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ARTICLE

Embodied virtual geographies: Linkages between bodies, spaces, and digital environments

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Abstract

Within an ongoing debate about the relationships between the body and technological experiences within virtual reality (VR), there has hitherto been limited consideration of the spatial. Geographers, meanwhile, have only just begun to engage with VR and its spatialities but have paid less attention to its embodiment. The technology allows users to go beyond merely imagining themselves in a different world, creating a real sense of presence in the digital realm. Immersion and presence in VR are, however, a mix of space, embodiment and the digital. As such, any discussion of VR requires critical consideration of both embodiment and space. This paper therefore explores some of the linkages between bodies, spaces and VR to demonstrate how engagement with VR can enrich geographical scholarship.

KEYWORDS

avatars, digital geography, dislocation, embodiment, space, virtual reality (VR)

1 | INTRODUCTION

Virtual reality (VR) has arguably been an emerging technology for over 40 years (Evans, 2018). Since the commercial launch of Google Cardboard in 2014 and the Oculus Rift in 2016, however, the availability of high quality and inexpensive head mounted displays (HMDs) has led to renewed interest in the research possibilities of VR. Unlike the kinds of digital worlds consumed through a conventional display, such as video games and film, VR gives an illusion of being *present* in an entirely different environment, creating a variety of technologically mediated experiences and encounters.

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When immersed in VR, the user feels as if they have 'gone beyond' their immediate geography to explore diverse digital environments. While the imaginative side of the self is amenable to this dislocation into a digital world, the fleshy body does not transcend—although, as we shall demonstrate, the body is *moved*. In the early literature on VR, however, it was argued that “virtual reality promises a kind of transcendence of the limits of physical reality” (Biocca et al., 1995, p. 6). For these writers, VR epitomised the Cartesian dualism and the dismissal of embodiment (Biocca, 1992; Penny, 1993). Of course, many scholars within and beyond geography have shown that the body is not obsolete in discussions of the digital (Farman, 2020; Hillis, 1999) but that there is potent interlinking between technologies, space, and bodies (Kinsley, 2014; Longhurst, 2013; Rose, 2021). Indeed, across (digital) geography there has been a continued consideration of the “ways in which technical activities convene assemblages of bodies, objects, languages, values and so on and fold them in and out of spatial practice” (Kinsley, 2014, p. 378). So notwithstanding the early neo-Cartesian theorisations and the promise of a transcendence machine, we build upon geographical understandings of space and the body to explore how VR is far from a disembodied experience but a uniquely intense blending of space, the digital, and the body. Thus, we argue that body and space need to be considered together in discussions on VR and explore the linkages between bodies and space in VR experiences.

Since the 're-emergence' of consumer VR from 2014, geographers have had a surprisingly limited engagement with these technologies (Blackman, 2019; Bos, 2021). Nonetheless, there have been thorough and extensive discussions on the spatialities of the digital (Ash et al., 2018; Haefner & Sternberg, 2020; McLean, 2020). Conversely, while media- and game studies scholars have long been theorising and discussing questions of embodiment in VR, they have broadly overlooked the spatialities of the virtual. This paper combines these two disparate bodies of work and explores three linkages between VR space and the body to stress the importance of considering both space and the body when discussing VR. This paper explores three linkages between bodies and space in VR: the embodied feelings of being immersed, the phenomenon of dislocation, and the emotional entanglements between the user's body and avatars.

2 | SPACE, EMBODIMENT AND IMMERSION

Questions of relationship between space and the virtual have animated discussions within geography over several decades now. In the introduction to a special issue examining the virtual, Rob Shields (1999, 3) suggested that “[t]he virtual is real without being actual’ arguing that the reality of the virtual is signalled by the ways in which the virtual has the power to shape society. Those late 1990s discussions of the virtual were taking place at a point where the digital was just starting to touch all aspects of our lives. Two decades later, Ash et al. (2018) could reflect on a mutual co-constitution of space and the digital that is now inescapable. These understandings mirror the theorisations of space in geography as an unbounded, socially linked, always becoming, and heterogeneous (Massey, 2005). This points to the impossibility of separating ‘real’ from ‘virtual’ spaces as they are always enfolded.

For all that we would agree that distinguishing virtual from real spaces is unhelpful, it is important to reflect that different digital technologies produce spaces in different ways. One of the problems with writing about VR is that the hype that surrounds this technology is predicated precisely on the idea that virtual spaces can be understood to be *distinct* from experiences in material environments, for all that geographers might protest that this is an impossibility. The point of VR in its marketing discourse is to be transported somewhere else that only exists in a virtual realm (Egliston & Carter, 2020). Crucial to this is the role of the body and the greater or lesser extent to which it acts *within* virtual space. Virtual reality is thus interesting because it forms a more extreme manifestation of the enmeshing of digital and material worlds that we have previously seen in studies of, for example, locative media (de Souza e Silva & Sutko, 2011; Thielmann, 2010).

While we might agree, in line with Massey, that digital spaces are always-already part of the same space as the material world, the experience of putting a headset on is to suddenly *feel* as though one is in an altogether different space. For the most part, the virtual spaces of VR are designed to reproduce a coordinate-based Cartesian spatial

logic. These Cartesian grids are animated through the body—indeed, it is the body driving the illusion that VR takes us *elsewhere* (Chan, 2014). Hence it is crucial to consider the role of the body in creating the feeling of being in a distinct space. This embodiment of VR space is not ocularcentric, however, with sound and haptic stimuli commonly accompanying the visuals with some VR experiences also adding smell and taste (Lécuyer, 2017). Far from being a smooth, psychologically neutral surface, the spaces of VR are messy, emotional and affectual.

One of the reasons why consumer-facing VR failed in the 1990s was that the technology was simply not ready to deliver embodied immersion at a low-enough price point (Rebenitsch, 2015). Screens with low refresh rates and inadequate movement tracking resulted in nausea because of a mismatch between embodied perception and the digital environments being simulated. By the late noughties there was an appetite in Silicon Valley for revisiting VR, driven by innovations in screen and sensor technology pioneered in smartphones. Thus the 'wow-factor' (Heim, 2017) that so impresses people exposed to VR for the first time suddenly became possible at a consumer price point. A number of technology firms thus began developing headsets, chasing the elusive 'next big thing' driving future profits.

Even with today's much-improved devices, cybersickness can still be a major issue, making VR a physically challenging experience for a significant minority of people (Curry et al., 2020). The fact that the technology has physical effects underpins much of the work undertaken on VR within psychology, which frequently relies on an examination of embodied response. Tech firms themselves are working actively in this area, attempting to reduce ill effects and thus increase user engagement. Conventional physiological measures such as heart rate, electrodermal activation and eye-tracking are widely used in such research (for example, Tabbaa et al., 2021), as are standardised tests such as the Simulator Sickness Questionnaire (Bouchard et al., 2021). Leaving aside such advanced methodologies, even a simple fitness band will show that players of horror games will experience elevated heart rate as their stress levels rise. Contra the neo-Cartesian fantasy of leaving the body behind, therefore, immersion in VR is highly embodied.

This embodiment operates at several levels. Today's VR technology is not akin to the common representations shown in the media (e.g., the Matrix or Avatar) where users were 'plugged-in' and their sensory inputs wholly rewired (Chan, 2014). Instead, VR users must wear a clumsy HMD while their body's physical movements are tracked and replicated in the digital realm. The headset needs to be adjusted to the demands of different bodies—indeed, older models revealed an inherent sexism with designs that assumed a greater distance between the eyes than would be optimal for women whose average head size is smaller than that of men (Stanney et al., 2020). More powerful graphical experiences usually require headsets that are tethered to a computer, giving ample opportunities for tripping up in the real world while walking around 'in' VR. In short, we do not leave our bodies behind in VR; we take them with us, with varying degrees of success.

Nonetheless, VR can generate a convincing sense that the user has been transported elsewhere. The 'place illusion' arises when we believe that we are inside a virtual environment, while the 'plausibility illusion' occurs when we believe that the scenario being depicted is actually taking place (Slater, 2009). The two come together to create an immersive experience when the VR user believes that the scenario is happening to them, even if they know objectively that it is an illusion. This quality can have tremendous power within research. For example, Reger et al. (2011) used VR as part of exposure therapy for veterans suffering from post-traumatic stress disorder. Replicating the embodied feeling of being in a combat space by adding additional sensory stimuli (combining VR with vibration plates and the smell of weapons, fire, and burning bodies) allowed participants to work through their response to extreme trauma.

The degree of *immersion* is a product of the different technologies used to create the illusion of being inside a digital environment. However, a sense of *presence* is more subjective depending on how far the individual accepts the illusion created by the immersive technology (Bowman & McMahan, 2007). Presence is thus not simply about technical quality but has social aspects, where users feel a sense of emotional connection to both the environment and the avatars represented within it (Lombard & Ditton, 1997; Riva et al., 2007). There are also important questions around the individual user's embodied familiarity with the interface through which they interact with the digital space (Verhulst et al., 2018). Loading a virtual gun in the game *Half-Life: Alyx* (Valve, 2020), for example, requires players to undertake a process of clicking controller buttons in a coordinated sequence alongside physically reaching over the shoulder (to collect ammunition from a virtual backpack) and bringing their hands together (to place the new

magazine within the weapon). For experienced players, this becomes a smooth and natural process, which can feel very satisfying. For novices, this process can be challenging, even frightening, especially for a player who is struggling to remember the embodied sequence of actions they need to follow to defend themselves against an antagonist.

Interestingly, one of the primary industrial uses of VR is in training employees to become familiar with particular spaces and routines without the expense (and potential dangers) of training in the physical locations. Power distribution companies in Australia, for example, have built VR simulations of substations and aerial work platforms as part of their 'Safe Approaches Distance' training for new employees (Pordage, 2020). Virtual reality training packages build on the approach that saw the development of flight simulators, which allowed pilots to become familiar with cockpit spaces and controls before they entered a real aircraft. Where flight simulators could cost tens of millions of dollars (Baarspul, 1990), today's VR offers considerably lower costs with significantly increased opportunities to model a variety of different scenarios, from fork-lift training (Lustosa et al., 2018) to practising customer service interactions (Metzger et al., 2017). This flexibility also offers researchers opportunities to look at participant responses to different scenarios and how this reflects or even alters their pre-existing embodied tendencies. Baker et al. (2020), for example, took advantage of room-scale movement tracking within VR to design an experiment where participants were asked to walk across a (virtual) bridge made out of ice blocks. Participants were physically walking across the room whilst seeing and hearing some of the ice blocks cracking as they stepped on them in the digital space. This allowed researchers to test different participants' approaches to risk-taking. There are even opportunities to experiment with using VR to enhance participants' skillsets, such as Repetto et al. (2016) work using VR as a tool to help older people to enhance their memory.

3 | DISLOCATION AND THE BODY

A key appeal of VR technologies is its ability to immerse people in spaces beyond their immediate geography. As a result, VR is increasingly being applied in journalism (Jones, 2017) and especially tourism, where it offers 'try-before-you-buy' experiences (Guttentag, 2010). Virtual reality is used in many aspects of the tourism sector, from planning and management to marketing and education (Guttentag, 2010; Merckx & Nawijn, 2021). Tussyadiah et al. (2018), for example, explored the effectiveness of VR in shaping people's tourist behaviour. In their study, they immersed over 900 participants in either Toyko (Japan), Porto (Portugal), or the Lake District (United Kingdom) and used questionnaires to assess the level of presence, enjoyment in the VR experience, and their intentions to visit the spaces in the future. Their results showed that the feeling of presence in the digital environment stimulated a stronger liking of the physical environment, which, in turn, encouraged the likelihood of future visits. This ability to experience spaces and places anywhere in the world represents a novel embodied and spatial experience; the dislocation of oneself.

Recent discussions in media and communications studies on VR argue that when the user is immersed, they are placed in a dislocated space where "the digital no longer augments the physical, but rather the digital supersedes the physical [and] enacts a more nuanced form of dislocation that more effectively - though never completely effectively - folds the physical into the digital" (Saker & Frith, 2019, p. 225). For example, in their work on the use of VR in art museums, Parker and Saker (2020) explored the lived experience of using VR in a museum. Their findings demonstrate that the social order of space shifted with enhanced anxiety about how one would look in the VR HMD while in a (quasi-)space, such as tripping over or "look[ing] silly" (2020, p. 1165). Similarly, they found a disconnect between those wearing the HMD and those watching since the watchers could not have the same experience simultaneously and thus, altering the social meaning or sense of solidarity in the museum space. Secondly, the attendees could hear and feel other visitors around them and were not entirely cognitively removed from the material space of the museum and therefore linked by the haptic qualities of the space (i.e., a breeze, the feeling of the floor underfoot). Thus, corporeality is not circumvented but instead incorporated into the digital space contained within the headset to the extent that "when a user enters a VR simulation, body boundaries become ambiguous. Body motions affect what happens in the simulation, so that one both is and is not present in the body and in the simulation"

(Hayles, 1996, pp. 12–14). Thus, different degrees of presence in VR becomes a question of a multisensory enfolding of different spatialities and embodiments that are always emerging in the moment.

Beyond the dislocative capabilities of VR, the video games and experiences designed specifically for VR often provide users to go above and beyond their everyday fleshy existence, whether that is fighting aliens in a post-apocalyptic world, shooting zombies, or exploring a character's psyche in an eerie institute (Williams, 2018). The horror genre, across different media, is built upon discomfort and the entanglement of fright and fascination while maintaining a safe distance (Spadoni, 2007). VR's distinct ability to dislocate the user in an otherworldly or horrific scene simulates an ideological presence and absence makes it an effective medium for the horror genre (Pallavicini et al., 2018; Williams, 2021). With the framelessness of VR media, the horror genre is revolutionised, not only by filming techniques and surround sound design, but crucially how the user is no longer a voyeur hidden safely behind the screen; now, the user is stalked (Staubli, 2017). There is no escape for the user; they are part of and trapped in the horror, yet aware that it is not real. Not only does this 'horrific' dislocation of the self-lead to a variety of embodied responses, but it epitomises the possible emotional and affectual effects of the body's dislocation: it can be confusing and anxiety-inducing (Parker & Saker, 2020) and frightening (Williams, 2021), but also extends experiences beyond one's immediate geography (Tussyadiah et al., 2018). Crucially, and despite the realism of or immersive qualities of the VR experience, the user is always between here and there when in VR; the digital space is enfolded into the physical space, and the user cannot be disconnected from their body and immediate surroundings.

4 | EMBODYING AVATARS

When immersed in a VR environment, the user can have interactive agency through an avatar: a digital alter-ego that is an embodied and tangible representation. The avatar is usually designed for VR games, but users can create their own digital body in some platforms. Beyond being an embodied representation of the user, avatars have the potential to transcend flesh and bone and intellectual disembodiment (Featherstone & Burrows, 1996). Yet, the immersion in, and representation of, the body cannot be removed from the contexts of the user since these technologies are "crucial tools for recrafting our bodies [and] instruments for enforcing meaning" (Haraway, 1991, p. 161). There is a reciprocal flow between the fleshy and virtual bodies, wherein the user shapes the avatar, and the avatar can shape the user.

Avatars in VR environments allow for new understandings of social dynamics in virtual environments encompassing self-presentation or performance and embodied interactions through the digital (Freeman et al., 2020; Schroeder, 2012). Although it is common for the avatars to be pre-designed in VR games, in many SocialVR platforms, avatars are digital bodies that represent an online user's physical self through the conscious crafting and personalisation of this virtual (second) self (Schroeder, 2012). For example, in her auto-ethnographic work in the VR Church community, Keen constructed her AltSpaceVR avatar to personify her identity (as a young white woman). Like Keen, there were members of the congregation whose avatars matched their physical appearance and those who chose to construct their own visual identities, thus enabling a sense of anonymity in the virtual space (Jones & Osborne, 2022). Therefore, avatars are a crucial communicative and performative actor for the self in virtual worlds; they are a digital representation of the self and social values (Nowak & Rauh, 2006) but also afford the capacity for experimentation with new identities or reaffirmation of existing identities (e.g., queering avatars) (Ruberg & Shaw, 2017). Yet, just like the intertwining of the spatial 'here and there', our offline identities, body, and social contexts blend with our online selves and performances (Eklund, 2011; Ruberg & Shaw, 2017). Through this blending of selves and ascribing personalities, intentions and style to the avatar, there is an affective flow between the user and the avatar (Wilde, 2018) whereby the user cares for, protects and worries about their virtual self (Schroeder, 2012) to the extent that it can lead to negative feelings if one's avatar is subject to harm or dies (Wolfendale, 2007).

Beyond creating a digital representation of our own identities, VR also has the curious capacity to inhabit bodies different from our own, inducing psycho- and physiological effects. In the late 1980s, a group from 'VPL Research'

began to explore how VR users responded to controlling avatars radically different from the human body (such as a lobster body). From their explorations, they found that:

“people could quickly learn to inhabit strange and different bodies and still interact with the virtual world. I became curious about how weird the body could get before the mind would become disoriented. I played around with elongated limb segments and strange limb placements” (Lanier, 2010, p. 186).

This ability to adapt to unfamiliar (physical) bodies in VR is termed ‘homuncular flexibility’ and is a testament to neural plasticity and the flexibility of embodiment (Won et al., 2015). While this work could be of interest for geographers as a means for encouraging greater understanding of more-than-human bodies, social scientists need to embrace homuncular flexibility in their considerations of VR because the concept facilitates a “greater control of space in mediated environments, allow users to organize information more efficiently, and use more of their body to navigate virtual worlds” (Won et al., 2015, p. 255). Crucially, the form of the avatar body, whether humanoid or not, shapes how the user responds to the virtual space they are immersed in.

Whilst the user has the freedom and capacity to immerse themselves in a purposely designed virtual body, it is important to stress that this ‘body transfer’ (Slater et al., 2010) can impact the perception, attitudes, and behaviour of the user. This is known as the ‘*proteus effect*’, wherein avatar’s appearances influence the users’ social behaviours in the virtual environment. For example, Yee and Bailenson (2007), in their experiments on how people act using avatars with different heights and levels of attractiveness, found that their participants who embodied attractive avatars were more willing to approach strangers, and those with taller avatars were more confident when during a negotiation task. Yet more recent research has explored the *proteus effect* beyond the virtual world and explored to what extent the behavioural changes transfer into real life. Fox et al. (2013) found that avatar attire can shape user’s opinions on rape myth acceptance and body-related thoughts, and it has also been shown that avatar skin colour has demonstrated the potential to both increase (Groom et al., 2009) and decrease (Peck et al., 2013) implicit racial bias. Indeed, numerous VR films and experiences have been developed in recent years to tell people’s stories and encourage empathy from those immersed, such as *Travelling While Black* (Williams, 2019) and the Oscar-winning *Carne y Arena* (Iñárritu, 2017). And whilst *Travelling While Black* and *Carne y Arena* are VR films and do not use avatars, they still demonstrate the empathetic potential of VR by immersing users in the experiences, spaces, and the virtual body of another and the blurring of physical and virtual bodies and spaces.

5 | CONCLUSION

A great deal of scholarly activity, not least in digital geography, has gone into exploring the ways in which digital and material spaces are entwined (Ash et al., 2018; Kinsley, 2014). We have argued here that VR is interesting because while in some ways it epitomises this entwining, the *experience* of VR is an illusion of leaving a material space and entering an entirely *separate* digital space. Because the material cannot be left behind entirely, however, the user feels elements of the material world *intruding* into a digital space. That intrusion is understood and mediated through the body.

Virtual reality thus has qualities that make it incredibly valuable for researchers. Theoretically, VR allows us to move beyond now glib phrases about the inseparability of material and digital, to start thinking about how different technologies are being constructed to blur that boundary in quite disturbing ways. In the case of VR, its promoters are actively framing it as a means of severing a sense of connection to material space—instead, we should spend our time in a digital ‘metaverse’ that is entirely controlled and curated by tech companies. The future being imagined is one in which leisure, play and work should all take place in clear view of the all-seeing corporate eye. This is more than simply a case of the digital *mediating* space as we have seen with locative technologies; with VR, we see a transparent

attempt to *dominate* space. There is thus a key role for researchers here in looking at the kinds of discourses that are being embedded into VR experiences, to understand and critique how this remaking of space is being operationalised.

Messy, multisensory embodiment currently acts as a barrier to this terrifying corporate fantasy: the voices of people in the museum that break the illusion of being alone inside a digital exhibit; the limited haptic stimuli that are an inadequate substitute for touch; and, of course, the headache and nausea that many feel when wearing a headset for an extended period. There is much ethnographic work for geographers in exploring the ways in which bodies interact with the spaces of VR to create a unique set of experiences for its users. We have written elsewhere (Jones & Osborne, 2022) about the kinds of methodologies that scholars can use to critically examine the spaces of VR as well as using VR as an approach to gathering new kinds of data about the experiences people have within it. Geographers are well placed to add to the critical discussions on VR, not only through our extensive theorisations of the digital (Ash et al., 2018; Haefner & Sternberg, 2020; McLean, 2020) but also through the discipline's detailed consideration of embodiment, affect, and identity. For example, geographers could bring nuances to notions of place in these virtual worlds, add to the discussions on social VR, and use VR in as a method to expand existing research. Virtual reality has lots of methodological and epistemological promise for the discipline, yet we have shown how a reflection upon both space and the body is paramount in work on VR.

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REFERENCES

- Ash, J., Kitchin, R., & Leszczynski, A. (2018). Digital turn, digital geographies? *Progress in Human Geography*, 42(1), 25–43. <https://doi.org/10.1177/0309132516664800>
- Baarspul, M. (1990). A review of flight simulation techniques. *Progress in Aerospace Sciences*, 27(1), 1–120. [https://doi.org/10.1016/0376-0421\(90\)90006-6](https://doi.org/10.1016/0376-0421(90)90006-6)
- Baker, C., Pawling, R., & Faircough, S. (2020). Assessment of threat and negativity bias in virtual reality. *Scientific Reports*, 10(1), 17338. <https://doi.org/10.1038/s41598-020-74421-1>
- Biocca, F. (1992). Virtual reality technology: A tutorial. *Journal of Communication*, 42(4), 23–72. <https://doi.org/10.1111/j.1460-2466.1992.tb00811.x>
- Biocca, F., Kim, T., & Levy, M. R. (1995). The vision of virtual reality. In F. Biocca & M. R. Levy (Eds.), *Communication in the age of virtual reality* (pp. 3–14). Lawrence Erlbaum Associates.
- Blackman, T. (2019). *Digital worlds: Performativity and immersion*. VR Videogames University of Victoria.
- Bos, D. (2021). *Geography and virtual reality*. Geography Compass.
- Bouchard, S., Berthiaume, M., Robillard, G., Forget, H., Daudelin-Peltier, C., Renaud, P., Blais, C., & Fiset, D. (2021). Arguing in favor of revising the simulator sickness questionnaire factor structure when assessing side effects induced by immersions in virtual reality. *Frontiers in Psychiatry*, 12. <https://doi.org/10.3389/fpsy.2021.739742>
- Bowman, D. A., & McMahan, R. P. (2007). Virtual reality: How much immersion is enough? *Computer*, 40(7), 36–43. <https://doi.org/10.1109/mc.2007.257>
- Chan, M. (2014). *Virtual reality: Representations in contemporary media*. Bloomsbury.
- Curry, C., Li, R., Peterson, N., & Stoffregen, T. A. (2020). Cybersickness in virtual reality head-mounted displays: Examining the influence of sex differences and vehicle control. *International Journal of Human-Computer Interaction*, 36(12), 1161–1167. <https://doi.org/10.1080/10447318.2020.1726108>
- de Souza e Silva, A., & Sutko, D. M. (2011). Theorizing locative technologies through philosophies of the virtual. *Communication Theory*, 21(1), 23–42. <https://doi.org/10.1111/j.1468-2885.2010.01374.x>
- Egliston, B., & Carter, M. (2020). Oculus imaginaries: The promises and perils of facebook's virtual reality. *New Media & Society*, 24(1), 70–89. <https://doi.org/10.1177/1461444820960411>

- Eklund, L. (2011). Doing gender in cyberspace: The performance of gender by female World of Warcraft players. *Convergence*, 17(3), 323–342. <https://doi.org/10.1177/1354856511406472>
- Evans, L. (2018). *The Re-emergence of virtual reality*. Routledge.
- Farman, J. (2020). *Mobile interface theory: Embodied space and locative media*. Routledge.
- Featherstone, M., & Burrows, R. (1996). *Cyberspace/Cyberbodies/Cyberpunk: Cultures of technological embodiment*. SAGE.
- Fox, J., Bailenson, J. N., & Tricase, L. (2013). The embodiment of sexualized virtual selves: The Proteus effect and experiences of self-objectification via avatars. *Computers in Human Behavior*, 29(3), 930–938. <https://doi.org/10.1016/j.chb.2012.12.027>
- Freeman, G., Zamanifard, S., Maloney, D., & Adkins, A. (2020). *My body, my avatar: How people perceive their avatars in social virtual reality*. Extended Abstracts of the 2020 CHI Conference on Human Factors in Computing Systems. Honolulu HI.
- Groom, V., Bailenson, J. N., & Nass, C. (2009). The influence of racial embodiment on racial bias in immersive virtual environments. *Social Influence*, 4(3), 231–248. <https://doi.org/10.1080/15534510802643750>
- Guttentag, D. A. (2010). Virtual reality: Applications and implications for tourism. *Tourism Management*, 31(5), 637–651. <https://doi.org/10.1016/j.tourman.2009.07.003>
- Haefner, L., & Sternberg, R. (2020). Spatial implications of digitization: State of the field and research agenda. *Geography Compass*, 14(12). <https://doi.org/10.1111/gec3.12544>
- Haraway, D. (1991). *A cyborg manifesto: Science, technology, and socialist-feminism in the late twentieth century* (pp. 149–182). Routledge.
- Hayles, N. K. (1996). Embodied virtuality: Or how to put bodies back into the picture. In M. A. Moser & D. MacLeod (Eds.), *Immersed in technology: Art and virtual environments* (pp. 1–28). MIT press.
- Heim, M. R. (2017). Virtual reality wave 3. In J. Gackenbach & J. Bown (Eds.), *Boundaries of self and reality online* (pp. 261–277). Academic Press.
- Hillis, K. (1999). *Digital sensations: Space, identity, and embodiment in virtual reality*. University of Minnesota Press.
- Iñárritu, A. G. (2017). *Carne y Arena (Virtually present, Physically invisible) [virtual reality]*. In M. Parent (Ed.), *Fondazione Prada & Legendary Entertainment*.
- Jones, P., & Osborne, T. (2022). *Virtual reality methods: A guide for researchers in the social Sciences and humanities*. Policy Press.
- Jones, S. (2017). Disrupting the narrative: Immersive journalism in virtual reality. *Journal of Media Practice*, 18(2–3), 171–185. <https://doi.org/10.1080/14682753.2017.1374677>
- Kinsley, S. (2014). The matter of 'virtual' geographies. *Progress in Human Geography*, 38(3), 364–384. <https://doi.org/10.1177/0309132513506270>
- Lanier, J. (2010). *You are not a gadget*. Alfred Knopf.
- Lécuyer, A. (2017). Playing with senses in VR: Alternate perceptions combining vision and touch. *IEEE Computer Graphics and Applications*, 37(1), 20–26. <https://doi.org/10.1109/mcg.2017.14>
- Lombard, M., & Ditton, T. (1997). At the heart of it all: The concept of presence. *Journal of Computer-Mediated Communication*, 3(2), JCMC32. <https://doi.org/10.1111/j.1083-6101.1997.tb00072.x>
- Longhurst, R. (2013). Using skype to mother: Bodies, emotions, visibility, and screens. *Environment and Planning D: Society and Space*, 31(4), 664–679. <https://doi.org/10.1068/d20111>
- Lustosa, E., de Macedo, D., & Formico Rodrigues, M. (2018). *Virtual simulator for forklift training 20th symposium on virtual and augmented reality*.
- Massey, D. (2005). *For space*. SAGE.
- McLean, J. (2020). *Changing digital geographies*. Palgrave Macmillan.
- Merkx, C., & Nawijn, J. (2021). Virtual reality tourism experiences: Addiction and isolation. *Tourism Management*, 87, 104394. <https://doi.org/10.1016/j.tourman.2021.104394>
- Metzger, D., Niemöller, C., Wingert, B., Schultze, T., Bues, M., & Thomas, O. (2017). *How machines are serviced - design of a virtual reality-based training system for technical customer services* Proceedings der 13. Internationalen Tagung Wirtschaftsinformatik.
- Nowak, K. L., & Rauh, C. (2006). The influence of the avatar on online perceptions of anthropomorphism, androgyny, credibility, homophily, and attraction. *Journal of Computer-Mediated Communication*, 11(1), 153–178. <https://doi.org/10.1111/j.1083-6101.2006.tb00308.x>
- Pallavicini, F., Ferrari, A., Pepe, A., Garcea, G., Zanacchi, A., & Mantovani, F. (2018). Effectiveness of virtual reality survival horror games for the emotional elicitation: Preliminary insights using resident evil 7: Biohazard. In: M. Antona & C. Stephanidis (Eds.), *International Conference on Universal Access in Human-Computer Interaction* (pp. 87–101). Springer.
- Parker, E., & Saker, M. (2020). Art museums and the incorporation of virtual reality: Examining the impact of VR on spatial and social norms. *Convergence*, 26(5–6), 1159–1173. <https://doi.org/10.1177/1354856519897251>
- Peck, T. C., Seinfeld, S., Aglioti, S., & Slater, M. (2013). Putting yourself in the skin of a black avatar reduces implicit racial bias. *Consciousness and Cognition*, 22(3), 779–787. <https://doi.org/10.1016/j.concog.2013.04.016>
- Penny, S. (1993). Virtual bodybuilding. *Media International Australia*, 69(1), 17–22. <https://doi.org/10.1177/1329878x9306900105>

- Portage, C. (2020). *Energy powerhouse turns to virtual reality*. Retrieved from <https://utilitymagazine.com.au/energy-powerhouse-turns-to-virtual-reality/>. accessed 8 April 2022.
- Rebenitsch, L. (2015). Managing cybersickness in virtual reality. *XRDS: Crossroads, The ACM Magazine for Students*, 22(1), 46–51. <https://doi.org/10.1145/2810054>
- Reger, G., Holloway, K., Candy, C., Rothbaum, B., Difede, J., Rizzo, A., & Gahm, G. (2011). Effectiveness of virtual reality exposure therapy for active duty soldiers in a military mental health clinic. *Journal of Traumatic Stress*, 24(1), 93–96. <https://doi.org/10.1002/jts.20574>
- Repetto, C., Serino, S., Macedonia, M., & Riva, G. (2016). Virtual Reality as an embodied tool to enhance episodic memory in elderly. *Frontiers in Psychology*, 7(1839). <https://doi.org/10.3389/fpsyg.2016.01839>
- Riva, G., Mancuso, S., Capideville, C. S., Preziosa, A., Morganti, F., Villani, D., Gaggioli, A., Botella, C., & Alcaniz, M. (2007). Affective interactions using virtual reality: The link between presence and emotions. *CyberPsychology and Behavior*, 10(1), 45–56. <https://doi.org/10.1089/cpb.2006.9993>
- Rose, G. (2021). Representational and animatic corporeality: Refiguring bodies and digitally mediated cities. In A. Milion, C. Haid, I. C. Ulloa & N. Baur (Eds.), *Spatial transformations: Kaleidoscopic perspectives on the refiguration of spaces* (pp. 204–215). Routledge.
- Ruberg, B., & Shaw, A. (2017). *Queer game studies*. University of Minnesota Press.
- Saker, M., & Frith, J. (2019). From hybrid space to dislocated space: Mobile virtual reality and a third stage of mobile media theory. *New Media & Society*, 21(1), 214–228. <https://doi.org/10.1177/1461444818792407>
- Schroeder, R. (2012). *The social life of avatars: Presence and interaction in shared virtual environments*. Springer Science & Business Media.
- Slater, M. (2009). Place illusion and plausibility can lead to realistic behaviour in immersive virtual environments. *Philosophical Transactions of the Royal Society B: Biological Sciences*, 364(1535), 3549–3557. <https://doi.org/10.1098/rstb.2009.0138>
- Slater, M., Spanlang, B., Sanchez-Vives, M., & Blanke, O. (2010). First person experience of body transfer in virtual reality. *PLoS One*, 5(5), 10564. <https://doi.org/10.1371/journal.pone.0010564>
- Spadoni, R. (2007). *Uncanny bodies: The coming of sound film and the origins of the horror genre*. University of California Press.
- Stanney, K., Fidopiastis, C., & Foster, L. (2020). Virtual reality is sexist: But it does not have to be. *Frontiers in Robotics and AI*, 7(4). <https://doi.org/10.3389/frobt.2020.00004>
- Staubli, M. (2017). VR unleashes new dimensions of horror. *Frames Cinema Journal*, 11.
- Tabbaa, L., Searle, R., Bafti, S. M., Hossain, M. M., Intarasisrisawat, J., Glancy, M., & Ang, C. S. (2021). VREED: Virtual Reality Emotion Recognition Dataset using eye tracking & physiological measures. *Proceedings of the ACM on Interactive, Mobile, Wearable and Ubiquitous Technologies*, 5(4), 1–20. <https://doi.org/10.1145/3495002>
- Thielmann, T. (2010). Locative media and mediated localities. *Aether: The Journal of Media Geography*, 5(1), 1–17.
- Tussyadih, I., Dan, W., Jung, T., & Dieck, M. C. T. (2018). Virtual reality, presence, and attitude change: Empirical evidence from tourism. *Tourism Management*, 66, 140–154. <https://doi.org/10.1016/j.tourman.2017.12.003>
- Valve. (2020). *Half-Life: Alyx*. Bellevue WA. Valve Corporation.
- Verhulst, E., Banville, F., Richard, P., & Allain, P. (2018). Interaction techniques and pointing task: A preliminary analysis to understand how to characterize the user abilities in virtual environment. In S. Yamamoto & H. Mori (Eds.), *Human interface and the management of information. Information in applications and services* (pp. 217–227). Springer International Publishing.
- Wilde, P. (2018). Avatar affectivity and affection. *Transformations*, 31, 25–34.
- Williams, R. R. (2019). *Traveling while black* [virtual reality]. In A. Nadarajah, J. Robinson & L. Srivastava (Eds.). Felix & Paul Studios.
- Williams, V. R. (2018). Frameless fictions: Exploring the compatibility of virtual reality and the horror genre. *Refractory*, 30.
- Williams, V. R. (2021). *Frameless fictions: Embodiment, affect and unruly encounters in VR and virtual environments*. University of Birmingham.
- Wolfendale, J. (2007). My avatar, my self: Virtual harm and attachment. *Ethics and Information Technology*, 9(2), 111–119. <https://doi.org/10.1007/s10676-006-9125-z>
- Won, A. S., Bailenson, J. N., & Lanier, J. (2015). Homuncular flexibility: The human ability to inhabit nonhuman avatars. In R. Scott & S. Kosslyn (Eds.), *Emerging trends in the social and behavioral Sciences*. <https://doi.org/10.1002/9781118900772>
- Yee, N., & Bailenson, J. N. (2007). The Proteus effect: The effect of transformed self-representation on behavior. *Human Communication Research*, 33(3), 271–290. <https://doi.org/10.1111/j.1468-2958.2007.00299.x>

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