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Popat, SH orcid.org/0000-0001-9864-5496 (2017) *Virtually Touching: Embodied engagement in telematic and virtual reality performance*. In: Butterworth, J and Wildschut, L, (eds.) *Contemporary Choreography: A Critical Reader*. Routledge .

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<https://www.routledge.com/Contemporary-Choreography-A-Critical-Reader-2nd-Edition/Butterworth-Wildschut/p/book/9781138679986>.

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Virtually Touching: Embodied engagement in telematic and virtual reality performance

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Published in Jo Butterworth and Liesbeth Wildschut (eds.) *Contemporary Choreography: A Critical Reader* (2nd edition), Routledge, 2017.

My research into digital dance and performance over more than twenty years stems primarily from my love of movement. In the mid-1990s, I suffered a back injury whilst studying for a Dance degree. I could not take technique classes, so instead I spent time in the library discovering a new medium called the Internet. I was intrigued by the amount of dance-related works appearing in digital formats at this time (see Dixon 2007), given the apparent disembodiment of remote communications technologies. To misquote artist Roy Ascott's seminal 1990 essay, could there be love in the telematic embrace? Initially I was sceptical, but over time I saw and experienced more and more performance works which convinced me that virtual touch was more than mere illusion. In this chapter, I recall three of these performances in which touch between remotely-located performers and/or participants played a key part; *Telematic Dreaming* by Paul Sermon (1994), *Escape Velocity* by Company in Space (1999) and *Unheimlich* by Steve Dixon, Paul Sermon, Andrea Zapp and Matthias Fuchs (2005). I will explore why people often try to touch each other and objects around them in virtual and telematic environments, where touch in any physical form is obviously impossible. My argument draws upon understandings of the body through proprioception, somatics and movement memory to explain how the act of reaching out to touch enables us to experience presence in telematic and virtual reality environments. The discussion will be expanded through an account of my experience of Gibson/Martelli's *White Island* (2014), in which an Oculus Rift¹ head-mounted display unit places the viewer/participant in a virtual reality hot air balloon drifting over an Arctic landscape amongst icy cliffs. I will conclude by considering the importance of dance and embodied knowledge to the future design and analysis of virtual worlds.

A short history of virtual touch in three telematic performances

One of my earliest influences in dance and technology research was Susan Kozel's 1994 essay in *Dance Theatre Journal* titled 'Spacemaking: Experiences of a Virtual Body' (see Kozel 2007: 92-102). In this essay she described her experiences of performing in Paul

¹ For more information about Oculus Rift, see <https://www.oculus.com/en-us/rift/> (accessed 23 February 2016). Oculus Rift is one of a number of new virtual reality head-mounted display units in development, including HTC Vive, Samsung Gear VR and Sony Playstation VR.

Sermon's *Telematic Dreaming* earlier that year in Finland. In the 1994 version, *Telematic Dreaming* was an installation involving two beds, one in a gallery with the public passing through it, and one in a separate location. Kozel performed on the bed in the separate location (let us call it Bed A), which was covered with a blue-screen sheet. A camera directly above Bed A sent its video feed to a projector directly above the bed in the gallery (Bed B), so that Kozel's image was projected down onto Bed B, where it could be seen by people passing through the gallery. People could sit or climb onto the bed, attempt to touch fingers with Kozel via her image, or play and move with her image as she moved. Video cameras picked up the combined image of Kozel and the gallery visitors together on Bed B, and fed it to monitor screens positioned around both Bed B and Bed A. This enabled Kozel and the visitors to see themselves together in the virtual space represented on the monitors.

From the description, *Telematic Dreaming* might sound like a primarily visual experience, since everything is mediated via cameras and screens. Even Bed B in the gallery acts as a screen for the projection of Kozel's image. Yet Kozel's writing takes a phenomenological perspective to tell a different story. She wrote about the intensity of her embodied experience of being on the bed with the other participants – of her virtual lover, who moved with her and came back to place a red rose on the pillow of Bed B next to her virtual head; of the person who elbowed her image in the stomach, causing her to fold up as if physically hit (2007: 97). I was also struck by the description of how Kozel moved her hand to touch the hand of a participant that was resting upon her own virtual thigh, and she was surprised when her hand bumped into the bulk of her physical leg (100). Paul Sermon has created several other installations using similar techniques. He talks about 'touching with my eyes' in telematic work. The image of one's body acts as an extension into a virtual space, where it enables a visually constructed, haptic connection with other people and objects (see Dinkla and Leeker 2002). The level of embodied engagement described by Kozel demonstrated a strong connection between her physical and virtual bodies, and between her own body and those of the other participants.

Fast-forward to 1999 and the third International Dance and Technology conference (IDAT) at Arizona State University. I was in the audience of Company in Space's performance of *Escape Velocity*. We were in a white box studio in Tempe, Arizona, USA, facing towards a stage space where dancer Hellen Sky was performing. Another dancer, Louise Taube, was in Melbourne, Australia in a similar studio arrangement. Both dancers had shaved heads and they were dressed in similar clothes. Each dancer was accompanied by a camera operator, who was also effectively a performer. The camera operators moved around the dancers, recording video sometimes at a distance and sometimes tightly close up. The video feeds

from the two cameras were sent directly to a vision-mixing desk where a video artist mixed them together with background graphics. The combined video of both dancers was projected onto the back walls of each stage space. Thus each audience could see their 'local' dancer and camera operator on the stage, and behind them the video of both dancers performing together in virtual space. At one point, the dancers each made their way over to the white wall of their individual studios, and the camera operators recorded close up shots of them rubbing their heads tenderly against the walls. The video artist mixed the two video feeds so that the dancers appeared to be gently rubbing their shaved heads against each other. The dancers turned to watch the combined image projected at the back of each stage, each caressing the wall but seeing themselves caressing each others' heads. The deep sensuality, tenderness and intimacy of the connection between the two dancers belied the distance between them, literally half a world apart. This moment remained with me and other members of the audience, cementing my feeling that there was something more than the virtual illusion in that connection.

Forward again to 2005, when Steve Dixon, Paul Sermon, Mathias Fuchs and Andrea Zapp collaborated on *Unheimlich*. In this performance, two actors in a blue-screen studio in Manchester, UK interacted with an audience in USA to create an improvised performance. The video feed of the two actors in Manchester was mixed with the video feed of the stage in the USA, together with background images and graphics. This combined image was projected into both the Manchester studio and the USA stage space. Audience members could get up onto the stage and perform alongside the two actors, who were playing mischievous sisters whose parents had gone out for the evening. They could see the combined image and respond accordingly.² This improvised participatory performance is the first of my three examples in which audio was included, so the participants and actors could speak to each other as well as seeing their images together. Yet despite this option to talk and negotiate the space verbally, *Unheimlich* showed clearly how touch was both encouraged and desired. There were repeated examples of the participants and the actors attempting to touch, stroke, put an arm around, help up from the floor – many different little forms of physical contact, impossible to achieve physically when the participants and the actors were continents apart. Yet somehow it was an important part of the process of working together in that virtual space.

Virtually Touching

In 2008, Steve Dixon gave a speech in the historic Hellerau theatre in which he observed that people in telematic spaces will often attempt to touch each other more quickly and intimately

² *Unheimlich* movie documentation is available at <http://www.paulsermon.org/unheimlich/downloads.htm> (accessed 23rd February 2016)

than they would do normally in physical space. In telematics, the avatar is usually a direct visual representation of the participant, so on the screen I see the image of my own body reaching out towards the image of someone else's body. If the image of my body touches the image of the other person then we appear to make contact in that virtual space, even though we might be many miles distant from each other in the physical world, as in the case of Hellen Sky and Louise Taube in *Escape Velocity*. The fact that one cannot make physical contact with the flesh of the other person seems to suspend some of the social prohibitions associated with touching the bodies of relative strangers in Western cultures. Instead virtual reality allows, or even invites, experimentation with the culturally prohibited or 'un-doable', as 'real' world norms and rules seem less relevant.

Critically, the un-doable remains un-doable. You can try to touch the other person without the usual social consequences, because you both know that the touch will not occur in a physical sense, even if you both enact touching and being touched. So cultural norms can be safely suspended by agreement between participants. Such agreement is usually tacit in nature but managed through physical negotiation. Kozel explained in her article on *Telematic Dreaming* that interactions with participants tended to start as tentative fingertip-touching or other small contact-making, in order to establish the boundaries of touch and interaction in this context (2007: 93-4). In *Unheimlich*, the move to more intimate touching was generally much faster because the context was more clearly established by the theatrical framing of the performance. This negotiation of touch enables an intriguing playfulness by allowing the disruption of social norms, but it is also critical to the fundamental experience of the body's presence in the virtual world. By attempting to touch others and by seeing that touch received, a form of 'togetherness' is both perceived and acknowledged. I experience being in this virtual space with you because you acknowledge my touch as having validity, having a level of 'reality' in your experience, even though neither of us can feel it physically. Our mutual agreement to touch enables us to be present together.

Yet, as I mentioned earlier, there was more here than simply the illusion of touch. These telematic performances offered the affordance to experiment with the *doing of action*. Whilst the act itself could not be completed (i.e. we could not touch the flesh of the virtual other) the doing of that action drew upon embodied memories of the physical acts of moving and touching to inform the virtual experience. This led to some of the physical anticipation of the culmination of the act, as if a shadow of the act itself. So those cultural norms cannot be quite suspended, because the individual is engaged in the embodied experience of doing the action. Kozel explains:

digitally mediated communications can be construed as *processes* of connecting, *intents* to achieve proximity, and *attempts* at touching, rather than the accomplished states of communication, proximity and touch”. (2007: 141-2, my emphasis)

Those processes, intents and attempts contain the intention and the anticipation that are the precursors to the accomplished states, but in which the body is still implicated physically.

Talking about the physical world, Anne Cranny-Francis (2013: 20) explains how “uninvited or unexpected touch may be regarded as crude, ill-mannered, presumptuous or even criminal”. Touch that is unintentional, for example in a crowded train, is often followed by an apology or ignored as if it had not occurred. Connection and touch are inseparable for Cranny-Francis:

One cannot *not* touch, so one is always connected to the world – to other people, species, objects, phenomena.” (2013: 20, my emphasis)

So for example my hands touch the keyboard as I type these words, while my body is in contact with the chair in which I sit and my feet rest upon the carpet. Yet in a virtual environment, one *cannot touch* the virtual objects, people and phenomena, although one can touch one’s own body and the physical objects around it (which may or may not be visible, for example if you are using a head-mounted display unit). So the touch-connection is a constant factor in the physical or material world but it is missing from the virtual world, leaving us adrift in a visually prioritized existence that apparently highlights the separation of our bodies from that which we see. This explains the significance and urgency of the reach, as you and I in our telematic environment enact touching and being touched as part of the process of constituting our presence together in that virtual space, connecting our physicality to the virtual through the doing of actions.

White Island

So far I have discussed performances in which performers, or performers and participants, have used touch to connect with other people in virtual spaces. There is a strong sense that connection between individuals can be achieved because both individuals enact the touch, i.e. touch is both extended and received through mutual agreement. Yet Cranny-Francis explained that not only are we physically connected to other people, we are also in constant physical contact with the world. I am going to draw now upon an installation titled *White Island* by

Gibson / Martelli³, in order to discuss in more detail how proprioception, corporeal understandings of space and embodied knowledge come into play in touch within virtual reality.

Ruth Gibson is a dancer specializing in Skinner Releasing Technique and Bruno Martelli is a digital artist and computer programmer, and they collaborate with other artists on a project-by-project basis. *White Island* is an installation within their *80°N* exhibition of 2014. It incorporates an Oculus Rift virtual reality head-mounted display unit to take the participant on a journey in a hot air balloon over the Arctic Circle. It was inspired by the doomed Arctic exploration trip led by Solomon August Andrée in 1897. Andrée and two fellow explorers attempted to navigate a specially designed balloon over the ice to the North Pole, but misfortune resulted in a crash and the loss of the lives of all three explorers. Their story was discovered in 1930 when their bodies were found on Kvitøya (White Island), preserved by the cold, along with expedition documentation in the form of diaries and photographs.

In *White Island*, the participant enters a virtual world in which he or she is suspended in a hot air balloon basket over the vast Arctic landscape, driven and buffeted by gales and snowstorms. The installation comprises a thick, rough rope stretched vertically floor to low ceiling, attached at the base to a stage weight and at the top to a metal rig. Next to the rope, an Oculus Rift headset dangles by a wire from the overhead rig. Experiencing this installation at the Coleman Project Space, London in June 2014, I put on the headset and found myself in a hot air balloon, floating over a snowy landscape. Snowflakes were blowing past as I hung suspended in the dark basket, just big enough for one person, with the handrail encircling me at waist-height. Looking upwards, I saw a large black hot air balloon with dark wing-like sails jutting out of either side. There were black ropes running vertically between the basket and the balloon. My hand gripped the physical rope, which helped me to balance as I looked around. Below the basket were white hillsides, glaciers and valleys, with occasional dark rivers snaking their way along the clefts. The howling wind was suggested in the low sound track played into the room and in the horizontal snowflakes flying past my face. The basket travelled with some speed in a relentless motion that could sometimes change quite suddenly with the vagaries of the wind. I tugged and hauled on the physical rope to go upwards and downwards, lifting the basket so that it scraped over hills and dropping down into vales.

The three-dimensional virtual reality of the Oculus Rift headset immersed me in the experience as I turned and saw the world all around me and looked up at the balloon. Slight

³ See <http://gibsonmartelli.com/WhiteIsland.html> (accessed 23 February 2016)

disorientation occurred when I glanced towards the places where I could feel my hand on the rope and my feet on the floor but I saw nothing except the basket, ropes and the driving snow. Unlike in the telematic performances that I described earlier, there was no representation of my body in this installation, no avatar to show me where I was in this virtual space. I looked ahead to the side of a huge mountain looming towards me and I decided (as one often does in virtual worlds) to see what would happen if I let the balloon crash into it. The basket careened towards the white slopes, which filled my field of vision. Instinctively I cowered away, raising my arms to my head for protection. I felt my arms brush my face but I saw nothing come between my eyes and the enormous, snowy rock face. I shut my eyes, and the reassuring visible bulk of my physicality was restored by the dark of my eyelids, as I heard a crashing boom on the sound track that seemed to reverberate dully through my body. Opening my eyes I saw the landscape flashing with pale color and then returning to monochrome as the balloon somehow skimmed over the top of the mountain and continued on its previous journey through the snow-filled skies.

Proprioception

The Oculus Rift head-mounted display unit provides the visual impression that the participant is located physically within the virtual environment. When the participant turns around, or looks up or down, she sees the virtual environment all around her, as the headset presents a three-dimensional stereoscopic image on two screens directly in front of her eyes. This results in visual perception similar to the way in which the eyes and brain perceive the physical world. This impression is underscored by the way that the movement of participant's head and body is reflected in the perspective displayed on the screens before her eyes, which adjusts her view of the virtual world to match her positioning in a manner that matches physical-world expectations. So for example, when I leant forward to look over the edge of the basket, I could see the different perspective as if I were present in a three-dimensional world. (This is different from working with a two-dimensional monitor screen, where one may try to lean forward or sideways to look around a corner but it makes no difference to the image displayed.) In *White Island* there was no avatar to represent my body; I could see but I could not be seen – not even by my own eyes. When I looked at where I felt my arms or my legs to be, there was nothing. Instead I experienced what seemed to be a phantom body that existed only via my internal senses, which made me think of the phantom limb phenomenon that is sometimes experienced by amputees. In his fascinating book titled *The Man Who Mistook His Wife for a Hat* (2015[1985]), neurophysiologist Oliver Sacks wrote about phantom limb pain, leading him to describe the set of internal senses known as the proprioceptive senses. He explained that the term 'proprioception' was first coined in the 1890s by a doctor called Sherrington, referring to:

that continuous but unconscious sensory flow from the movable parts of our body (muscles, tendons, joints), by which their position and tone and motion is continually monitored and adjusted, but in a way which is hidden from us because it is automatic and unconscious. (47)

Sherrington called proprioception our “sixth sense”, encompassing internal connectivity, spatiality and movement. It brought with it new ways of knowing the world for the twentieth century. These ways of knowing are now much more commonly recognized, particularly in the field of dance, where understanding of proprioception is an important aspect of somatic practices.

I was aware of my own physicality within the virtual reality of *White Island*, as my proprioceptive senses provided feedback on the interconnectivity and movement of my muscles, tendons and joints. It was through my proprioceptive senses that I knew my arms were raised in front of my face, even though I could not see them. Yet there was no avatar onto which I could map the sensations of my bodily interiority. This seemed to be fundamentally at odds with so many screen-based virtual worlds in which the body is at least nominally represented. For example, in multiplayer online games like *World of Warcraft* or *Fallout 4*, or in dedicated avatar design games like *Cosplay*, the emphasis is on the visual design of the avatar’s body features and clothes. The visual image is everything! In *White Island*, the visual image of my body simply did not exist, despite the fact that I was located in a naturalistic visual representation of the Arctic and the hot air balloon, experiencing gravity on both my body and the balloon. Sacks explains that the removal of a sense often results in intensification of one or more other senses in compensation. In the absence of a visual reference point, my proprioceptive senses defined my physicality. This highlighted my awareness of my whole bodily interface with the virtual environment.

Shortly before Sherrington coined the term ‘proprioception’, philosopher Henri Bergson (1911) had become deeply interested in the body’s actions and their relationships with matter and memory (the title of his seminal book). Bergson acknowledged the materiality of the body, and its connection as a material thing to the material world in which it existed. He prioritized the body’s actions as the route via which it received from and gave back to the material world. He wrote: “My body, an object destined to move other objects, is, then, a centre of action”. (1911: 5) This relates back to Cranny-Francis’ comment, “one cannot not touch”, since being a material body in a material world means that one is inextricably entwined with the other. Bergson’s position contrasts starkly with the virtual environment,

where the digitally generated world has none of the materiality of the body. This inconsistency in the materialities of body and world impacted strongly upon my experiences in *White Island*. I chose to keep hold of the physical rope for the majority of the time that I wore the Oculus Rift headset, and there were two main reasons for my reticence to release it. Firstly, it was the only method of controlling the height of the hot air balloon in which I drifted amongst steep mountains and valleys. Whilst crashing was an irresistible temptation from time to time, it was also interesting to explore the virtual world and so I chose to maintain control as far as possible for much of the time. However, my choice not to let go was also related to a desire to maintain grounding in the physical world. The roughness of the rope against my palm and its resistance to free movement (fixed at top and bottom) gave me a physical reference point that was both physically stabilizing and psychologically comforting. In Bergson's terms, it permitted an exchange between the materiality of my body and the world, and for Cranny-Francis, it was a point of connection to the world. The fact that I vaguely associated the rough physical rope with the virtual ropes that I could see around me added to the sense of connection with both the physical and virtual worlds. This became important to me as the mismatch between my proprioceptive and visual perceptions of my body sometimes caused me to feel unstable. At one point I reached out to grip the hot air balloon's basket railing, but my invisible hand groped about in the air, searching for the virtual railing that I could see in front of me. I felt a momentary loss of balance caused by my subconscious anticipation of grasping the rail. Much contemporary philosophy defines the 'real' by lived experience rather than by definitions of physical and virtual (Hansen 2006: 5). But which was more real to me – my proprioceptively present, visually absent hand or the visually present, proprioceptively absent railing? Without feeling the roughness of the rope in my other hand, I found that I was not necessarily certain. Such confusion did not occur in my experiences of any of the performances that I discussed earlier. The two beds provided consistent visual and physical reference points for Kozel and the participants in *Telematic Dreaming*, on which they could see their body images together. Both bodies and objects were virtually represented in *Unheimlich*, and the theatrical context encouraged playful engagement with 'what if' and 'imagine that' activities. *Escape Velocity* was a rehearsed improvisation by two performers in which both illusion and experience played their parts. But in *White Island*, I was immersed in a three-dimensional world that looked and felt 'real' in my experience, and yet in which I apparently did not exist as anything other than a ghostly, invisible presence.

Can the body be fooled?

Deidre Sklar writes about the relationship between seeing and not seeing in relation to knowledge. Coming from the dual perspectives of dance and philosophy, she contrasts visual

and proprioceptive perceptions and the ways in which they are considered to relate to objectivity and subjectivity:

Seeing implies an object, something to see. And in order to see an object, one must be separate from it, at enough distance to bring it into focus. ... The objectification implicit in seeing is associated with the objectivity of the mind, while the somatic sensation implicit in touch is associated with nearness and the subjectivity of proprioception. (2008: 87)

If we cannot see our bodies from the outside then the only immediate perception of physical being is via our proprioceptive senses (including touch), and thus those senses tend to be foregrounded where normally they might recede from conscious attention. For example, when trying to find my way in a dark room, I might experience a stronger sense of my moving body and its contact with the objects around it. The lack of a visible body in *White Island* leads to the denial of objective knowledge of the body, prioritizing subjective engagement and somatic sensation. Sklar draws attention to the problem of the limitations of language, with its separatist consequences forcing me to describe my body as if it were something that “belongs” to me. Yet, as her explanation demonstrates, it is partly the ability to see the body that leads to this objectification, since the body can be observed as if from outside via the eyes. Interestingly, many computer gamers choose to play games in ‘first-person’ perspective, rather than ‘third-person’, i.e. the screen becomes the viewpoint from avatar’s ‘eyes’, rather than the avatar’s body being visible on the screen. Martelli explains that first-person perspective gives him a stronger sense of being ‘there’ in the virtual world (cited in Popat 2012: 16); perhaps engaging body-based knowledge more readily to play the game more effectively. However, even first-person games generally show the avatar’s arm in the lower right portion of the screen (rarely are avatars left-handed) in order to provide a visible body presence. The absence of visual engagement with my body when it would normally be visible draws attention to its subjective presence in relation to the virtual space.

Yet how is the experience of space constructed? Anthropologist Maxine Sheets-Johnstone (1990) draws upon her interest in movement and dance to consider Merleau-Ponty’s examination of George Stratton’s experiments with inverted vision. In these experiments, Stratton’s research team wore glasses that inverted the image so that the world appeared to be upside down. Over time, the researchers noticed that their brains compensated for the inversion, and they began to see the world the right way up whilst still wearing the same glasses. Merleau-Ponty (1962: 246) proposed that space is essentially visually constructed, and that better understandings of spatial concepts might be achieved through the disruption or

distortion of normal modes of perception as demonstrated in this experiment. Critiquing Merleau-Ponty's argument, Sheets-Johnstone proposes a corporeal perspective. She points out that it is possible to invert vision and thus temporarily confuse spatial orientation, but it is not possible to undertake such an inversion of the proprioceptive senses:

[T]he tactile-kinaesthetic body cannot be fooled. ... Space at its source is a corporeal space defined by the intrinsic spatiality of animate form and the inherent spatial possibilities of the tactile-kinaesthetic body. (1990: 286-7)

In *White Island*, the space is visually constructed in a similar manner to Stratton's glasses, as the participant sees the three-dimensional virtual world via the two screens before her eyes within the Oculus Rift headset. My tactile-kinaesthetic body inhabited that visual space to some extent as a corporeal space, feeling slight vertigo when the balloon was at its highest, and reacting to the impact of the crash. Yet my attempt to touch the basket railing resulted in confusion between corporeal and visual experience. If my body cannot be fooled, why did that momentary confusion occur?

In *White Island*, embodied experience is subtle and blurred. Conceptually we understand that the environment is realistic but we know also that we are not actually there. Yet the body's experiences that environment as if it were real, or perhaps more accurately as if it were 'not not real'. Indeed cognitive neuroscience research has shown that we readily fall into a mode of 'response-as-if-real' in virtual reality environments, even at low-resolution (de la Peña 2010: 293). According to Sheets-Johnstone, the body cannot be fooled, so perhaps it is drawing upon knowledge to which cognitive perception does not have access. Henri Bergson argued that every being is surrounded by "the zone of indetermination" (1911: 23); its amplitude dependent upon the relations of that being to other things. This zone consists of all of our memories, experiences and past relationships with objects and people. It contains our histories and our habits; "impregnated with our past" (24). Bergson argues that this indetermination "constitutes the principal share of individual consciousness" in the ways that we perceive the world (25). So I carry with me all of my experiences of being a material body in this material world, and of taking action in the world. These embodied, kinetic memories exist at a deep level, separate from our conscious thought, accrued via a lifetime of physical action. Bergson refers to this as "bodily memory", which he describes as "the sum of the sensori-motor systems organized by habit" (197). So, for example, you never forget how to ride a bike because it is in your bodily memory. In *White Island*, these embodied or "bodily" memories were collided with the conceptual understanding that I could not have physical contact with the virtual world. My body became blurred, existing between the

definable points of physical and virtual, so that the experience of the environment was ‘not not real’. I braced myself for impact against the mountainside, my pulse raised slightly in anticipation. I knew that I would not crash but I experienced the act of crashing as *not being not real*. Clearly my body was not fooled – anticipation of a real crash would have resulted in much stronger physical responses – but my perceptions of the virtual experience were deeply informed by my embodied knowledge of the physical world. The space was neither corporeal nor virtual, since it was defined by my body’s deep proprioceptive knowledge colouring the virtual world with shades of physical experience. I did not know whether my body or the railing was more ‘real’ as I reached out to grip it, because my objective knowledge of the world was disrupted by my missing body, and my proprioceptive senses refused those binaries of physical/virtual, real/unreal.

Some final thoughts

Telematic Dreaming, *Escape Velocity* and *Unheimlich* all draw upon the deep proprioceptive knowledge and embodied memories of the body. It is this that leads participants to desire touch as a way of constituting their presence together in virtual space, since it connects one body with another, and the virtual with the physical action. I feel myself reaching out proprioceptively, and you feel your physical response to receive or return that virtual touch. This access to embodied knowledge is so strong that it can lead to instinctive responses despite knowing that we are not actually in the virtual world. For example, Kozel folded up when her virtual body was suddenly elbowed in the stomach, and I could not help but cower with beating heart in anticipation of crashing into the virtual mountainside. Embodied memories accessed proprioceptively enable us to do the un-doable, rehearse the un-rehearsable in virtual worlds, gaining something of the embodied experience through the doing of actions that can never be completed.

Other disciplines, including philosophy and cognitive neuroscience, have engaged in various ways with knowledge located within the body. However, dance is still better equipped than most to draw directly upon experiences of embodied knowledge, since such knowledge is accessed regularly within the study of dance. In my interdisciplinary research with scientists, engineers and computer programmers, we always start by taking a dance class together so that we begin to develop a shared basis for talking about movement as experience and knowledge. The field of virtual reality was burgeoning in the 1990s, but it lost much of its momentum in the early part of the new millennium. The fresh emergence of contemporary, commercially viable, lightweight headsets is likely to lead to a revival of interest and growth in virtual reality products for the home entertainments and other markets. Dance has much to offer to the understanding and development of virtual reality as lived experience, and there is also

much that dance as a discipline might learn about movement by engaging deeply in embodied experiences within virtual worlds.

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