Courtroom Applications of Virtual Environments, Immersive Virtual Environments, and Collaborative Virtual Environments

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Abstract

This paper examines the possibilities and implications of employing virtual environments (VEs), immersive virtual environments (IVEs), and collaborative virtual environments (CVEs) in the courtroom. We argue that the immersive and interactive reality created by these tools adds significant value as a simulation of experience to enhance courtroom practice. The obvious boundaries between real and virtual enhance the attractiveness of these tools as technologies of rhetorical persuasion that can be used to demonstrate subjective perspective, strengthen or impeach the credibility of witnesses and provide the trier of fact with a better understanding of each side's perception of the facts at issue. In the first section, we introduce the concepts of VEs, IVEs, and CVEs, describe the manners in which these technologies have been applied to settings other than the courts system, and review the relevant psychological and legal literature. In the second section, we discuss specific applications of the technology to the court system and suggest how it could improve upon current procedures. Finally, in the third section we discuss some of the limitations and problems. This last section suggests legal reforms necessary to the adoption of these technologies, specifically rules of procedure that provide for all parties to be able to access, manipulate and inspect any virtual environment, the trier of fact to be able to interact with, rather than just accept the lawyer's rendition, and rules that provide for the parties to introduce at trial an inventory of all digital assets contained in the virtual environment, making those that are stipulated to and those that are in controversy.

While virtual environment technology is not yet fully realized, eventually it will provide distinct advantages to litigators within and outside of the courtroom. Its adoption should be promoted and even underwritten by the courts because this technology offers practical advantages for recreating crime and accident scenes, preparing witnesses, and experts, and conducting police lineups. But these immersive virtual environments are more than just faster videoconferencing techniques. While they offer practical advantages, as we shall discuss, they also represent a qualitative advance over earlier technologies. Unlike prior tools used for recreations and simulations, these are both immersive and interactive. There are those that argue that the risk of manipulation should prevent multimedia from being adopted in trial practice, but it is precisely because these new technologies produce simulated yet interactive reality that they are an ideal technique for rhetorical persuasion and argument. They are particularly well-suited for use in contexts where a subjective measurement of perspective is called for and where that perspective needs to be tested and even impeached. This article seeks to provide the raw material – an understanding of the technology – to argue for the use of these technologies and to enable lawyers and policymakers to make informed decisions about how these technologies will be introduced into the legal process. The immersive, interactive and highly mutable quality of these virtual environments does not vitiate their value to the legal process. Rather the characteristics of the technology point toward adopting procedural rules that allow all parties to “play” with the virtual reality simulations. This means that judge, jury and litigants should be able to test the immersive experience. All parties should have access to the simulation to be able to alter the perspective and impeach the credibility of the simulation. Finally, parties should be required to submit a list of “assets” or virtual objects included in a simulation and to mark graphically within the simulation those that are stipulated those, those that constitute dramatic interpretation and those that are known to be controverted.

Introduction to Virtual Environments

The term virtual reality has been widely used and often creatively exaggerated by Hollywood producers and science fiction writers for decades. Consequently, there are many misconceptions and expectations about the nature of the technology. For the purposes of this paper, we define virtual environments (VEs) as “synthetic sensory information that leads to perceptions of environments and their contents as if they were not synthetic” (Blascovich, et al., 2002, pg. 105). Typically, digital computers are used to generate these images and to enable real-time interaction between a user and the VE. In principle, people can interact with a VE by using any perceptual channel, including visual (by wearing a head-mounted display with digital displays that project objects in the VE), auditory (by wearing earphones that are conducive towards playing sounds that seem to emanate from a specific point in space in the VE), haptic (by wearing gloves that use mechanical feedback or air blasts towards the hands when a person makes contact with an object in the VE), olfactory (by wearing a nosepiece that releases different smells when a person approaches different objects in a VE), or gustatory senses.

Our definition of VE would include non-digital information. For instance, a scarecrow in a field is an example of physical, synthetic, sensory misinformation that deceives crows into thinking the farmer is guarding the crops. Along similar lines, lawyers have often employed physical virtual environments in courtrooms, for example using physical objects to indicate a suspect's and witnesses' relative positions. Like the scarecrow that is meant to deceive the crow into thinking that the farmer is in the garden, VE technologies create a richly-instantiated but still simulated version of reality. The boundaries of the physical virtual environment are evident, allowing the use by lawyers in the courtroom of these tools as a mechanism for argumentation and persuasion.

In this report, however, we focus on digital VEs. Current software (i.e., Vizard, 3D Studio Max, 3dMeNow, Poser) makes it quite easy to produce digital virtual worlds, and consequently, digital VE simulations can be produced to fit almost any specific application with only moderate degrees of cost and effort. The similarity between non-digital and digital VEs remains important; researchers and litigators who employ digital VEs are not engaging in any qualitatively new or unsound technique. Instead of using maps, charts and cardboard cutouts, proponents of VEs are using computers.

An immersive virtual environment (IVE) is one that perceptually surrounds the user of the system. Consider a child's video game; playing that game using a joystick and a television set is a VE. On the other hand, if the child were to have special equipment that allowed her to take on the actual point of view of the main character of the video game, that is, to control that character's movements with her own movements such that the child is actually inside the video game, then she is interacting in an IVE.

In other words, in an IVE, the sensory information of the VE is more psychologically prominent than the sensory information of the physical world. For this to occur, IVEs often employ two characteristic features. First, the users are unobtrusively tracked as they interact with the IVE. User actions such as head orientation and body position are automatically and continually recorded and the IVE in turn is updated to reflect the changes resulting from these actions. In this way, as a person in the IVE moves, the tracking technology senses this movement and renders the virtual scene to match the user's movement. Second, sensory information from the physical world is kept to a minimum. For example, in an IVE that relies on visual images, the user wears a head-mounted display (HMD) or sits in a dedicated projection room. By doing so, the user cannot see the objects from the physical world, and consequently it is easier for them to become enveloped by the synthetic information. Two important features of IVEs that will continually surface in later discussions are: 1) IVEs necessarily track a user's position and head direction, facial expression and sometimes eye direction to render the scene, providing a wealth of information about where the user is focusing his or her attention and what can be observed from that specific vantage point, and 2) The designer of an IVE has a tremendous amount of control over the user's experience, and can design the virtual world to look and feel in almost any desired manner.

IVEs can be configured and displayed in a number of ways. Figure 1 shows one

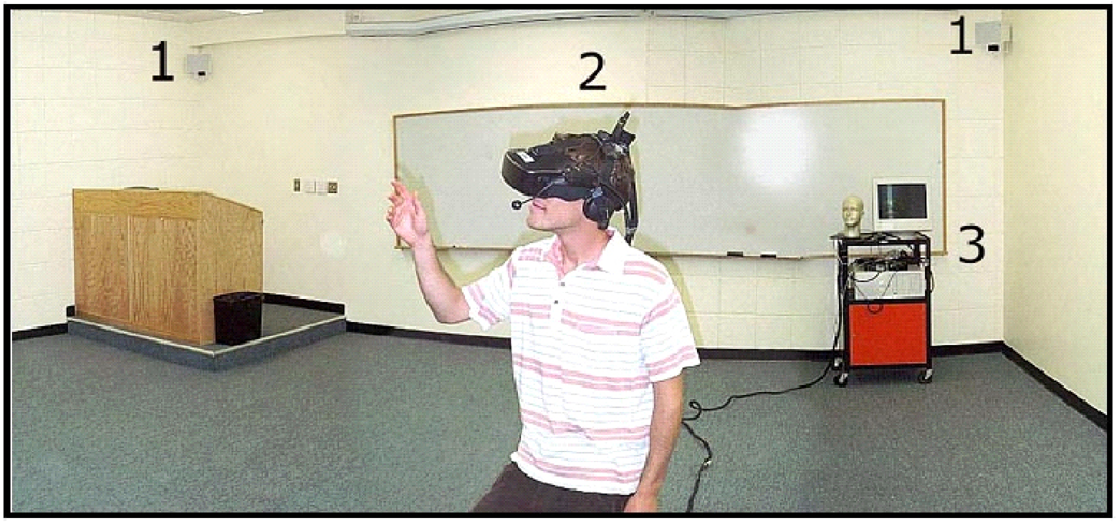

Figure 1: A depiction of an HMD based IVE. The components are: 1) position tracking cameras. 2) HMD and orientation tracking sensor, and 3) image generator.

example, a system in which a user wears an HMD that displays images via small computer screens over each eye. As the user in this example interacts with the virtual world, an optical motion sensor tracks his position in the room and an inertial motion sensor tracks his head orientations. Both of these devices are lightweight enough to be attached to the user's HMD and provide accurate and fast screen updates, that is, a constant redrawing of the VE for the user as a direct function of his translation and orientation. In other words, sixty times per second, the system redraws the objects in the virtual world. Every time it redraws the virtual world, it checks to see if the user, in the physical world, has turned his or her head, or if the user has walked in any direction. If he or she has changed their orientation or position, then the system redraws the virtual objects in the VE to reflect those exact changes. In this sense, the person moves through the VE in the same way that he or she would move through the physical world. Furthermore, the HMD provides the user with distinct images for each eye, providing stereoscopic depth cues, the information concerning distance and depth that people receive from having two eyes facing in the same direction, inside the IVE.

Together, this system convinces the user's perceptual system that he or she is contained inside an actual 3D world and allows the user to actively explore that world in any manner he or she chooses. Research demonstrates that people walking through IVEs can navigate and perceive directional information quite proficiently, almost as well as in the physical world (Chance, Guanet, Beall, & Loomis, 1998), although operating joystick-based desktop VEs causes spatial performance to drop (Richardson, Montello, & Hegarty, 1999).

An alternative IVE configuration is a Cave Automatic Virtual Environment (CAVE). In this system, the user stands inside a cube-shaped room with rear-projection screens as walls. The user's position is usually tracked by a type of an electromagnetic device and orientation tracking is unnecessary (since the world is projected all around the user on the six sides of the cube). However, instead of wearing the HMD, the user wears shutter-glasses (for stereoscopic vision) and receives updated visual images by looking at the screens covering the walls.

A large amount of research regarding IVEs centers on the notion of presence, the degree to which the user actually feels as if they are present in the IVE (as opposed to present in the physical world). A wealth of research seeks to understand the phenomenon of presence: understanding the mechanisms that underlie the subjective experience of "being in another world" strikes at the very heart of the virtual reality experience. To validate IVEs as a usable courtroom technology, it is important to consider the extent to which a user is immersed in the digital world created by the lawyer (as opposed to the physical courtroom).

Attempts at capturing the subjective experience of presence in an objective manner have proceeded along several different lines, including questionnaire ratings (Short, Williams, & Christie, 1976; Held & Durlach, 1992; Witmer & Singer, 1998), physiological measures (Meehan, 2001; Weiderhold, Gervirtz, &, Wiederhold, 1998), and behavioral measures (Zahorik, 1998; Meehan, 2001; Bailenson, Beall, & Blascovich, 2002; Mania & Chalmers, 2001; Welch, 1999). Despite broad research on the topic of presence, reliable, objective measures are still lacking, and much debate as to how to improve current measures continues (Loomis, 1992; Lombard & Ditton, 1997; Slater, 1999).

Often times, multiple people interact with one another inside of the same IVE or VE; this arena is called a Collaborative Virtual Environment (CVE). A basic example of a CVE is an Internet chat room. In these collaborative environments, users may or may not be located in the same physical environment; however, their movements, nonverbal behaviors, and voices are all projected into a single VE or IVE. In CVEs, a user is typically represented by some type of a visual form called an avatar (see Bailenson & Blascovich, 2002, for an extended definition). In addition to experiencing presence in a CVE, users also experience social presence (also known as copresence) while interacting with other avatars. Social presence reflects the degree to which a user of a CVE feels that he or she is in the presence of and interacting with other veritable human beings (Blascovich et al. 2002; Bailenson, Blascovich, Beall, & Loomis, 2002, 2001; Heeter, 1992; Short, Williams & Christie, 1976). Many factors contribute to social presence, including the photographic realism of the avatar (i.e., how much the avatar looks like a real person), the behavioral realism of the avatar (i.e., the richness and naturalness of the avatar's gestures, speech, and actions), and the personal relevance of the interaction within the CVE to the user (i.e., how personally involved the user becomes in the interaction). A detailed discussion of the interaction of these factors is provided by Blascovich and colleagues (Blascovich et al., 2002).

The use of VEs and IVEs is becoming more commonplace, both in scientific research and in practical applications. The technology is used in medical settings for purposes of training and for distracting patients during complicated or painful procedures (Kamberova & Bajcsy, 1999; Sadagic et al., 2001). It is used in psychological therapy to treat, for example, fear of heights, flying and public speaking (Riva, Wiederhold, & Molinari, 1998). And it is used to implement tutoring agents, online computer programs that teach students over distance learning networks (Moreno, Mayer, Spires, Lester, 2001; Cassell, Sullivan, Prevost, & Churchill, 2000), and to establish effective systems of communications that remedy some of the delay issues and gaze direction problems inherent to videophones (Beall, Bailenson, Loomis, Blascovich, & Rex, 2003; Lanier, 2001; Reeves & Nass, 1996).

Applications of IVES, VEs, and CVEs to the Courtroom

In this section we discuss how IVEs and CVEs can be used situations that relate to the court system, to aid in trial preparation, to present evidence and support argument during trials, to impeach witnesses and provide an additional form of record keeping during trials. Specifically, this technology would presumably be used primarily by attorneys for presentations to the triers of fact (judge or jury), as well as a springboard used to elicit reactions and opinions for expert or non-expert witnesses, either in preparation for or at trial. They can be used to put the trier of fact in the position of the parties and witnesses to the events surrounding the litigation. While there has been some work discussing the legal implications of VEs in terms of intellectual property rights and ownership (see Lastowka & Hunter, 2003, for a review), there is little work discussing courtroom applications and none from a technological perspective that provides a taxonomy of the available tools with a survey of the psychological literature concerning their use. The current work attempts to provide this much-needed discussion. We begin by discussing how the re-creation of crime and accident scenes can benefit from the use of virtual technology.

Recreating Crime and Accident Scenes. One of the most promising courtroom applications of IVEs is re-creating crime and accident scenes (i.e., Phillips, 1990). In other words, lawyers can create an extremely realistic schematic of the exact site on which a crime or accident occurred, including inanimate objects from the scene, witnesses, victims, and suspects from the scene, atmospheric conditions from the scene such as bright light or fog, background noise such as traffic sounds, and literally any sensory information that may have been on the scene. Figure 2 depicts a recreation of a blackjack table at a casino (Swinth & Blascovich, 2001).

Figure 2: An IVE recreation of a crime scene at a casino

In this recreation, many specific details are rendered, such as the clothing of the dealer and the players, the layout of the cards, and the visual noise on the carpets and the walls. Furthermore, the visual VE is augmented with auditory cues such as casino sounds and voices.

This simulation can be extremely useful in elucidating what happened at a crime or accident scene. While we would not suggest that any tool can be used to ascertain an objective truth, these immersive simulations can greatly help to impeach the testimony of unreliable witnesses, test forensic assertions and enhance understanding of a past experience. For example, assume that the dealer accused the man on the left of cheating with his right hand, and the woman testifies that she witnessed this behavior. Because it is possible to render an IVE from any orientation in the room, it is possible to demonstrate whether the woman had the vantage point to witness the man cheating. As Figure 3 demonstrates, given their seating arrangements, the suspect's right hand was not visible to her.

Figure 3: The witness's view of the suspect during the alleged cheating

This type of scene recreation could facilitate witness preparation before trial and cross examination of witnesses at trial, helping to assess whether the physical facts are as the parties purport them to be. A defense attorney would be able to conduct direct examination of the suspect (i.e., to support his testimony that it was not possible for anyone to see what he was doing with his right hand), and conduct a cross-examination of the witness (i.e., to show that what the she could not have possibly witnessed the alleged cheating from her viewpoint).

To further illustrate, examine the configuration of medical personnel around a patient undergoing open heart surgery depicted in the virtual simulation in Figure 4.

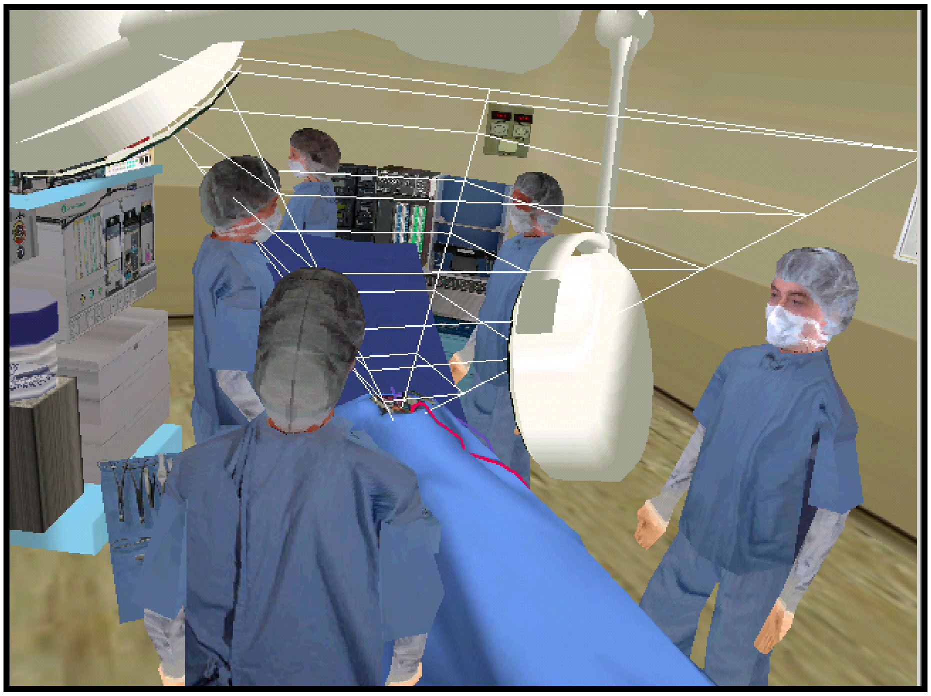

Figure 4: A simulation demonstrating witness viewing abilities with a view frustum created for the Federal Judicial Center and utilized in Courtroom 21 at William and Mary.

Consider a situation in which a heart surgeon purportedly acted incompetently during the surgery, causing the death of the patient. This simulation is valuable in demonstrating the viewing ability of each of the witnesses in the room. In this IVE, we inserted a view frustum (i.e., the white mesh structure). If a person's head was not contained within this frustum, then they would not have been able to see the surgeon's hands operating within the heart cavity. Consequently, lawyers can use this simulation to credit or discredit testimony.

A lawyer could also use an IVE to give jury members a 'first hand' experience of a crime or accident scene. Unlike a map or chart or another audiovisual aid introduced by lawyers at trial, the IVE can be manipulated by the jurors themselves who interact with the virtual environment. By bringing a juror into an IVE, the lawyer can give the juror her client's perspective view of the scene and the juror can manipulate and "play" with the digital assets to test the credibility of that perspective. Lawyers can use these recreations to establish the emotional state of the defendant (i.e., was an assault actually a case of self-defense?), the witness (i.e., would the average person been able to remember a given number of details under stress?), or the victim (what type of emotional distress did the victim suffer?).

One criticism of using IVEs to recreate crime or accident scenes is that it is superfluous, in that there is no point in recreating a virtual accident scene when the court already has procedures to allow visits to the actual scene when appropriate. But, if we conceive of IVEs as a persuasive tool, then the point is not to recreate reality or truth but to show the lawyer's argument of what that truth was. Practically speaking, the IVE can also be useful in those cases where it may not be possible to visit the original scene. For example, it would be difficult for the judge and jury to visit a crime or accident site that is located a distance from the courtroom, and is impossible to visit a site when it has changed in significant ways (i.e., from construction or landscaping) since the crime was committed or accident took place. Furthermore, using an IVE, lawyers can recreate the exact conditions of the accident or crime in the scene, such as lighting due to time of day, weather conditions such as fog or rain, and background noise due to differential traffic. Similarly, because lawyers have complete control over the simulation, IVEs allow the scene to be regulated such that every single user (jurors, witnesses, or suspects) experiences the same sensory input (as opposed to a physical site visit, where people might be focusing on different things). Finally, in some instances it may be less expensive to build an IVE than to transport the entire courtroom staff and equipment to a remote location.

One important concept to discuss is the method of creating such a crime-scene IVE. These environments will be created based on a witness's assumptions about what actually happened, and those assumptions may or may not be made explicit. This fact leads to a number of fundamental policy questions. For example, whose assumptions Should underlie the creation of an IVE? If two parties hold fundamentally different assumptions about the spatial layout or the event sequence in a given area, it may be difficult to resolve these disparities into a single unified virtual world. However, one of the advantages of many IVEs is the ability to simply adjust already existing IVEs. Consequently, given two IVEs, built on two vastly different assumptions about some concrete fact, the parties can continually adjust or morph the IVEs until they reach a version that represents a compromise of their assumptions.

However, this compromise strategy only works when these assumptions are explicit and are disclosed to the other side. It remains to be seen if the structural details of the IVE are objective enough to be easily shared and agreed upon. Furthermore, sharing of assumptions in this regard may only be possible if both sides have access to the technology. If one side does not have the technical capabilities or the financial resources to properly contribute to or even understand the IVE, it may be extremely difficult to settle upon a common set of assumptions and stipulations. Similarly, the side that in fact has the technology may be at an unfair advantage in presenting and organizing their evidence. It may be possible for this technology to be used not only as a neutral tool to create a crime scene depiction that can be used by both parties, but to instead be used for adversarial leverage, if it is only in the hands of a single side. It is up to the courts to determine if is necessary to counter this one-sided use of IVEs. Currently, a given party can unilaterally employ an expensive legal team and hire expert witnesses, regardless of the behavior of the other party. Perhaps IVEs will be treated in a similar manner.

Demonstrating Eyewitness Testimony. Currently, researchers are exploring the use of IVEs as a mechanism to demonstrate witnesses' identification of suspects in lineups. The use of these technologies in identifying suspects improves upon earlier technology by making it possible to gauge degrees of certainty and better understand the subjective perspective of the witness.

Graphics software can produce digital busts, three-dimensional reproductions of human faces which are quite accurate. Figure 5 shows an example of an individual whose head has been reconstructed using this technique. Research by the authors of this report (Bailenson, Beall, Blascovich & Rex, 2004, Bailenson, Beall, & Blascovich, 2003)

Figure 5: Five viewpoints of a three-dimensional digital bust

demonstrates that, in a series of studies, people are quite good at learning and recognizing these digital busts. In those studies, experimental participants were trained to learn alleged suspects by either watching videotapes or by studying photographs. Then, the same participants had to identify those suspects by examining additional photographs of the suspects or by examining images of the virtual busts of the suspects. The results of over a dozen studies using over 300 experimental participants indicate that, given current technology, people are slightly better at recognizing photographs of faces than still-images of the digital busts. However, as this developing technology for crafting the three-dimensional heads improves, this difference should diminish. It is important to point out that, just as photographs are not perfect representations of live human faces, neither are digital busts. However, due to being able to capture three-dimensional information concerning depth, as well as being able to portray faces from variable angles and distances, in the near future digital busts should easily outperform two dimensional photographs.

Lineups are traditionally conducted during pretrial investigation, with a number of established guidelines concerning the choice of distracter heads, method of presentation, and the wording of instructions given to the identifier (see Wells, 2002, for a review). However, using IVEs, lawyers would be able bring a lineup into the courtroom for high-impact demonstrations of identification (i.e., “Do you see that man in the courtroom now?”). In the courtroom, this technology could be used for the purpose of demonstrating witnesses’ ability or inability to recognize suspects. Figure 6 demonstrates a live lineup and a virtual version of the same lineup.

Figure 6: Humans in the physical room (left) and virtual humans in the virtual room (right)

Note that the background in the IVE is the same as the background in the physical room. This is an important advantage of using IVEs; the witness can be required to identify the suspect, with both the suspects and the foils (i.e., the distracter people in the lineup) appearing in the context of the crime scene. Previous research on eyewitness testimony uses contextual cues from the crime scenes to maximize eyewitnesses' recognition ability: showing photographs of the environment (Cutler, Penrod, & Martens, 1987), showing objects from the environment (Krafka & Penrod, 1985), on site lineups (Davies & Milne, 1985), and Mental Contextual Reinstatement cues (Hershkowitz, Orbach, Lamb, Sternberg, & Horowitz, 2001; Cutler, Penrod, O'Rourke, & Martens, 1986). In particular, memory for faces is aided greatly by background context. Research by Memon & Bruce (1983) demonstrates that in certain situations, the background context of a photograph can have a greater impact on recognition than the features of the face itself. Consequently, using VEs and IVEs to aid the recognition process during lineups should be a valuable tool for lawyers who use IVE lineups during the courtroom procedure.

Furthermore, IVE lineups have the advantage of allowing for a more controlled use of foils, in that lawyers would not have to rely on recruiting live actors who are similar to the suspect. Instead, they could draw the foils from a large database of digital busts. Furthermore, the digital busts are composed of an underlying mesh, as

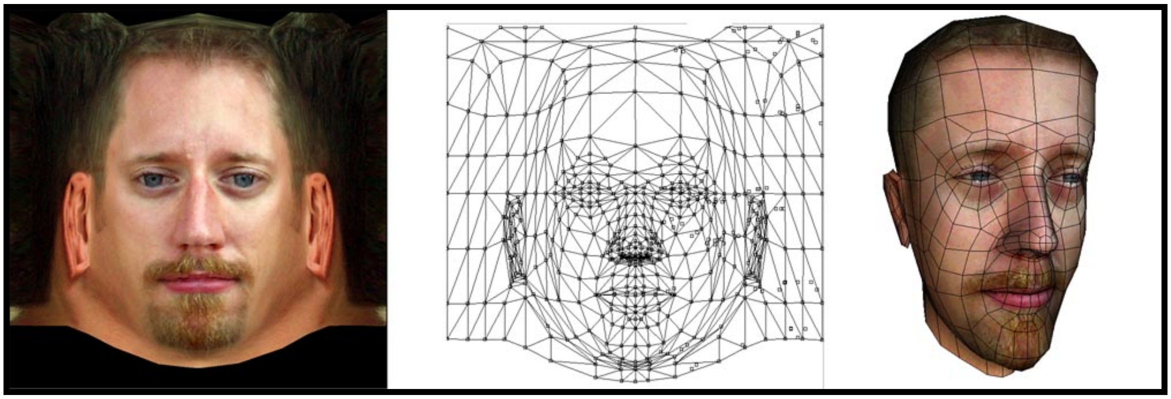

Figure 7: The left panel shows the standard face/head texture map used in our 3D reconstruction process. The middle panel shows the normalized low-resolution geometry mesh. The right panel shows the end result of mapping the two together and warping the result

Figure 7 demonstrates. This mesh can be easily changed using morphing techniques (Rizzo, Neumann, Enciso, Fidaleo, & Noh, 2001; Blanz & Vetter, 1999). Consequently, it is possible to produce foils by stretching the underlying mesh or pigmenting the texture map of the suspect to whatever degree of dissimilarity is necessary.

Remote Witness/Remote Expert testimony. Courtrooms use videoconferencing technology as a way to provide testimony and cross examination of remote witnesses, particularly expert witnesses. This technology allows for people who would be unable to attend the trial otherwise to still provide useful testimony. Currently, researchers are exploring the possibilities of using CVEs as a substitute for videoconferencing (Slater, Sadagic, Usoh, & Schroeder, 1999; Normand et al., 1999; Colburn, Cohen, & Drucker, 2000; Vertegaal, Slagter, van der veer, & Nijoholt, 2001; Bailenson, Beall, Loomis, Blascovich & Turk, 2004) due to the numerous shortcomings of current videoconferencing technology. IVEs, by providing greater graphical context, can help to reintroduce the ritual and solemnity of the courtroom while taking advantage of the convenience of testimony across the distance.

First, with videoconferencing, it is often extremely difficult to achieve natural mutual gaze (Chen, 2002; Gale & Monk, 2000) due to physical misalignment between the image of a person's face and the video camera's lens. In video conferencing, the video camera serves as the other person's eyes. Consequently, in order to convey the impression to the other that one is making eye contact, one must look directly at the lens. In most arrangements, one cannot simultaneously look at both the camera lens and the image of the face of the other, and instead merely looks at the image of the face of the other. This behavior leaves the other person with the impression that mutual eye contact is never achieved. On the other hand, CVEs potentially achieve a more complete sense of mutual gaze due to the ability to track each user, and in turn render the appropriate looking direction of each avatar in the CVE.

Second, video conferencing requires extremely high bandwidth in order to send real-time high-resolution video and audio streams over a network. Consequently there is often a noticeable transmission delay to conferencing partners. This delay often causes the interaction to be awkward, especially when video and audio are out of sync. CVEs, however, do not need to continuously send detailed images over a network. The three-dimensional models of the users only need to be sent once, after which, the only information that goes back and forth over the network is tracking data of the users. This amounts to several orders of magnitude less bandwidth than true video. Consequently, CVEs may be equipped to communicate the emotional content of voice or nonverbal movements better than traditional videoconferences, and may be a more effective medium for jurors to assess and evaluate credibility. Moreover, using the technology to engage physically remote jurors in the trial also becomes a possibility (Marder, 2005).

Another advantage of using CVEs for remote conferencing (as opposed to videoconferences) is the ease of recording and symbolically coding the interaction. Because a CVE automatically tracks looking direction and body position, it records the interaction in ways that is not possible with a simple videoconference (i.e., Bente, Kramer, Peterson, & de Ruiter, 2001). For example, it is possible to implement post-hoc algorithms that automatically can go through recordings of interactions to detect the degree to which users were maintaining mutual gaze and paying attention to questions. Furthermore, it may be possible to analyze the tracking of nonverbal gestures gleaned from the tracking data to detect patterns of affect or even intentional lies or confabulation (i.e., Ekman & O'Sullivan, 1991).

Pre-Trial Application. Lawyers can employ IVEs to acquaint witnesses with the stress and rigors of being in a crowded courtroom. Currently, lawyers dedicate ample amounts of time and resources towards practicing examinations with witnesses and experts. Research with IVEs demonstrates that people speaking in front of groups of 'virtual people' in an IVE feel similar degrees of social anxiety and stress that they do speaking in vivo in front of actual people (Pertaub, Slater, & Barker, 2001). Consequently, practicing testimony in front of a group of virtual jurors, judges, and lawyers may be more ecologically valid and effective than simply practicing inside an empty legal office or in front of paid college students who do not vary in terms of age, race, and emotional disposition. Furthermore, with crime and accident scene recreations, lawyers will be able to more easily understand a witnesses' experience before the trial begins. Along the same lines, using an IVE accident scene recreation, plaintiffs and defendants should be able to gain a thorough understanding of each others' cases before going to trial. This mutual understanding may result in an increase of out of court settlements.

Limitations of Using VEs and IVEs in the Courtroom

Lack of Realism. Although, the past few years have demonstrated a sharp acceleration of the realism of VEs and IVEs, the technology still has a long way to go before the photographic realism of crime and accident scenes and the behavioral realism (i.e., gestures, intonations, facial expressions) of avatars in CVEs approaches the realism of actual situations and people. Furthermore, given current programming tools, the time and resources required to produce VEs and IVEs with sufficient realism arguably dwarf the advantages for using the technology in the courtroom. Without near-perfect realism, there are those who argue that an IVE may not be of any greater use than a two-dimensional display, or worse yet, might be misleading. Finally, while technology for visual VEs and IVEs steadily develops, systems for the other senses (i.e., auditory and haptic) are not progressing as quickly. Consequently, it may be some years before the technology rivals a "real world" experience.

Our inability to create perfectly simulated reality is the reason why these technologies should be adopted. If the recreations are too perfect, then the risk of manipulation and abuse goes up. But so long as we can see the wizard behind the curtain, the more we can trust the trier of fact to distinguish between the "truth" and rhetorical persuasion. At the same time, the levels of realism of VEs and IVEs have grown exponentially over the past few years, and the resources required to create and experience the worlds have fallen drastically (see Burdea & Coiffet, 2003 for a review).

Over the next few years, the quality of IVET should continue to increase while the cost decreases, making the simulation experience more effective without erasing the boundaries between virtual and real.

Experiential Inflammatory Bias. One potential pitfall with implementing VEs and IVEs in the courtroom is that the persons interacting within the IVE may be so persuaded by its lifelike nature that they may become unable to visualize an opposing viewpoint of those events. This is precisely the reason why all parties to the litigation must be allowed to manipulate and alter any virtual environment introduced into evidence. Given that IVEs perceptually surround the jurors, the potential for them to become swept up in the emotional content (i.e., experiencing an extremely high degree of presence in the crime or accident scene recreation) are much larger than with two-dimensional photographs, videos or first-person accounts (i.e., Slater, Linakis, Usoh, Kooper, 1996). To prevent any bias from the emotional experience, either judges or the federal and state rules of civil procedure might implement stringent requirements that IVEs: 1) not intentionally deceive, 2) be substantially similar to actual events, 3) be rendered so as to minimize the chances jurors might mistake argument for fact, and 4) give rise to sanctions for lawyers who intentionally misuse them, 5) and most important, be subject to inspection, manipulation and modification by the opposing party.

While people tend to have a difficult time objectively removing information from their decision calculus (see Kassin & Studebaker, 1998 for a review) alternative evidence suggests that juries are capable of displaying appropriate amounts of cynicism, rejecting blatant attempts at inflammation by jurors and gratuitous use of technology (Lederer, 2004). At any rate, the ability to provide inflammatory information certainly exists in the courtroom today without IVET, and there is no reason to suspect that the inability of juries to disregard inflammatory information should be uniquely exacerbated using digital technology. For example, Sherwin (2000) describes the dramatic physical reenactment of four large men surrounding a dummy in the Bernhard Goetz trial. The rules for determining inflammatory simulations should be no different with digital large men.

At any rate, if both sides in a trial have access to the same tools to utilize, this potential for inflammation does not serve either asymmetrically. While it will likely turn out to be the case that IVET favors parties who have the money to spend on building the simulations and to hire the experts to testify about them, this disparity is no different from any other type of high-priced trial consultancy.

Potential for Manipulation. Given the potential for creating emotional bias with an IVE, lawyers could intentionally or inadvertently use the technology in arguable inappropriate ways. With a simulation that perceptually surrounds the user, it is possible and to subtly change the simulation to create certain moods and affective states for the user (Rizzo, Wiederhold, & Buckwalter, 1998). Consequently, lawyers would be able to include subtle mood-changing environments in their IVE simulations that could be used to create positive or negative associations towards a plaintiff or a defendant. Furthermore, lawyers might be able to include details in a simulation that were not present in the actual crime. Given the rich amount of detail in a realistic IVE simulation of an accident or crime scene, these ‘planted’ objects might not be noticed by opposing lawyers, and may function as subtle cues for jurors.

The court should maintain an active role as gatekeeper of scientific and technical evidence presented. If this solution were to come to fruition, then the court must determine (1) the acceptable standards for creating IVEs (e.g., the general technical procedures and protocol) and (2) whether the proffered IVE meets those standards. In regards to the first point, the standards that apply to non-digital VEs, for example, cardboard cutouts depicting locations of people and objects in a crime scene, should apply, although the process of validating a digital VE may be more involved and will necessarily require different types of experts. When determining whether a particular IVE meets acceptable standards, the court must decide if the questions answered by the party proffering the exhibit (or asked by opposing counsel and the court) are important enough to justify bringing in this new technology.

Our analysis of the technology suggests, for example, that the legal framework in which these tools are introduced, should provide, not only, as previously suggested, for all sides to have access and the trier of fact to be able to interact with the simulation but for an inventory of digital assets within the IVE to be submitted to the court. Uncontroversial objects or assets to which the parties have stipulated will appear normal in the simulation. Assets that are controverted and the subject of debate and discussion by the parties should have a special appearance. They might blink or be a different color or indicate their controversial status when "moused over." While this rule of presentation would interfere with the verisimilitude of the presentation, they would help to ensure that the argumentative and persuasive nature of the technology's courtroom use will be clear.

However, it may be the case that the court will not, at least initially, have the expertise, time, and resources to play an active and effective gatekeeper. Many attorneys attempt every possible strategic ploy within the rules to win for their clients. Given this predisposition, attempting to bias jurors through subtle manipulations in the virtual environment demonstrations may become the rule rather than the exception, and the creation of virtual environments will probably become part of the growing repertoire of trial consultants and companies that produce courtroom exhibits, displays and demos. Where attorneys come to agreement in advance of a trial on the digital portrayal of a crime scene or accident it will may prove too difficult for the courts to exercise a gatekeeper role. In this instance, the impact of these potential manipulations becomes much less harmful if each side presents their own IVE as a mechanism to present evidence. In this sense, each side's IVE simply becomes a more effective way of highlighting arguments and evidence than other traditional methods.

Simulator sickness. One problem with the use of IVEs and VEs is the potential for the user to experience simulator sickness. This experience is similar to what one might feel from riding a roller coaster at an amusement park, and usually results from some sort of mismatch of sensory information. For example, as a user moves about in an IVE, her visual experience (i.e. optic flow) is often different from her proprioceptive experience (i.e., vestibular and kinesthetic cues) due to imperfect tracking devices and distortion when rendering the virtual images. In extreme cases, this disparity can cause nausea, dizziness, and other symptoms. An abundance of research documents the conditions that promote simulator sickness and discuss the implications of it (Barret & Thornton, 1968; Biocca, 1992; Kennedy, Lane, Berbaum, & Lilienthal, 1993). This problem is not as prevalent in current IVEs and CVEs. For example, Bailenson & Yee (in press), have conducted a longitudinal study in which groups interacted via CVEs for a period of 10 weeks. In that period, not a single person experienced any significant bouts of simulator sickness.

Conclusions

In conclusion, we believe that IVE technology is mature enough to be seriously considered for courtroom use. Indeed, three-dimensional visualizations (i.e., animations) are already used as demonstrations in the courtroom, and rigorous debate occurs as to whether the use of technology is useful, advantageous or inflammatory. There is no reason to suspect that any qualitative changes to this debate will arise with the advent of IVEs. In other words, there is already a developing paradigm that is simultaneously embracing and vilifying technology in the courtroom; IVEs should not be treated any differently than other types of digital animations and visualizations.

To the contrary, immersing these two-dimensional visualizations into interactive and realistic virtual environments will only improve the process by making these visualizations much easier for the lay person to comprehend. As we discuss in the first section of this paper, the immersive quality of VEs and CVEs can have greater impact than simple animations in terms of facilitating memory recall, activating affect, and aiding in conceptualization and integration of visually complex scenes. If a picture is worth a thousand words, than an immersive virtual reality simulation should be worth at least ten thousand. Given this potential for improvements, it is especially crucial for the courtroom to ensure that the use of IVEs is regulated properly, such that the technology aids the search for truth, as opposed to providing unnecessary “bells and whistles” to woo a jury. Future research should examine in depth the actual advantages that one accrues from the substantial process of creating an IVE, and determine the optimal situations for the parties, courts, and jurors to dedicate their time and money towards an IVE solution.

References

Anstis, S., Mayhew, J., & Morley, T (1969). The perception of where a Face or Television "Portrait" is Looking. American Journal of Psychology, 474-489.

Bailenson, J.N., Beall. A.C., & Blascovich, J (2002). Mutual gaze and task performance in shared virtual environments. Journal of Visualization and Computer Animation, 13, 1-8.

Bailenson, J.N., Beall, A.C., & Blascovich, J. (2003). Using Virtual Heads for Person Identification: An Empirical Study Comparing Photographs to Photogrammetrically-Generated Models. Journal of Forensic Identification, 53 (6), 722-728.

Bailenson, J.N., Beall, A.C., Blascovich, J., & Rex, C. (2004). Examining Virtual Busts: Are Photogrammetrically-Generated Head Models Effective for Person Identification? PRESENCE: Teleoperators and Virtual Environments, 13(4), 416-427

Bailenson, J.N., Beall, A.C., Loomis, J., Blascovich, J., & Turk, M. (2004). Transformed Social Interaction: Decoupling Representation from Behavior and Form in Collaborative Virtual Environments. PRESENCE: Teleoperators and Virtual Environments, 13(4), 428-441

Bailenson, J.N., Blascovich, J., Beall, A.C., & Loomis, J.M. (2001). Equilibrium revisited: Mutual gaze and personal space in virtual environments. PRESENCE: Teleoperators and Virtual Environments, 10. 583-598.

Bailenson, J.N., Blascovich, J., Beall, A.C., & Loomis, J.M., (2003). Interpersonal distance in immersive virtual environments. Personality and Social Psychology Bulletin, 29. 1-15.

Bailenson, J.N. & Yee, N. (in press). A Longitudinal Study of Task Performance, Head Movements, Subjective Reports, Simulator Sickness, and Transformed Social Interaction in Collaborative Virtual Environments, PRESENCE: Teleoperators and Virtual Environments.

Beall, A.C., Bailenson, J.N., Loomis, J., Blascovich, J., & Rex, C. (2003). Non-Zero-Sum Mutual Gaze in Collaborative Virtual Environments. Proceedings of HCI International, 2003, Crete.

Bente, G., Krämer, N. C., Petersen, A. & de Ruiter, J. P. (2001). Computer Animated Movement and Person Perception: Methodological Advances in Nonverbal Behavior Research. Journal of Nonverbal Behavior, 25 (3).

Bailenson, J.N., & Blascovich, J. (2004, in press) Avatars. Encyclopedia of Human-Computer Interaction, Berkshire Publishing Group, 64-68.

Blascovich, J., Loomis, J., Beall, A., Swinth, K., Hoyt, C., & Bailenson, J.N. (2002). Immersive virtual environment technology as a methodological tool for social psychology. Psychological Inquiry, 13, 103-124.

Barrett, G. V. & Thornton, C. L. (1968). Relationship between perceptual style and simulator sickness. Journal of Applied Psychology, 52(4), 304-308.

Beall, A.C., Bailenson, J.N., Loomis, J., Blascovich, J., & Rex, C. (2003). Non-Zero-Sum Mutual Gaze in Collaborative Virtual Environments. Proceedings of HCI International, 2003, Crete.

Biocca, F. (1992). Will simulation sickness slow down the diffusion of virtual environment technology? Presence, 1(3), 334-343.

Blanz., V. and .Vetter, T. (1999). A morphable model for the synthesis of 3d faces. In SIGGRAPH'99 Conference Proceedings, pages 187—194.

Burdea, G. C., & Coiffet, P. (2003) Virtual Reality Technology– 2nd Edition, IEEE Press – Wiley.

Cassell, J., Sullivan, J., Prevost, S., & Churchill, E. (Eds.). (2000). Embodied conversational agents. Cambridge: MIT Press.

Chance, S. S., Gaunet, F., Beall, A. C., Loomis, J. M. (1998). Locomotion mode affects the updating of objects encountered during travel: The contribution of vestibular and proprioceptive inputs to path integration. Presence: Teleoperators and Virtual Environments, 7, 168-178.

Chen, M. (2002, in press). Leveraging the Asymmetric Sensitivity of Eye Contact for Videoconference. Proceedings of CHI 2002.

Colburn, R. A., Cohen M. F., & Drucker, S. M. (2000). The role of eye gaze in avatar mediated conversational interfaces. Microsoft Research Technical Report.

Cutler, B. L., Penrod, S. D., O'Rourke, T. E., & Martens, T. K. (1986). Unconfounding the effects of contextual cues on eyewitness identification accuracy. Social Behavior, 1, 113-134.

Cutler, B. L., Penrod, S. D., & Martens, T. K. (1987). The reliability of eyewitness identifications: The Role of System and Estimator Variables. Law and Human Behavior, 11, 233-258.

Davies, G & Milne, A. (1985). Eyewitness composite production: A function of mental or physical reinstatement of context. Criminal Justice & Behavior. 12 (2), 209-220.

Gale, C. & Monk, A.F. (2000). Where am I looking? The accuracy of video-mediated gaze awareness. Perception and Psychophysics, 62, 586-595.

Heeter, C. (1992). Being there: The subjective experience of presence. Presence: Teleoperators and Virtual Environments, 1(2), 262-271.

Held, R., & Durlach, N. (1992). Telepresence. Presence: Teleoperators and Virtual Environments, 1(1), 109-112.

Hershkowitz, I., Orbach, Y., Lamb, M. E., Sternberg, K. J., & Horowitz, D. (2001). The effects of mental context reinstatement on children's accounts of sexual abuse. Applied Cognitive Psychology 15 (3): p. 235-248

Kamberova, G. & Bajcsy, R. (1999). "Teleimmersion for the Doctor's Office", invited paper, Proc. Medicine Meets Virtual Reality: 7, San Francisco, CA, 1999.

Kassin, S. & Studebaker, C. A. (1998). The Admonishment to Disregard and the Jury. In Intentional Forgetting: Interdisciplinary Approaches (Golding ; MacLeod, Eds.). Lawrence Erlbaum.

Kennedy, R. S., Lane, N. E., Berbaum, K. S., & Lilienthal, M. G. (1993). A simulator sickness questionnaire (SSQ): A new method for quantifying simulator sickness. International Journal of Aviation Psychology, 3(3) 203-220.

Krafka, C. & Penrod, S. (1985). Reinstatement of context in a field experiment on eyewitness identification. Journal of Personality & Social Psychology. 49 (1), 58-69.

Lanier, J. (2001). Virtually There, Scientific American, April, 66-75.

Lastowka, G. F., & Hunter (2003). The laws of the virtual worlds, Institute for Law & Econ Research Paper 03-10.

Lederer, F. L.(2004) "Courtroom Technology: For Trial Lawyers, the Future Is Now." Criminal Justice, 14.

Lombard, M. and T. Ditton (1997). At the heart of It all: The concept of presence. Journal of Computer Mediated Communication, 3(2).

Loomis, J. M. (1992) Distal attribution and presence. Presence: Teleoperators and Virtual Environments, 1, 113-119.

Mania, K. and Chalmers, A. (2001). The Effects of Levels of Immersion on Memory and Presence in Virtual Environments: A Reality Centered Approach. CyberPsychology & Behavior, 4(2), pp. 247-263.

Marder, S. N. (2005). Cyberjuries: The Next New Thing?, Information and Communication Technology Law, 83.

Meehan, M. (2001). Physiological reaction as an objective measure of presence in virtual environments. Doctoral Dissertation. Computer Science. University of North Carolina, Chapel Hill, NC, USA.

Memon, A & Bruce, V. (1983). The effects of encoding strategy and context change on face recognition. Human Learning: Journal of Practical Research & Applications, 2 (4): p. 313-326.

Moreno, R., Mayer, R. E., Spires, H., & Lester, J. (2001). The case for social agency in computer-based teaching: Do students learn more deeply when they interact with animated pedagogical agents? Cognition and Instruction, 19, 177-214.

Normand, V., Babski, C., Benford, S., Bullock, A., Carion, S., Farcet, N., Frecon, E., J.Harvey, N. Kuijpers, N. Magnenat-Thalmann, S. Raupp-Musse,T.Rodden, M. Slater, G., Smith, A., Steed, D., Thalmann, J., Tromp, M., Usoh, G., Van Liempd, N., & Kladias, (1999). TheCOVENproject: exploring applicative, technical and usage dimensions of collaborative virtual environments, Presence: teleoperators and virtual environments, Vol.8, No2, pp.218-236.

Pertaub, D-P., Slater, M., Barker, C. (2001, in press) An Experiment on Public Speaking Anxiety in Response to Three Different Types of Virtual Audience, Presence: Teleoperators and Virtual Environments,.

Phillips, Erich. (1990). Vision and visibility in vehicular accident reconstruction. Journal of Passenger Cars, 99, 547-561.

Reeves, B., & Nass, C. (1996). The media equation: How people treat computers, television, and new media like real people and places. New York: Cambridge University Press.

Richardson, Anthony E.; Montello, Daniel R.; Hegarty, Mary, (1999). Spatial knowledge acquisition from maps and from navigation in real and virtual environments, Memory & Cognition, 27(4), 741-750.

Riva, G., Wiederhold, B., & Molinari, E. (Eds.). (1998). Virtual environments in clinical psychology and neuroscience: Methods and techniques in advanced patient-therapist interaction. Amsterdam: IOS Press.

Rizzo, A.A., Neumann, U., Enciso, R., Fidaleo, & Noh, J.Y. (2001). Performance-driven facial animation: Basic research on human judgments of emotional state in facial avatars. CyberPsychology & Behavior, 4, 471-487.

Rizzo, M., Wiederhold, M., & Buckwalter, J. G. (1998). Basic issues in the use of virtual environments for mental health applications, Virtual Environments in Clinical Psychology and Neuroscience, Ios Press: Amsterdam, Netherlands.

Sadagic M., Towles, H., Lanier, J., Fuchs, H., van Dam, A., Daniilidis, K., Mulligan, J., Holden, L., & Zeleznik, B., "National Tele-Immersion Initiative: Towards Compelling Tele-Immersive Collaborative Environments", presentation given at Medicine meets Virtual Reality 2001 conference, January 24-27, 2001, Newport Beach, California.

Sherwin, Richard K. (2000). *When Law Goes Pop: The Vanishing Line Between Law and Popular Culture*. Chicago: University of Chicago Press.

Short, J., Williams, E., & Christie, B. (1976). The social psychology of telecommunications. London: Wiley & Sons.

Slater, M. Linakis, M., Usoh, R. Kooper (1996) Immersion, Presence and Performance in Virtual Environments: An Experiment with Tri-Dimensional Chess, ACM Virtual Reality Software and Technology (VRST), Mark Green (ed.), ISBN: 0-89791-825-8, p 163-172.

Slater, M., Sadagic, A., Usoh, M.., & Schroeder, R. (2000). Small-group behavior in a virtual and real environment. Presence, 9, 37-51.

Slater, M. (1999). Measuring Presence: A Response to the Witmer and Singer Presence Questionnaire. Presence: Teleoperators and Virtual Environments, 8(5): 560-565.

Stephenson, N. (1993). Snow crash. New York: Bantam Books.

Swinth, K. R, & Blascovich J. (2001). Conformity to group norms within an immersive virtual environment. Paper presented at the annual meeting of the American Psychological Society (APS), Toronto, Ontario, June 2001.

Vertegaal, R., Slagter, R., van der Veer, G., & Nijholt, A. (2000). Eye gaze patterns in conversations: There is more to conversational agents than meets the eyes. SIGCHI, '01, Seattle, WA

Weiderhold, B. K., R. Gervirtz and M. D. Wiederhold (1998). Fear of flying: A case report using virtual reality therapy with physiological monitoring. CyberPsychology and Behavior, 1(2): 97-104.

Welch, R.B. (1999). How Can We Determine if the Sense of Presence Affects Task Performance? Presence, 8(5), pp. 574-577.

Wells, G. L. (2002). Eyewitness identification: Psychological aspects. The encyclopedia of crime and justice. New York: Macmillan.

Witmer, B. G., & Singer, J. M. (1998). Measuring presence in virtual environments: A presence questionnaire. Presence: Teleoperators and Virtual Environments, 7(3), 225-240.

Zahorik, P., & Jenison, R. L. (1998). Presence as Being-in-the-World. *Presence, 7*, 78-89.

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Appendix A: Glossary

Avatar: term derived from religious origins, a representation of a person in a virtual environment.

CAVE: Cave Automatic Virtual Environment, an immersive virtual environment technology in which images are projected onto the walls of a room-sized cube. The image projections change as the user walks around and moves his or her head.

Collaborative Virtual Environments: virtual reality simulations in which multiple users exist in the same shared space. CVEs are similar to videoconferences, except instead of sending video signals over a network, it sends information concerning the actions of digital models.

Digital: as opposed to analog, represented by binary information and often stored on a computer.

Immersive Virtual Environment: A synthetic environment that perceptually surrounds a user and allows for naturalist movements (i.e., walking and turning one's head, as opposed to manipulating a joystick).

Orientation Tracking: Tracking a person's head movements.

Position tracking: Tracking a person’s change in position, that is, where he or she has moved in the room.

Presence: the degree to which the user actually feels as if they are present in the IVE (as opposed to present in the physical world).

Social Presence: also known as copresence, social presence reflects the degree to which a user of a CVE feels that he or she is in the presence of and interacting with other veritable human beings

Stereoscopic Depth Cues: Visual phenomena that occur in any environment, either physical or virtual, that allow people to perceive distance information in a scene.

View Frustrum: A digital projection that extends from a CVE user’s face and allows others to see exactly what they are looking at.