makes it feel distinctive from other media. As Evans (2018) puts it, '[being] immersed in a VR world might just be the most intense media experience we can have' (p. 5). Owing to this intensity, VR has the potential to simulate experiences that are simply not possible with other media. While the virtual should not be conflated with the digital, then, it is our contention that this does not mean the digital cannot configure new virtualities that require scholarly attention. As Drotner and Schrøder (2014) note, '[the] virtual . . .is not necessarily a digital place (although it may be)' (p. 29).

In the next section, we further develop our understanding of the virtual outlined earlier, by examining surrounding notions of immersion and presence that are commonly understood as being vital phenomenological dimensions of the VR experience (Shin, 2018; Slater, 2018).

Immersion, presence and 'being there' in VR

For Slater and Wilbur (1997), immersion is 'a description of a technology that describes the extent to which the computer displays are capable of delivering an inclusive, extensive, surrounding and vivid illusion of reality to the sense of a human participant' (p. 606). From this vantage point, immersion is 'simply what the technology delivers from an objective point of view' (Slater, 2003: 1, cited in Grimshaw, 2014). The technological properties of the medium are understood as determining the users' experience. However, while the technology involved is, of course, important in the context of related understandings and experiences of immersion, '[this] conception of media technologies does not give enough importance to the key role that interpretation and agency play in creating a sense of presence' (Calleja, 2011: 20). From a Heideggerian position, our understanding of any given environment, and thus, how we act in an environment, involves an

implicit and internalised knowledge of the said environment (Evans, 2015). When we are faced with environments we do not understand, our phenomenological mode of being changes (Heidegger, 1962). In other words, while the notion of immersion is commonly associated with the environmental form, presence is often understood as being more cerebral in nature. Attending to these terminological differences will provide a clearer understanding of the suggested experience of VR.

As Calleja (2011) explains, '[*presence*] is derived from *telepresence*, a term coined by Marvin Minsky (1980) in his paper "Telepresence"' (p. 18, italics in original). Here, Minsky reflects on the phenomenological practice of inhabiting a distant space through remotely operated machinery:

> This sense of presence is created through a combination of the operator's actions and the subsequent video, audio, and haptic feedback. A term was needed to account for the awareness of the potential to act within two spaces: the physically proximal and the physically remote. (Calleja, 2011: 18)

The term presence has gradually extended beyond referring to virtual environments (Sheridan, 1992), and is now frequently used to indicate 'experience in both virtual and actual environments' (Calleja, 2011: 19). As Calleja (2011) continues, '[these] differences are not merely terminological, but ontological' (p. 19). This terminological and ontological shift implicitly intimates an equivalence of sorts between sensations experienced in both virtual and physical environments, which circuitously suggests something meaningful about the very real potential of the virtual (Shields, 2005), and in the context of this article, the very real status of VR. As a feature of this parity, rather than simply being the experiential outcome of a certain technology, presence is comprehended as indicating a state of consciousness (Slater and Wilbur, 1997: 607) that establishes a certain mode of being.

At this juncture, an argument could be made that if presence is predicated on a particular psychical sensibility, or mode of being, there is no reason to suggest this sensation is necessarily bound to VR. And to a certain extent, this is a reasonable assertion. Other media can, of course, facilitate various forms of immersion and presence. The physical setup of the cinema, for instance, explicitly limits the awareness an audience has of its concrete surrounding, while redirecting physical sensibility to the action taking place on the screen. Consequently, it is now taken as a given that presence can be experienced in both media that requires and does not require 'non-trivial' effort to 'traverse' (Aarseth, 1997: 1). Aarseth defines the former category as being representative of ergodic media (see also Calleja, 2011; Grimshaw, 2014; Lee, 2004; Marsh, 2003; Schubert and Crusius, 2002; Witmer and Singer, 1998). This is not to suggest, however, that VR is not distinct from 'non-interactive narrative texts' (Waggoner, 2013: 117), like reading a book, for example. Just as gamic environments can provide a level of agency that is markedly absent from, say, film (see Calleja, 2011), traditional VR has the potential to create a form of presence that is outwardly 'dislocated' from its physical setting (Saker and Frith, 2019). And this phenomenological effect is rooted in the sensorial configuration of the technology. 'A VR headset provides an enclosed visual field for the user; headphones cancel out the sound of the outside world; haptic devices can provide sensory feedback

loops of touch, pain, heat or cold' (Evans, 2018: 5). In the context of VR, then, a more nuanced understanding of presence is required since it is precisely this experience that facilitates the simulated transgression of place, which has long been a key feature of the technology (Manovich, 2001).

A recurring description of the kind of experience commonly associated with VR is the 'feeling of being present in an environment' (Schroeder, 2010: 25; see all Rubin, 2018). More succinctly, in much of the literature surrounding this technology, the elicited feeling is defined as 'being there' (Saker and Frith, 2019; Bailenson, 2018; Evans, 2018; Schroeder, 2010; Schubert, 2009; Slater and Wilbur, 1997). Helpfully, Bailenson (2018) provides a vivid account of precisely what this sensation looks like when he describes Mark Zuckerberg's visit to the multisensory room in the Virtual Human Interactive Lab (VHIL) at Stanford University in March 2014. As is common practice with new users, Bailenson started Zuckerberg off on 'The Plank'. This involved him experiencing the sensation of 'standing on a small shelf about 30 feet in the air, connected by a narrow plank to another platform about 15 feet away' (Bailenson, 2018). At the moment, Zuckerberg's legs began to buckle and he raised his hands to his heart, Bailenson (2018) indicates he was experiencing 'a taste of "presence", that peculiar sense of "being there" unique to virtual reality' (n.p.) – which is also a 'critical aspect of [its] commercial appeal' (Evans, 2018: 49). The presence VR can facilitate, then, is very much positioned as being a 'dimensional construct' (Strack et al., 2016: 86; see also Botella et al., 2009; Diemer et al., 2015; Slater and Wilbur, 1997). VR users are effectively transported to a dislocated space (Saker and Frith, 2019) that is visually and audibly distinct from the space outside of their headset.

As a by-product of this process, it is often assumed that the more sophisticated the technology is the better able it is to simulate a 'highly presence inducing' (Slater, 2003) experience. Certainly, '[the] unique selling point (USP) of VR is that this feeling of fidelity with media is a part of the experience of VR' (Evans, 2018: 50). And there is evidence that the technology involved is implicated in the level of immersion experienced, and therefore, the degree of presence felt, in a manner that exceeds non-VR based technologies. As Diemers et al. (2015) explains,

> [although] some researchers have failed to find an effect of immersion on presence, in general, research indicates that more sophisticated simulations (higher immersion) result in increased presence, especially in virtual environments not designed to induce particular emotions. (p. 89)

The suggestion, of course, that the more realistic an environment appears, the more likely it is to 'greatly influence the level of mental immersion experienced by the participant' (Sherman and Craig, 2018: 383), as well as the 'the presence experienced by the user' (Salen and Zimmerman, 2004: 450), is reasonable. For Calleja (2011),

> [at] times immersion seems to be seen as something of a holy grail within the game industry because of its connection with an engagement that draws players so deeply into the game world that they feel as if they are part of it. (p. 25)

To be clear, however, this longing to create seemingly unmediated–mediated experiences is not necessarily unique to VR. As François Laramée points out, '[all] forms of entertainment strive to create suspension of disbelief, a state in which the player's mind forgets that it is being subjected to entertainment and instead accepts what it perceives as reality' (cited in Salen and Zimmerman, 2003: 450).

A significant trope running through much of the literature on presence is 'the perceptual illusion of non-mediation' (Lombard and Ditton, 1997). Likewise, in the context of virtual environments, Bolter and Grusin (1999) propose that the logic of transparency is a salient feature of immersion. 'Transparency erases the interface and offers the viewer or user as direct an experience of the represented space as possible' (Calleja, 2011: 23). Regarding the experience of VR, then, the experience of presence can be understood as the extent to which 'one feels present in the mediated environment, rather than in the immediate physical environment' (Biocca and Levy, 2013: 36). Through this feeling of presence, '[the] medium becomes invisible' (Grau, 2003: 349). It is precisely this notion of transparency, of physical removal, that is increasingly seen as being a desirable quality, particularly for game designers. Accordingly, the potency of VR lies in its ability to create experiences that ostensibly transcend the concrete realm – albeit fleetingly – and feel real to the extent that an awareness of their mediation is concealed. For Bailenson (2018), recent developments in VR means that 'the gap between "real" experience and mediated experience is about to get a whole lot smaller' (n.p.).

Yet, even if '*immersion as absorption*' (Calleja, 2011, italics in original) were achievable or desirable, the concrete setting would still frame the ensuing experience (Saker and Frith, 2019). To be clear, just because physical space is not an explicit part of the mediated display of VR, does not mean that it does not affect how any given VR application is experienced. 'If the same VR system and application are placed in two different venues, such as an entertainment arcade versus the Guggenheim Museum, there will be a significant difference in the way the experience is perceived'. At the same time, and importantly, in the context of this article, it is equally our contention that the current generation of VR involves a relationship between physical and digital space that has moved beyond the implicit effect of the former on the latter, as well as its concealment. More specifically, we argue that the balance between concrete space and the mediated space of VR is subtly changing, as presence within virtual environments increasingly involves physical space being aesthetically and coextensively woven into the experience through the development of recent design features.

In the next section, we introduce the concept of coextensive space as a way of understanding the emerging relationship between the physical, digital and concrete reality being enacted by current VR systems.

Wireless VR

Older forms of VR, such as the Oculus Rift, HTC Vive and PSVR, have necessitated a reasonable sized room dedicated to the 'dimensional construct' (Strack et al., 2016) that underpins the application of this technology (Karpathy, 2017; Kumparak, 2016). These systems have also required that various sensors be placed around established play areas for users to experience the full 6DOF within three-dimensional space. Because of these

requirements, 'traditional VR [has] necessarily [been] bounded and physically demar-
cated' (Saker and Frith, 2019: 10) – and not particularly comfortable (Jenkins, 2019).
Consequently, the phenomenology of VR has been firmly hinged on the separation of the
physical from the digital. By focusing their primary senses on the mediated space of VR,
users are partially able to forget about the physical setting surrounding them. The role of
VR, then, has often been to transport users to a separate virtual environment that fleet-
ingly creates the illusion of difference by removing the visual inclusion of concrete real-
ity. As Manovich (2001) prophesised, 'we are one step away from VR, where physical
space is totally disregarded, and all "real actions" take place in virtual spaces' (p. 114).
The design features of the current generation of VR, however, go some way towards
reshaping this relationship between the physical, the digital and concrete space. Exploring
this development forms the exigency of our article.

Recent wired and wireless systems, such as the Oculus Rift S (released in March
2019) and the Oculus Quest (released in May 2019) differ from older VR systems when
it comes to establishing virtual environments, which is precisely why we have focused
on these headsets. As detailed earlier, both the Oculus Rift S and Oculus Quest enable
users to implement a play space without the need for external sensors, which has long
been a feature of this technology. The Rift S and Quest do this with the assistance of
several wide-angle cameras located on the outside of the headsets. Through the 'Guardian
System', as it is officially termed, users employ their hand controllers to mark out a
physical area that is then tracked within their display. Accordingly, both systems require
an acknowledgement of physical space and are similarly limited by the available space
of users. When a new user places the headset on, they are presented with the message to
draw their boundary. Oculus recommends the boundary be at least $6.5\,\text{ft}^2 \times 6.5\,\text{ft}^2$, which
is a sizable space to carve out in one's living area. Once a play space has been set up,
users are instantly alerted if they come close to breaching this boundary by the visual
inclusion of a red grid. Should this threshold be breached, users' display quickly changes
to a monoscopic and monochrome image of their concrete surroundings, which Oculus
refers to as Passthrough.

To reiterate, while these systems exemplify the current generation of VR, there are
notable differences. The Oculus Quest is the first commercially available VR system that
allows users to experience 6DOF without needing the headset to be connected to a sepa-
rate and powerful personal computer (White, 2019). Consequently, this device can be
played practically anywhere (White, 2019), just as it can be used pretty much straight out
of the box. In contrast, the Rift S needs to be tethered to a Personal Computer that meets
the necessary specifications to run VR applications. This does mean, however, that the
Rift S can support more graphically intensive experiences. Likewise, while Passthrough
is only activated on the Quest when users breach their play space, Rift S users can manu-
ally activate this 'on-demand'. It is our contention that this current generation of VR
implicates a relationship with concrete reality that markedly differs from older under-
standings of the phenomenological experience of VR; understandings that have previ-
ously been contextualised with surrounding notions of virtuality, immersion and
presence, alongside the implicit separation of the physical from the digital. More specifi-
cally, in this article, we suggest that modern VR systems are forging an altered relation-
ship between the physical, the digital and concrete space, through the mediated inclusion

of concrete reality. The work of Saker and Frith (2019) is helpful in beginning to unpack this conceptual shift.

Saker and Frith (2019) examine emerging uses of Mobile Virtual Reality (MVR) systems in outdoor environments. In particular, their analysis focuses on the employment of related headsets (such as the Oculus Go) in public spaces, like a crowded subway on the way to work. Here, the employment of MVR effectively permits users to temporarily remove themselves from their concrete surroundings and inhabit a different, digital domain. It would be wrong, however, to suppose the 'dislocated space' this practice is predicated on is exempt from the effects of concrete reality. As they explain,

> our conceptualization of MVR as dislocated space is not a straightforward return to earlier conceptualizations of mobile media use as 'separate' or 'absent' from the physical. Rather, the shared norms of actual space dislocate the user, but remain a constraint upon actions in the virtual space. (Saker and Frith, 2019: 10)

What changes with the current generation of VR, then, is that recent systems do more than simply implicate physical space in a manner that remains either implicit and outside of the mediated experience or limited in its relational dynamism. Significantly, the MVR Saker and Frith (2019) discuss involved headsets limited to three degrees of freedom (3DOF). Only 'the rotation of the tracked object is being reported to the software, but the position is not' (Pangilinan et al., 2019: 140). In other words, while users might experience the digital simulation of ambulation, actual physical movement beyond the rotation of the headset is not mirrored in the display of their headset. In contrast, the development of 6DOF coupled with the design features of current systems (exemplified by the Guardian System and Passthrough outlined earlier) means that the actual space enveloping the use, and indeed user, of VR is integrated into the digital space of VR in a manner that differs from the spatial practice of MVR. To be clear, these differences equally extend to older forms of tethered VR.

To account for this shift, we introduce the term coextensive space as a useful way of understanding the changing relationship between the physical, digital and concrete reality enacted by current VR systems. Coextensive space describes a symbiotic relationship between physical and digital that is increasingly proximate, extensive and transformative. This relationship is twofold. First, movement within the digital realm of VR is mirrored in the physical, and vice versa, with actual space visually encroaching upon the digital display, should a threshold be reached. Second, concrete reality can be included in the mediated space of VR, either in the form of a relational grid or a monoscopic and monochrome image of the concrete surroundings outside of the headset. An important part of the development of VR, then, is specifically this visualised symbiosis between the physical and digital. The purpose of this assimilation, which moves beyond the contiguous and interstitial, is not so much to deny the concrete setting outside of the system, as might have been the case with older VR, as well earlier forms of MVR predicated on 3DOF, but to incorporate concrete surroundings into the digital site of play. And the development of coextensive space has a number of implications for theorising the phenomenological experience of this technology.

On a macro level, the fluid connection between the physical and the digital can be demonstrated by the various VR experiences (e.g. Zero Latency) that are now available in

many major cities around the world. These experiences (which include zombie out-breaks, escape rooms and space explorations) are often termed location-based VR (Sag, 2019) and commonly offer warehouse-size spaces for small groups of users to play in. As Jenkins (2019: n.p.) explains,

> [these] are brick-and-mortar venues where participants use virtual reality in custom-designed spaces freely moving alongside a small group of fellow participants who appear to each other as avatars when wearing VR headsets manufactured by Oculus, HTC and others.

Importantly, the advancing freedom of VR means that players are not restricted to a limited environment but can physically roam a much broader, coextensive space. Of course, the scope of this extension is further accentuated through the advent of wireless VR systems that allow 6DOF. In the context of location-based VR, then, concrete reality is an integral part of the experience, with progression through certain gamic experience explicitly centred on physical mobility and freedom within three-dimensional space. Here, the gap between actual reality and mediated experiences, which is notably reduced, fractures with the restricted experience of older VR systems.

Similarly, but albeit on a smaller scale, it is also our contention that this shifting relationship between the physical and digital through coextensive space can also be identified within the private sphere. As a result of the physical freedom of current VR systems, multiple play spaces can readily be established in the setting of the home. Users' awareness of their physical environment, therefore, necessarily shifts depending upon what experience they choose. Watching Netflix in a virtual log cabin, for example, might be relaxing, but it is not physically demanding, nor does it necessitate a large play space. In stark contrast, a boxing game like *Thrill of the Fight*, which can be experienced within a 400^2 ft game space, requires a much higher degree of mobility and interaction with the physical surroundings. And the incorporation of concrete space here is more dangerous because of the increased risk users have of accidentally injuring themselves (White, 2019). The developing nature of VR, then, means that users might think more critically about the relationship between their physical setting and the gamic environment. Accordingly, the visual integration of concrete reality through coextensive space is not necessarily actioned to materialise its involvement *per se* but can also be included to limit unwanted physical intrusions (White, 2019). In other words, the establishment of a play space safeguards the digital from unexpectedly assuming a more tangible form.

However, in other instances, the inclusion of concrete reality is not undertaken to limit its impact, but to allow it to seep into the game space of VR. Indeed, another important facet of the transformative potential of coextensive space, and the higher degree of physical freedom it permits is the ability to instigate a different kind of relationship with the social, which has always had a fragmented and tortuous relationship with the virtual, as a result of the solipsistic nature of this technology. The experience of 'being there', which is unique to VR, as explicated earlier, has conventionally implicated a 'being there' that has heavily leaned on the digital side of this partnership and divide. As Saker and Frith (2019) put it, '[corporeality] is not circumvented but rather incorporated into the digital space contained within the headset' (p. 9). Consequently, through the headsets relying on external sensors, users' dominant senses have been siloed into the digital

space of VR, which has meant the social connections outside of headsets have remained on the outside. With coextensive space, this situation changes.

Concrete reality beyond the headset can now be incorporated as a monoscopic and monochrome image displayed within the mediated realm of VR. This is particularly the case with current systems like the Rift S, which allows users to activate the Passthrough mechanism 'on-demand', without physically breaching the established play space. As Oculus (2019) states, 'you'll be able to check your surroundings without removing the headset any time you want'. Through this mechanism users can quickly move between the virtual space of VR and their concrete surroundings without needing to remove their headset. Equally, users can socialise with those outside of the headset, who have been mediated into the digitality of the display. In the context of the Quest, this also means users can navigate beyond their established play space to undertake action in concrete space without needing to leave the virtual realm of VR. While this might sound relatively insignificant and perhaps immaterial, this progression alludes to the developing relationship between the physical and the digital, and the increasing inclusion of concrete reality in the digitality of VR. This is noteworthy given the theoretical understandings of the virtual outlined earlier (Shields, 2003). Furthermore, it is equally plausible that current systems might introduce new VR experiences that are explicitly predicated on the ability of VR to move between these spaces. In the near future, there might be additional opportunities for concrete reality to be more purposely incorporated into the digital world of VR.

In sum, then, coextensive space establishes the conceptual advancement of VR. The visual incorporation of concrete reality within the space of VR effectively transforms the physical setting into a digital representation that is then aesthetically incorporated into the physical–digital assemblage of the technology. Following this inversion, the virtual is not limited to the realm of the real but can also encircle the realm of the actual. This fluidity challenges previous understandings of presence in the context of the virtual (Manovich, 2001), which have conventionally been measured by 'the extent to which one feels present in the mediated environment, rather than in the immediate physical environment' (Biocca and Levy, 2013: 36). With the introduction of recent design features, the separation between 'the mediated environment' and the 'immediate physical environment' is increasingly lessened (Bailenson, 2018). In the context of the current generation of VR, then, concrete reality is no longer a problem to be transcended, but rather blended and traversed within the coextensive space of VR.

Conclusion

VR has long been hyped as the next big thing. Yet, the technology failed to gain widespread acceptance through the 1990s and 2000s, and it was not until the 2014 Oculus Kickstarter campaign and Facebook's later purchase of Oculus that we began to see a possible VR renaissance (Evans, 2018). That renaissance is now in full swing, and the 2019 releases of the Oculus Quest and Rift S may be a watershed moment in the development of the next generation of VR.

This article examined how this new generation of VR may subtly shift the relationship between the body, the digital and physical space. We did so through a concept we termed coextensive space, which captured some of the potentials of the new camera capabilities

of newer VR systems. We argued that coextensive space conceptualises what happens now that the physical and digital are dynamically intertown in new ways that move beyond the contiguous, predicated on the ability of current systems to enact a pseudo-camera view through the VR headset. This subtle shift in how the virtual and physical relate may impact conceptualizations of VR and open up opportunities to blur the physical and digital in novel ways as the technology continues to advance.

At the same time, this concept also resonates with other media technologies that effectively blur the boundaries between the physical and the digital aspects of daily life. This kind of blurring can readily be identified with locative media (Frith and Saker, 2017; Saker and Frith, 2018). And this is, especially, the case with early location-based social networking sites (LBSNs). Though this kind of physical and digital blending has been deftly conceptualised through De Souza e Silva's (2006) seminal notion of 'hybrid space', we would argue coextensive space has the potential to provide a complementary approach to comprehending the nuanced phenomenology underpinning recent hybrid reality games (HRGs), such as Pokémon Go. As surrounding research demonstrates, this HRG can readily impact experiences of place, and reshape concomitant mobilities (Woods, 2019). In the main, these contours coalesce around the augmented reality (AR) functionality of this HRG. As Mäyrä (2017) explains, '[the] "augmented reality" . . . component of *Pokémon GO* relies firstly on the (optional) use of camera and gyroscope that are used to visually overlay available Pokémon to the actual physical surroundings' (p. 2). Because of this, players are visually presented with a coextensive space where the relationship between the physical and digital is similarly proximate, extensive and transformative. Equally, concrete reality is effectively included in the mediated space of Pokémon Go, as it precisely physical space that forms the visual foundation underpinning the digital architecture of the game. While the sensorial implication of HRGs necessarily differs from VR, we would nonetheless suggest that the relationship between the physical and digital aspects of these games coextend in a manner that exceeds the limited experience of early LBSNs. As a corollary, then, coextensive space can be applied to the phenomenology of technologies beyond VR.

In conclusion, for a technology that has only recently begun to be widely adopted, VR has a large body of academic theory that focuses on its impact. This article engaged with that theory, particularly concepts of the virtual, presence and immersion. Part of our argument is that future VR research should both rely upon extant research dating back more than 20 years, while also examining how recent technological shifts may fit within – and sometimes shift – the way we understand VR. This is just one early example of one of those shifts, and with the massive investment from major corporations such as Facebook in the VR space, we can expect to see additional developments in future years that may further implicate the relationship between the virtual and physical. It is, therefore, our intention that this article may serve as a primer for future discussions about this advancing relationship.

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Note

1. It should be noted that this feature is coming to the Quest in early 2020.

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