# The Feeling of Being 'There': Presence and the Role of Virtual Reality as a Research Tool

Alec McLeod

Simon Fraser University

This paper provides evidence to suggest that Virtual Reality (VR) technology offers psychology a more ecologically and internally valid research tool than traditional means of research. As generalizations about certain areas of psychological research, such as in neuropsychology, are benefited by this brand of ecological validity, VR has the potential to radically change how research is performed. This paper offers presence, an individual's feeling of being in a virtual environment, as the metric that dictates the realness of experience in VR. A focus on maximizing presence, then, should allow for the most ecologically valid research. Means of increasing an individual's presence are elaborated, and current implementations and future applications of VR for psychology are discussed.

Keywords: virtual reality, presence, ecological validity, internal validity

Since its inception, both in science fiction and in reality, Virtual Reality (VR) technology has been envisioned as an entertainment product; however, in recent years, science has slowly adopted the technology as an experimental and clinical tool. While it has been applied in the treatment of phobias (Klinger et al., 2005), eating disorders (Riva, 2011), and posttraumatic stress disorder (Rothbaum, Hodges, Ready, Graap, & Alarcon, 2001), many areas of psychology have yet to implement VR technology, often preferring traditional paper-and-pen assessment with computerized scoring (Parsons, 2011). Fortunately, many see VR as a viable new tool, offering greater ecological validity without compromising a researcher's experimental control (Loomis, Blascovich, & Beall, 1999; Campbell et al., 2009; Parsons, 2015). Crucial to VR is a measurement of an individual's 'presence' in the Virtual Environment (VE): Presence is the feeling of being 'there', and reflects to what degree an individual feels as though they are actually occupying a real environment. Essentially, then, an increase to presence equates to greater overall effectiveness of VR (Sanchez-Vives & Slater, 2005). Consequently, presence is an imperative factor in determining the ecological validity of VR, and its current and future role as a research tool in psychology.

VR is the simulation of an artificial, or virtual, environment through the aid of specialized hardware. Sitting in front of a desktop display that generates three-dimensional images can be considered VR, though non-immersive, as there is still a peripheral awareness of the direct environment. Conversely, the type of VR discussed here is immersive VR (Slater & Wilbur, 1997), which often uses head-mounted displays (HMDs) paired with head-tracking to create a more realistic experience. This type of VR setup necessitates other hardware, including audio equipment and motion based input devices, as well as computers sufficiently powerful to render a VE. A common drawback is cost (Bowman & McMahan, 2007), but with more off-the-shelf VR products reaching the market and the hands of researchers (Rand, Kizony, & Weiss, 2008), there is potential for the hardware to become less costly and more available in the near future (Desai, Desai, Ajmera, & Mehta, 2014). It is important to note that the level of immersion only objectively reflects the nature of the hardware used, and the experience available to the individual (Slater & Wilbur, 1997). Presence, on the other hand, measures the experience itself.

Presence is the feeling of physically being in a virtual environment rather than where your body is actually situated. Though insufficient psychological research has been performed on the phenomenon itself, presence is arguably the defining metric through which the effectiveness of VR can be assessed (Slater & Wilbur, 1997). Presence is typically assessed subjectively via self-reporting or through questionnaire, though there has been some evidence to suggest that it might be measurable objectively through changes in galvanic skin response (GSR; Lo Priore, Castelnuovo, Liccione, & Liccione, 2003). Presence can also be suggested through activation of the sympathetic nervous system as a response to threats in VR, as in one study, where GSR increased when participants observed their virtual bodies being stabbed (Hägni et al., 2008). In another study, participants suffering from acrophobia (the fear of heights) showed anxiety in VR (Hodges et al., 1995); while presence was not measured, if the participants felt anxiety, logically, they must have felt a degree of presence in the VE. Typically, though, as in the above studies, behavior in VR that is nearly identical to real-world behavior is sufficient to surmise a level of an individual's presence.

While a feeling of presence in VR is imperative, implementation of realistic and presence-inducing VR can be problematic. A typical VR experience is provided to individuals via HMD, with visual information being the primary, and often only source of stimulus; however, it has been recently argued that visual cues are insufficient for creating a cognitive spatial map of the virtual environment (Aghajan et al., 2015). Instead, cues from other modalities, such as through audition or haptic feedback, have been suggested as necessary for the brain to be passably fooled by VR (Ravassard et al., 2013). In fact, in rats, place cells of the hippocampus — a region of the brain involved in memory and station navigation — were found to be much less active if rats were unable to use proprioceptive cues, particularly vestibular cues, to assess position in a virtual environment (Aghajan et al., 2015). Strong feelings of presence can still be achieved during fMRI scans, where the head is fixed, and loud noises are occurring (Hoffman, Richards, Coda, Richards, & Sharar, 2003). Even so, feelings of presence appear to be the greatest when individuals have the ability to move freely and without restriction (Slater & Steed, 2000). Similarly, vestibular motion cues seem to be essential in convincing individuals of the occurrence of real motion, as well as decreasing the sickness sometimes associated with VR use (Harris, Jenkin, & Zikovitz, 1999). As a whole, it is apparent that presence in VR is strongest when movement is both visually and non-visually experienced just as it would be in the real world. Ergo, realistic perceptions of motion in VR are paramount to a realistic and thus presence-inducing experience.

Presence is best maximized by understanding and employing features that increase it. Because of the increased visual detail, some might assume that photorealism increases presence, but this does not appear to be the case (Zimmons & Panter, 2003). Likewise, the illusion of depth does not have any tremendous effect on an individual's feeling of presence (Baños et al., 2008). Instead, factors such as bodily representation (Slater & Usoh, 1994) and increased participant agency (Steuer, 1993) have a greater tie to perceived presence. When participants are led to believe that their VE is identical to the real world room they're occupying, they report increased feelings of presence in the VE (Bouchard et al., 2012). Similarly, being persuaded that virtual people encountered in VR exist for real also increases the presence of the participant (Nowak & Biocca, 2003). Taken together, realistic stimuli and persuasion of realism are sufficient to induce perceived realism in VR. Ultimately, then, a perception that VR is occurring believably offers the maximal potential feelings of presence.

Crafting a research environment that is realistic and believable creates potential for realistic participant experience and response; increased realism, then should increase ecological validity, and thus the overall validity of research. Ecological validity is the degree to which the methods and results of experimentation can be generalized to the real-world setting that is being researched. Opinions on the need for greater ecological validity in research are mixed, where some argue that failings or inaccuracies in methodology may not strongly impact results (Diamond, 1997) and that research validity ultimately depends on the kinds of claims being made about the results (Bornstein, 1999). A different pattern emerges from experimentation in neuropsychology, an area of psychology examining the relationship between the brain and behavior. For instance, Chaytor and Schmitter-Edgecombe (2004) analyzed the ecological validity of a sizeable number of neuropsychology experiments, finding that many of the tests — such as the Wisconsin Card Sorting Test and the Trail Making Test — were insufficiently related to outcome measures, reducing the potential generalizability of the results. This is particularly unfortunate, as in neuroscience, the activity of particular brain regions can be largely affected by the ecological validity of the measures used (Campbell et al., 2009). Clinically, too, a neuropsychologist's informed judgment of the scope of an impairment can be largely dependent on the ecological validity of the pertaining research (Kieffaber, Marcoulides, White, & Harrington, 2007), though this is not necessarily the case for neuropsychology generally. Fortunately, many assessment tools in neuropsychology are already designed with ecological validity in mind (Robertson, Ward, Ridgeway, & Nimmo-Smith, 1996; Lamberts, Evans, & Spikman, 2010). Thus, greater ecological validity allows for greater overall validity of neuropsychological research and allows for greater generalizability and breadth of potential claims. And, just as with perception of presence in VR, making an individual's experience believable and maximally realistic allows for more veridical behavior and valid measurement.

The creation or recreation of a large ecologically valid experimental environment, while beneficial, can be costly and difficult. However, VR also has the capacity to facilitate and ease internally valid research design. For instance, VR allows for greater and more precise control over participant's environment and stimuli, resulting in greater consistency and computational precision in assessing results (Parsons, 2015). A pivotal advantage of VR over traditional means of research is the ease of control over adjustments to particular variables. For example, a study researching nicotine craving used VR to easily present participants with varying environments containing either craving-inducing or neutral cues (Bordnick et al., 2004). VR allowed for identical environments to be rendered and presented to each participant, as well as allowing for social interaction to be fulfilled by virtual avatars. This supplanted any need to employ or instruct additional confederates as part of experimentation, and allowed for each participant to receive the same social interaction stimuli. Crucially, the application of VR facilitates experimental design, allowing for easily replicable experimental manipulations, and offers unmatched consistency in terms of experimental execution.

Implementing VR as a valid research tool doesn't necessarily impact results when compared to traditional paper-and-pen means. In the above nicotine study (Bordnick et al., 2004), VR experimentation results match nicotine craving research previously performed through traditional means (Sayette, Martin, Wertz, Shiffman, & Perrott, 2001). In another study, VR was used to measure attention in boys diagnosed with attention deficit-hyperactivity disorder (ADHD) in a virtual classroom (Parsons, Bowerly, Buckwalter, & Rizzo, 2007). As expected, ADHD-diagnosed boys were found to be more distracted than normal boys, as evident in their task-performance and bodily movement; also, the measured results mirrored results from traditional ADHD assessments of the same participants. Here, the virtual environment allowed for better control of potential distractors that might impact a traditional assessment (Parsons et al., 2007). The implementation of VR produces essentially the same or equivalent findings, and of equal importance, effectively erases any biases or errors that might occur as a result of the inclusion of human roles in the research process.

On the whole, VR offers greater validity without compromising control (Loomis et al., 1999), facilitates design (Bordnick et al., 2004), and eases replication (Blascovich et al., 2002). But, VR also has benefit in that it extends design beyond what is typically possible for traditional research; for example, VR allows for adjustment to the environment between conditions and in real-time, by altering the environment itself, or adjusting the scale of objects or the individual, or even exaggerating the effects of stimuli (Hodges et al., 1995). This has many benefits, including allowing precise control over exposure to phobic stimuli (Klinger et al, 2005). VR removes the necessity for many human roles in the research process; logically, the fewer human roles, be they as confederate, observer, coder, or otherwise, the less likely a human bias or error could negatively affect results, and the more internally valid those results are likely to be. Because of the digital nature of VR, methodology and complex research environments can be easily shared throughout the research community, ultimately offering greater ease of replication. Thus, while current technology used for neuropsychological assessment might be outdated (Parsons, 2011) and potentially negatively affected by human involvement, VR offers an equivalent, and much more valid tool.

VR has the ability to facilitate a new brand of valid research; furthermore, 'solving' presence, i.e., maximizing the presence felt by individuals in the virtual world, will allow for VR to become the foremost tool of psychological research. Though it has potential to generally benefit psychology (Loomis et al., 1999; Sanchez-Vives & Slater, 2005), it has particular benefit to cognitive psychology, especially in perception (Sanchez-Vives & Slater, 2005), social psychology (Blascovich et al., 2002), and neuropsychology. VR also has tremendous clinical applications, both in assessment (Parsons et al., 2007; Parsons, 2011; Parsons, 2015) and treatment (Hodges et al., 1995; Rizzo & Kim, 2005). In fact, one of the most striking implementations of VR is in the treatment of PTSD, where the precise recreation of traumatic events in a safe environment is paramount to patient amelioration (Rizzo et al., 2015). Due to the significant incidence rates of PTSD in military personnel internationally, as well as in survivors of terrorist attacks and other traumatic events, VR is and will continue to be an important tool in treatment. And, presence is crucial to its effectiveness.

Be that as it may, there is a tremendous lack of information in the scientific literature on presence, particularly on objective means of measurement. By the same token, there has been almost no neuroscientific research on the neural correlates of presence, though some initial evidence has shown brain activation in areas involved in spatial navigation (Baumgartner, Valko, Esslen, & Jäncke, 2006). By admission, there is some difficulty in simultaneously administering VR while imaging the brain through traditional means, though relatively recent advances in near-infrared spectroscopy are allowing for an easier non-invasive method of neuroimaging while in VR (Kober, Wood, & Neuper, 2013). Furthermore, there has been too little research or analysis directly comparing results of VR research against traditional means of research; while there is increasing evidence that VR experimentation produces results on par with previous findings (Bordnick et al., 2004; Parsons et al., 2007), a larger body of evidence will help to promote further trust in VR. Going forward, greater experimentation is recommended as to thoroughly flesh out the understanding of presence, and thus the underpinnings of VR. As it stands, VR technology is advancing quicker that the research community can accommodate. Though the tools of the trade can be understandably expensive, and the environments difficult to produce, they are not theoretical tools for the near future. Virtual reality is a tangible tool that is available now, primed and ready to join psychology's arsenal.

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