

How, When, and Why to Use Digital Experimental Virtual Environments to Study Social Behavior

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Abstract

Over the last decade, researchers have begun using immersive virtual environment technology (IVET; commonly known as virtual reality) to create digital experimental virtual environments (DEVEs) to investigate social psychological processes. Researchers increasingly recognize that IVET provides powerful and cost-effective ways to manipulate theoretical variables and to measure a host of outcome variables, while providing a remarkable level of experimental control and ecological realism. In this article, we discuss IVET, the nature of social influence within DEVEs, and the use of DEVEs to study social behavior.

Science fiction writers and futurists have long been fascinated with the notion of virtual reality. Novels like *Snowcrash* (Stephenson, 1992) and *Neuromancer* (Gibson, 1984), as well as movies like *The Truman Show* and *The Matrix*, depict virtual worlds which completely envelop people, taking them out of the natural world. While immersive virtual environment technology (IVET) is not yet as powerful as these fictional depictions, it has become increasingly sophisticated since the first crude implementations of computer graphics by pioneers in the 1960s (Heilig, 1960; Sutherland, 1965).

Seizing on recent developments driven in powerful digital graphics technology, more and more investigators have begun to use digital experimental virtual environments (DEVEs) as research platforms for understanding human social behavior. As Blascovich and colleagues (Blascovich et al., 2002; Loomis, Blascovich, & Beall, 1999) have described, such investigations enjoy many advantages made possible by IVET including increased precision and control over both experimental variables and ecological contexts, the unobtrusive collection of a wealth of implicit and explicit objective behavioral measures, and the implementation of experimental procedures that would have been difficult, if not impossible, in the past. These developments have opened a host of new possibilities for empirical investigations of social influence and interaction.

What are Virtual Environments?

Virtual environments (VEs) are synthetic environmental constructions or simulations that, it should be noted, are not necessarily constructed digitally. Immersion in such an environment occurs when an individual attends to it as though it was not synthetic (Blascovich et al., 2002), often to the extent that he or she is less consciously aware of the outside world. When immersed, one feels strongly present in the VE and is easily able to interact within it (Witmer & Singer, 1998). Today, when most people refer to ‘virtual reality,’ they are referring to a specific kind of VE called a digital IVE.

While DEVEs are relatively new, psychologists have long used physical experimental VEs to study social influence. Many of social psychology’s classic studies used shockingly

effective ones. The famous Stanford Prison Experiment, for example, produced a remarkable demonstration of the power of social roles by placing participants in a simulated prison in the basement of a building on Stanford's campus (Haney, Banks, & Zimbardo, 1973). Similarly, the environments Milgram created for his obedience experiments were quite compelling (Milgram, 1963). Indeed, the first reported social psychological experiment emulated the experience of riding a bike to look at social facilitation of performance in the lab (Triplett, 1898). Clearly, simulation has played an important role in the study of social influence.

While DEVEs fall in line with the tradition of simulation, the digital age has ushered in a new era of possibilities. We now have a wide range of options available for creating and controlling elaborate environments without the costs and constraints of hammer-and-nail, physical sets. As such, we can create a broader range of scenarios. Moreover, as the following discussion describes, DEVEs allow us to control and systematically vary features of an environment or its inhabitants in ways that are beyond what is possible with traditional methods of simulation.

Technological Overview

The technology underlying digital IVEs can be dissected into three integrated parts: modeling, input devices, and output devices (Figure 1).

Modeling

Digital modeling provides the static and dynamic, sensory and perceptual content of VEs. Although all types of sensory information can be modeled, vision and audition tend to be the focus. Computer-generated graphics engines have increased substantially in sophistication in recent years, allowing the creation and rendering of highly convincing spaces, objects, and human representations. The quality of animation of human representations is paramount for the creation of effective social DEVEs, particularly the animated motions of virtual humans, although as Heider and Simmel (1944) demonstrated long ago, a

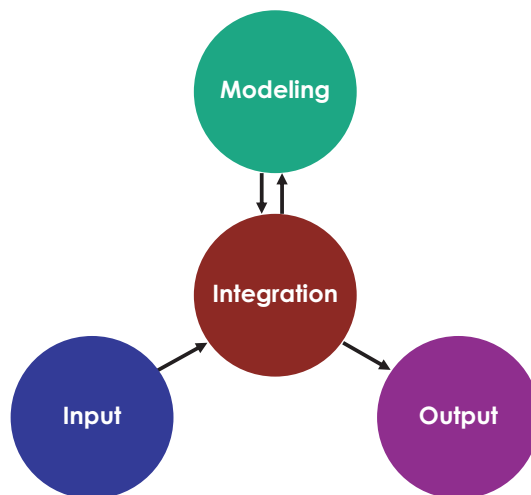


Figure 1 The four components of digital immersive virtual environments.

representation need not necessarily be anthropometrically or photographically realistic to evoke social responses. Nonetheless, anthropometric realism contributes to the effectiveness of the animated motions of virtual humans to the extent that appearing human in form contributes to recognizable lifelike motions (e.g., one cannot make an arm or hand gesture without representations of these appendages on virtual human representations). Photorealism is much less important (though increasingly possible) in terms of movement realism but can be very important in terms of connoting specific individual identity. Modeling other sensory domains, such as sound and haptics, allows for the creation of multimodal synthetic worlds.

Output devices

For many people, the first image to come to mind when talking about digital IVET is either an individual wearing a largish apparatus on their head or a cast member of *Star Trek* strolling around the 'Holodeck.' Those two are classic examples of IVET output devices, the hardware responsible for displaying VEs. Head-mounted displays (HMDs) are goggle-like devices that enable rendition of visual information in IVEs stereoscopically. One holodeck-style display is the 'CAVE' or 'computer-activated virtual environment.' Using CAVE technology, virtual worlds are projected onto the walls (and sometimes the ceiling and floor) that surround the user. Special glasses allow the projected IVE to appear in 3D as well.

Audio simulation via headphones or more sophisticated multichannel systems can contribute significantly to immersion. Haptic devices provide touch feedback so that the user can feel the edges and textures of objects, or even the handshake of another individual (Bailenson & Yee, 2007). In recent years, engineers have even developed displays to render gustatory, olfactory, and vestibular feedback (Iwata, Yano, Uemura, & Moriya, 2004; Maeda, Ando, & Sugimoto, 2005; Yanagida, Kawato, Noma, Tomono, & Tesutani, 2004). Together, these output devices increase the immersiveness of VEs.

Input devices

Input devices are necessary for pulling in data from the physical world and using those data to drive the virtual world. Tracking devices are uniquely important input devices for IVEs because they allow for translating participants' physical movements to virtual ones. Consider the importance of tracking head movements. Sitting on a virtual train traveling across a virtual Kansas, one should be able to turn his or her head toward the window and see the countryside whizzing by, or toward the aisle and see the passenger sitting in the next seat. If one gets up and walks up and down the aisle, one should see everything from the proper perspective in apparent real time. In order for the system to render the countryside and the other passengers at the right moments, it needs to know where the participant is situated in the VE and where the participant is looking. Tracking devices can provide these position and orientation data.

Recent years have witnessed great advances in tracking and other input devices. A range of optical, magnetic, and inertial sensors for position and orientation are commercially available along with more human-specific tools such as tracking gloves and whole-body tracking suits. The more of the physical body we can track, the more data the system can utilize to render the virtual body. Furthermore, the ability to track all these aspects of body motion allow for a broad range of near continuous and objective records of nonverbal behavior. Input devices are not limited to physical tracking. Any

device that can track human activity and produce a digital signal can be used to affect a virtual world. Keyboards, joysticks, and computer mice are familiar input devices and customized devices can be created for specific needs. Physiological data (heart rate, skin conductance, etc.), for example, can be transformed into a digital signal and used as input into a digital IVE.

Integration

Integrating the modeling and input components of a system allows data from the latter to render the former appropriately via output devices such as HMDs, CAVEs, etc. This integration affords the system interactivity, making DEVEs different from watching a 3D movie or passively consuming media in any other way, because it allows users to navigate within the virtual space or act on the virtual representations therein. Furthermore, integration of multiple systems allows multiple individuals to inhabit the same, shared DEVE, allowing for virtual social interactions between pairs or groups.

Consider the integration of various components in a DEVE we used in our laboratory to test the effects of social support during an anxiety-producing task (Figure 2; Kane, McCall, Collins, & Blascovich, 2009). For this experiment, we modeled a path along a steep ravine, including virtual vultures circling overhead, and the sounds of wind and rocks sliding. We also modeled a virtual human, animated to provide either supportive or nonsupportive nonverbal behaviors. With tracking input devices, we monitored the

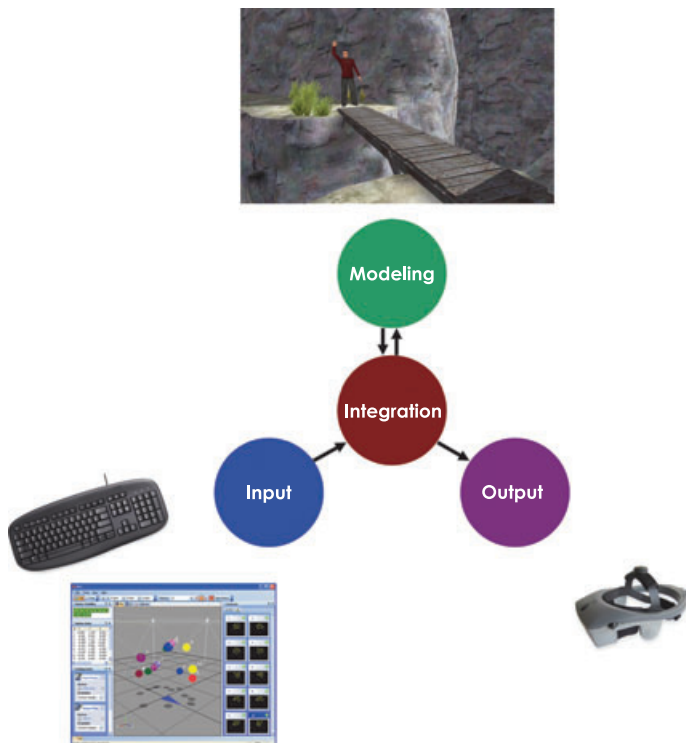


Figure 2 The four components of digital immersive virtual environments as used in an experiment. Tracking data and keyboard presses are used as input, a canyon and an avatar are modeled, a head-mounted display is used for output, and all of these are integrated to allow for interactivity.

translation (e.g., movements through the DEVE) as well as the orientation of the participant's head at all times. For an output device, we used a HMD with stereo headphones. The tracking data was used to move the participants' point of view in the DEVE so that they could walk along the cliff, navigating just as they would in the natural world. Input to the computer via an experimenter, meanwhile, controlled the nonverbal behavior of the virtual human in the world. All of this was, in turn, rendered in visual and audio stereo via the HMD. Together, the system produced an anxiety-provoking experience with a manipulated element of social support.

Cost

A decade ago, the cost of setting up an IVET laboratory was prohibitively expensive for most labs studying social behavior. Furthermore, the time required to learn how to write software and use the technology was beyond what most behavioral scientists (or graduate students) could afford. In recent years, however, the price of IVET hardware has dropped dramatically and the development of accessible software packages have made using IVET for social science far more feasible.

What's Real about a Virtual World?

An obvious question that arises when discussing the use of DEVEs to study social influence is whether or not human experiences in a VE are comparable to experiences in the physical world. Can we really make conclusions about how people behave in the natural world based on how they behave in a virtual world? Experimental psychologists, including social psychologists, have assumed so and accepted this premise as we began creating nondigital VEs via experimental procedures, including even the weakest form of virtual world, the vignette. A more important first question, then, is whether using DEVEs is as effective as using more traditional research scenarios.

Research suggests that it is. Consider proxemic behaviors such as interpersonal distance. In the natural world, we maintain a certain amount of distance between ourselves and others (Hall, 1959; Sommer, 1959) and that bubble of personal space has a particular shape (larger in front of the person than at their sides or behind them; Hayduk, 1983). Studies in our lab replicated these patterns in a DEVE (Bailenson, Blascovich, Beall, & Looms, 2001, 2003). Participants kept a significantly larger space between themselves and a virtual human when compared with a cylinder of the same height (Bailenson, Blascovich, Beall, & Looms, 2001) and the shape of the bubble around the virtual human was indeed larger in front than in back (Bailenson, Blascovich, Beall, & Looms, 2001). In addition, participants responded to the nonverbal behaviors of the virtual human such that if the virtual human gazed directly at them, they walked further around it. This is the same pattern others found using physical experimental scenarios and, more importantly, that one would expect in the natural world (Hayduk, 1981).

Research has also established congruence between DEVE and physical world experiences for more complex cognitive processes. Consider ingroup bias, the tendency for individuals to be more influenced by similar others or members of one's own group, than by dissimilar others or outgroup members (e.g., Brock, 1965; Cialdini, 2001; Mackie, Worth, & Asuncion, 1990). Accordingly, a study on persuasion in DEVEs (Guadagno, Blascovich, Bailenson, & McCall, 2007) found that participants were more persuaded by digital humans of their own gender. Moreover, this effect emerged despite the fact that participants knew that the digital humans were computer-controlled. Similarly, a study

on conformity and risk-taking conducted in a DEVE found that both women and men were more influenced by the betting behavior of virtual others at a blackjack table, even knowing that the virtual others were digital agents and particularly if those virtual humans appeared to be their same gender (Swinth & Blascovich, 2001).

In a particularly dramatic demonstration of social influence within DEVEs, researchers used a paradigm similar to the famous Milgram obedience experiments (Slater et al., 2006). In this study, participants administered a test to a virtual human that they knew was controlled by a computer algorithm (an agent). Over the course of the study, if the agent got a question wrong, participants were instructed to deliver a shock to her, increasing the voltage with each shock. Over the course of the experiment, the agent grew more agitated and began protesting more. Some of the participants in this study could see and hear the agent while others only communicated with her through text. As in the original study, participants who could see the agent were significantly more likely to want to stop the experiment, showed physiological signs of anxiety, and reported greater discomfort with the task.

Social Influence within Virtual Environments

Still, there are clear differences between virtual and physical environments. We do not consider gamers to be serial killers, despite the fact that they may shoot hundreds of virtual victims each day. So why would we expect social influence to occur in DEVEs and why would we expect the virtual nature of the environment to mitigate social influence?

The model of social influence within VEs (Blascovich et al., 2002) provides a testable answer to this question. This model is based on the notion that there is a threshold above (but not below) which social influence will occur in a VE. Four factors determine the shape of this threshold: (1) the amount of agency attributed to the virtual humans in the world, (2) the communicative realism of the virtual agents, (3) the target or response system level examined, and (4) the self-relevance of the interaction for the user.

The first factor, human agency, is anchored by two poles—agents and avatars. Human representations that are completely controlled by computers are labeled ‘agents’ whereas human representations that are completely controlled by humans are labeled ‘avatars’ (Bailenson & Blascovich, 2004). In between is a range of attributions that varies as a function of the participant’s explicit beliefs about how much the behavior is computer-controlled and how much it is human-controlled (Bailenson et al., 2005; Garau, et al. 2003). Agency attributions also vary as a consequence of social verification (Blascovich, 2002), the degree to which the user experiences the human representation as a living, animate person.

The second factor, communicative realism, refers to how people communicate in the natural world. In the model, communicative realism is a latent variable and, as such, can only be described and measured via manifest variables. The most important of these manifest variables involves movements; that is, the realism of communicative movements of the body and head. Supporting movement realism is anthropometric realism; that is, the familiar body parts of humans. Having a head is necessary to establish mutual gaze; having an arm and hand is necessary to have a hand gesture. Although naïve psychology supports the importance of photorealism as an important communicative realism variable, our model suggests that it is not. Photorealism, the degree to which virtual humans look like actual humans, is important in terms of communicative realism only to the extent that it communicates specific personal identity (e.g., ‘Barack Obama’). Indeed if photorealism is high it can counteract movement and anthropometric realism, a phenomenon known as the ‘uncanny valley’ (Mori, 1970/2003).

Compare, for example, Mickey Mouse with a wax model of Queen Elizabeth. The wax model of the queen may have been made with great skill and may match the living queen's appearance down to minute details, but if you put a speaker in its mouth to simulate speech, the experience will not be too compelling. Mickey Mouse on the other hand, is a completely photographically unrealistic creation. 'He,' or more appropriately 'it', does not even look like a mouse, let alone a human. Nevertheless, we attribute plans, thoughts and emotions to Mickey just as if he were one of us. That is because Mickey's animators focus on communicative realism. They give Mickey human-like facial features and bodily appendages and tap into expressive channels like gaze, facial expressions, and gestures, while making him move like a human. Mickey comes alive without any attempt at photorealism. The same pattern emerges in digital interactions. Compare, for example, using a text interface with a voice interface. Even if you know that the talking computer is controlled by an algorithm, your responses are more social than when you are simply entering and receiving text (Nass & Brave, 2005).

Human agency and communicative realism can be considered independently. You can imagine physical world cases in which agency is high but communicative realism is low (a human wearing a rigid mask), when agency is low but communicative realism is high (Mickey Mouse), when agency is high and communicative realism is high (an elaborate marionette), or when agency is low and communicative realism is low (a wax figure). Our model uses these dimensions to define the threshold for social influence (Figure 2). At low levels of human agency (where the user believes the virtual human is an agent), communicative realism will need to be high for the virtual human to have an influence. At high levels of human agency, however, communicative realism can be relatively low without losing social influence. In other words, the more one believes a virtual human is controlled by a computer, the more lifelike its behavior will need to be to influence people in the way that a human normally would (Figure 3).

The threshold for social influence is likely different depending on which of the users' response systems are targeted as outcome or dependent variables (Figure 4). If one

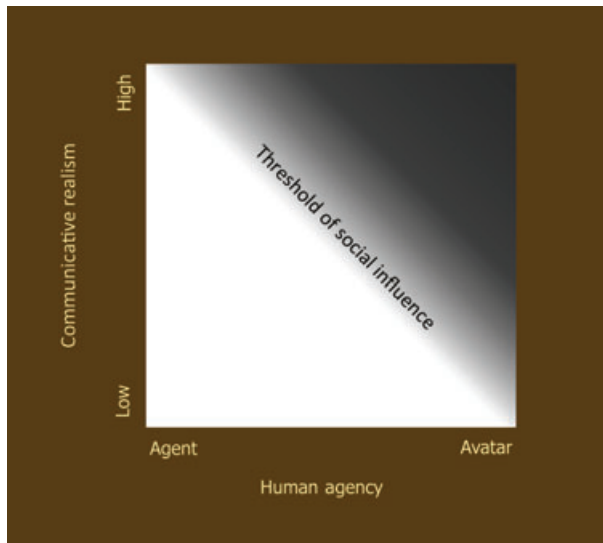


Figure 3 The model of social influence in virtual environments.

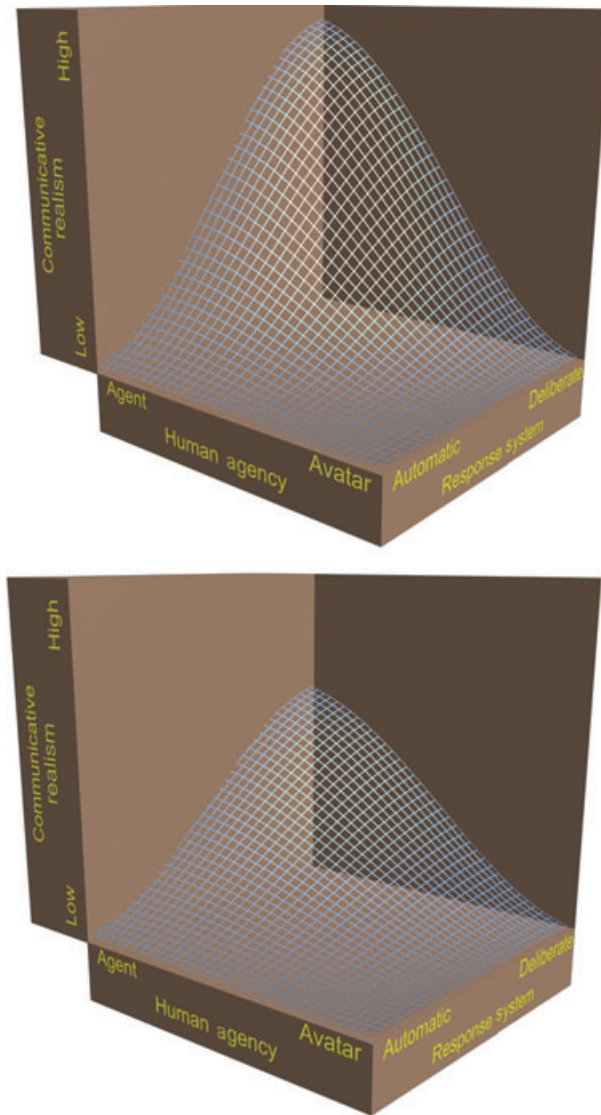


Figure 4 The model of social influence in virtual environments at high (top) and low (bottom) levels of self-relevance or high (top) and low (bottom) level response systems.

examines nonconscious, automatic responses, such as startle reflexes or semantic priming, the threshold for social influence should be relatively flat. For example, if a participant is in a DEVE and an agent shoots a gun and fires a bullet at her, the noise of the gun will most likely startle her (Persky & Blascovich, 2007); the level of agency and communicative realism are not likely to change that response. For higher level processes, however, the threshold we have described should be relatively steep. Imagine an in-depth conversation with a virtual human. In that instance, social influence is not going to occur unless the virtual human is known to be an avatar or the level of communicative realism is extremely high (such as a ‘guard’ or ‘prisoner’ in the Stanford Prison Experiment).

The threshold for social influence is also likely to be affected by how relevant the domain is to the user. There are plenty of instances in everyday life when it does not matter to most people whether they are interacting with a computer or a human. For example, most people would just as soon get cash from an ATM machine than wait in line to see a human. The interaction with either bank machine or teller will not be radically different, nor will it have different outcomes, if the agency and behavioral realism of the cash source varies. In this sense, the threshold for social influence flattens out at low levels of self-relevance (Figure 4). Conversely, we expect the threshold for social influence to be quite steep for highly self-relevant situations such as dates or job interviews. In these circumstances, the agency and the behavior of the other interactant are going to have a powerful effect on an individual's thoughts and behaviors.

The model of social influence in VEs provides a framework for evaluating the use of IVEs for social psychological research. It helps us answer, for example, the question of whether social interactions in DEVEs are different because participants consciously know they are in a synthetic environment. According to the model, we cannot expect normal social influence outcomes in high level domains if the user knows she is interacting with an agent, the communicative realism is low, and the content is highly self-relevant. Conversely, we can expect normal influence processes at lower level domains if the user is interacting with an avatar, the communicative realism is high, and the domain is of moderate self-relevance. The dimensional nature of the model, of course, also makes predictions for circumstances somewhere between these extremes. Moreover, a variety of research supports the model's claims (Bailenson, Blascovich, Beall, & Looms, 2003; Bailenson & Yee, 2005; Guadagno, Blascovich, Bailenson, & McCall, 2007; Schilbach et al., 2005).

Why use virtual environments to study social influence?

So, even if naturalistic social influence occurs in DEVEs, why bother using them? Cannot we just run the same experiments in the physical world without fussing with all this technology? A short review of recent research demonstrates that DEVEs grant us new and unique ways to manipulate and measure without any sacrifice to experimental control.

Consider Dutton and Aron's classic rickety bridge study (1974). In the original field experiment, a female confederate waited at the end of one of two bridges, a wobbly suspension bridge 250 feet above a canyon, and a solid wood bridge 10 feet above a quiet stream. Each time a man walked across the given bridge, the experimenter approached him with questions and, afterward, provided her phone number, ostensibly so he could contact her to learn more about the study. The researchers in this study were curious if participants would misattribute the arousal they experienced from crossing the rickety bridge as attraction to the female confederate. In line with this hypothesis, the men were more likely to include sexual imagery in their responses and more likely to call the female experimenter afterward.

While this study was a remarkably clever approach to the question, several confounds complicate the picture. Perhaps the men who crossed the suspension bridge chose to cross that bridge because they were more bold and daring by nature and, as such, were more aggressive with the experimenter. Alternatively, the experimenter may have inadvertently behaved differently at the two bridges, or perhaps there were other features of the environment around the rickety bridge that facilitated attraction toward the female experimenter. Whatever the case, this very clever paradigm was somewhat compromised

by the lack of experimental control. In a DEVE, however, these confounds can be removed. The height of the bridge can be manipulated independently while controlling all other aspects of the situation and male participants can be randomly assigned to either condition (Ma, Blascovich, & McCall, forthcoming).

Another great boon to experimental manipulation is the ability to manipulate identity (Hoyt, Blascovich, & Swinth, 2003). Imagine, for example, that an experimenter is running a study in the physical world and wants to see the influence of race on face-to-face social interactions. If using confederates, the investigator will need to employ a confederate of every race needed. This, however, presents a confound as each of those confederates is a different person and any bias that emerges in the study may be a product of individual differences between them. Moreover, each confederate knows his or her own race, so their expectations about the interaction might influence its outcomes. One can, of course, conceal the confederates' faces and have them communicate via an impoverished medium such as the telephone or text, but the wealth of meaning borne out of people interacting in-person is lost. With DEVEs, on the other hand, one can manipulate the identity of an individual without them knowing it while still allowing examination of interactions in real time (Blascovich, 2006).

Along those lines, self-identity can even be manipulated. For example, Hoyt, Aguilar, Kaiser, Blascovich, and Lee (2007) manipulated the identity of White and Latino participants to examine attributional ambiguity (Crocker & Major, 1989), a phenomenon in which stigmatized individuals have a difficult time interpreting performance feedback when it is not clear whether the feedback stems from their actual performance or from prejudice on the part of the other individual. In this study, participants were represented in the DEVE as Latino or White and then given both positive and negative feedback. In line with earlier findings, virtually stigmatized individuals experienced attributional ambiguity when given feedback. This ambiguity buffered individuals from the effects of negative feedback, but also prevented them from benefiting from positive feedback. Moreover, this pattern emerged for actually White as well as actually Latino participants, demonstrating that attributional ambiguity is a product of the stigmatizing situation.

Along these same lines, DEVEs have allowed for remarkable demonstrations of the dynamic influence of identity on social behavior. Studies on the Proteus Effect (Yee & Bailenson, 2007), the tendency for an individual's behavior to be influenced by their virtual representation, demonstrate that identity is quite plastic. In one of these studies, participants were randomly assigned an avatar. Some of these avatars were rated beforehand as attractive while others were not. After seeing themselves in a virtual mirror, participants interacted in a DEVE with other avatars. In the interactions with more attractive avatars, participants approached them more closely and disclosed more information to them. In a similar experiment, the height of participants' avatars was varied. When represented with taller avatars, participants were more confident in a subsequent negotiation task, regardless of the fact that the confederate with whom they were interacting was blind to their condition. The Proteus Effect appears to also extend into the natural world. In one study, participants who had been given taller avatars in a VE subsequently negotiated more aggressively in an interaction in the physical world (Yee, Bailenson and Ducheneaut, 2009).

Beyond manipulating identity, it is also possible to manipulate the behavior of digital virtual humans. One example is the study described above, in which participants received either supportive or nonsupportive nonverbal behavior while walking along a steep ravine (Kane, McCall, Collins, & Blascovich, 2009). Another example comes from a study on

mimicry (Bailenson & Yee, 2005). In this experiment, participant interacted with an agent who was delivering a persuasive message. The animation of the agent was either driven by the participant's own head movements (at a slight lag) or driven by the head movements of the previous participant. The data revealed that the mimicking agent received significantly more positive ratings and was more persuasive, despite the fact that participants failed to detect the mimicry. It is difficult to imagine a similarly powerful demonstration working within the physical world with the same amount of experimental control.

If it is difficult to control a confederate's nonverbal behavior in the physical world, it is exceedingly difficult to control a whole crowd. Within a DEVE, however, controlling multiple humans is hardly more difficult than controlling one. In a recent pilot study performed in our own lab (McCall, Bailenson, Blascovich, Miyanojara, & Beall, 2009), we were interested to see if participants would orient toward a speaker when other attendees did so (Figure 5). Despite the fact that audience behavior was irrelevant to the task (i.e., to listen and remember the speech), participants were more likely to attend to the speaker when the audience was also attending. Moreover, participants remembered more of the speech if the audience spent more time oriented toward the speaker.

Work by Pertaub, Slater, and Barker (2002) provides a similar example. In their experiment, participants were required to give a presentation to an audience of agents. There were three different audiences, varying in behavior from negative to positive. In the negative condition, the audience yawned, fell asleep, slouched, oriented themselves away from the participant, leaned backwards, and avoided eye contact. In the positive condition, the audience nodded, smiled, leaned forward, and oriented themselves toward the participant. Multiple measures showed that participants in the negative audience condition experienced significantly more anxiety about the speech. These results emerged despite the fact that participants knew that the virtual humans in the study were agents and not avatars.

In addition to the ability to manipulate all of these factors, DEVEs also offer new options for measurement. As we mentioned above, body tracking is critical to many DEVE systems. That tracking, in turn, provides a wealth of data concerning the nonverbal behavior of individuals in an immersive environment. As such, one can have a near continuous and objective measure of head position and orientation (and any other tracked object) over the course of an experiment. These data can be very useful. In a recent study, we found that avoidant gaze and personal distance during an interaction with a Black agent predicted aggression toward that agent in a subsequent and ostensibly unrelated task (McCall, Blascovich, Young, & Persky, 2009). Conversely, in another study, we found that approach behaviors toward a disadvantaged other in a virtual world (e.g., a beggar) were positively related to dispositional measures of compassion (Gillath, McCall, Shaver, & Blascovich, 2008).

A study by Dotsch and Wigboldus (2008) found that Dutch participants kept more distance between themselves and Moroccan-appearing agents, then between themselves and White-appearing agents, and that these differences were predicted by implicit measures of prejudice. Moreover, these researchers found that physiological measures (i.e., skin conductance) mediated the effects of implicit prejudice on interpersonal distance. This paradigm reveals the ease with which multiple, online measures can be used in coordination with DEVEs. Indeed, researchers have used immersive environments in combination with measures of cardiovascular reactivity (Blascovich, 2006; Persky & Blascovich, 2007), functional magnetic resonance imaging data (Schilbach et al., 2005),



Figure 5 Screenshots from a virtual environment in which audience behavior was manipulated such that attendees spent more or less time oriented toward a lecturer.

and measures of neuroendocrine activity (Kelly et al., 2007). In all of these instances, DEVEs provided a platform for manipulating a wide range of contextual variables while in the kind of controlled environment that many sophisticated physiological measures require.

Future Directions

Very likely, the use of DEVEs to investigate social psychological processes will expand in the coming years. As DEVE-based methodologies evolve, scientists will increasingly conduct research that would never have been feasible in the physical world. Currently, full body tracking devices are becoming more widely available and the quality of computer graphics and animations continues to improve. Considerable strides in hardware also promise to expand standard DEVE platforms beyond mere audio and visual feedback to haptic and other domains. Also of particular interest to social scientists are strides in the development of intelligent, emotionally, and physically responsive human agents (Kenny et al., 2007). Through advances such as these, the mappings of virtual experience to 'real world' experience will become more obviously transparent and, more importantly, the number and variety of variables we can manipulate will increase. As such, the nature of the questions that we can address with DEVEs will continue to grow. Together, this technological and intellectual progress will help transform digital virtual reality from futuristic fantasy to a basic tool of social science.

Short Biography

Cade McCall uses IVEs to study nonverbal behavior in social interactions. His work has been published in *Media Psychology*, *Social Influence*, *Self and Identity*, *Cyberpsychology and Behavior* and *Presence*. McCall's current research examines the nonconscious mechanisms that produce expressive motor behavior. This work looks at both the dynamics of the body during social exchanges and their underlying neural representations. McCall holds a BA in English Literature from Macalester College and a Masters in Psychology from the Graduate Faculty at the New School of Social Research. He is currently completing his PhD in Social Psychology at the University of California, Santa Barbara where he is the lab director for the Research Center for Virtual Environments and Behavior.

Jim Blascovich is Professor and past Chair of the Department of Psychology at UCSB. He co-directs the Research Center for Virtual Environments and Behavior at UCSB. He is a past president of both the Society for Personality and Social Psychology and the Society of Experimental Social Psychology. He is a member of the Academy of Behavioral Medicine Research, a charter fellow of the Association of Psychological Science, and a fellow of the American Psychological Association. Dr. Blascovich was awarded the Inaugural Australasian Social Psychology Society/Society of Personality and Social Psychology Teaching Fellowship as well as an Erskine Fellowship and a Science Prestige Lectureship at the University of Canterbury in New Zealand. He won the Gordon Allport Prize Intergruop Relations Prize for 2007. He has also received the Chancellor's Award for Undergraduate Research at the University of California, Santa Barbara. Dr. Blascovich has served on numerous grant review panels and was appointed to the National Research Council's Committee to Evaluate the Scientific Evidence on the Polygraph. He Chaired the Committee on Opportunities in Basic Research in the Behavioral and Social Sciences for the Military. He has served on many editorial boards of journals, including

Psychological Science and the Journal of Personality and Social Psychology, Psychological Inquiry, Media Psychology, and Presence. Dr. Blascovich's research has received continuous funding from the National Science Foundation for more than 18 years as well as periodic funding from many other agencies.

Endnote

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