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Employing Immersive Virtual Environments for Innovative Experiments in Health Care Communication

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Abstract

Objective—This report reviews the literature for studies that employ immersive virtual environment technology methods to conduct experimental studies in health care communication. Advantages and challenges of using these tools for research in this area are also discussed.

Methods—A literature search was conducted using the Scopus database. Results were hand searched to identify the body of studies, conducted since 1995, that are related to the report objective.

Results—The review identified four relevant studies that stem from two unique projects. One project focused on the impact of a clinician's characteristics and behavior on health care communication, the other focused on the characteristics of the patient. Both projects illustrate key methodological advantages conferred by immersive virtual environments, including, ability to maintain simultaneously high experimental control and realism, ability to manipulate variables in new ways, and unique behavioral measurement opportunities.

Conclusion—Though implementation challenges exist for immersive virtual environment-based research methods, given the technology's unique capabilities, benefits can outweigh the costs in many instances.

Practice Implications—Immersive virtual environments may therefore prove an important addition to the array of tools available for advancing our understanding of communication in health care.

1. Introduction

It has long been recognized that experimental methods play an important role in shaping scientific understanding of health care communication. Within the clinical encounter, however, use of experimental methods to study communication is rarely possible. It can be harmful or unethical to introduce some manipulations into the clinic, particularly when they may result in diminished quality of patient care. Furthermore, researchers are typically unable to manipulate variables with requisite levels of experimental control within clinical encounters. Standardization of communication variables, both verbal and non-verbal, is

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difficult to achieve between individuals and between encounters. In addition, communicator characteristics that are important to study, such as social characteristics or communication styles, are often confounded with one another, and with other key variables (1,2). Thus, with few exceptions (3,4), researchers have relied on simulation of clinical encounters to experimentally examine theoretically important variables with enhanced control (5). Simulation techniques include use of written or video vignettes (6,7), standardized actors playing the role of clinician or patient (8,9), or analog patients or clinicians who role-play in accordance with a clinical scenario (10).

As is the case with most research methods, various types of simulation have various tradeoffs between experimental control (elimination of extraneous variables and confounds) and mundane realism (the extent to which conditions in the study are analogous to reality) (11). For example, a standardized patient is very high in mundane realism though lower in experimental control because a conversation between two individuals will always have spontaneous elements. A written vignette scenario, on the other hand, is very high in experimental control, but low in mundane realism as it has no physical setting. Control and realism contribute directly to internal and external validity, and therefore each is important to maximize where possible. In addition, each simulation technique is accompanied by particular logistical and resource demands (12). Techniques with better control/realism tradeoffs (e.g., standardized actors) are often quite resource-intensive. There is therefore room for innovation and expansion in experimental simulation tools and methods.

1.1 Immersive Virtual Environments and Virtual Humans

Immersive virtual environments (IVEs), popularly known as virtual reality, are uniquely positioned to address some of the major challenges in experimental health care communication research. Researchers have identified several key methodological benefits that IVE tools can confer (13,14). These include the ability to maintain simultaneously high experimental control and mundane realism, the ability to allow manipulation of variables in ways that are traditionally very difficult or impossible, and an associated complement of behavioral measurement options. Perhaps most importantly, interactions in IVEs can be very psychologically compelling and elicit social processes analogous to real ones (15,16).

Digital IVE technology is essentially a collection of computer hardware and software designed to immerse users in artificially-created environments. There are multiple formats IVE systems can take. These formats vary in the extent to which they are immersive (i.e., the extent to which they envelop the user’s senses), however all capture user input for interactivity in some manner. One common IVE configuration is a head mounted display-based system where users view three-dimensional computer-generated images within a headset. In this system, users are typically free to move naturalistically within a defined space while their position and orientation are tracked and used to control events in the environment (see Figure 1).

Central to the use of IVEs for health care communication research are virtual human representations. In this domain, virtual humans typically represent a patient or a clinician that interacts with a research participant in some clinical scenario. In general, virtual humans range widely in their degree of realism and in their capabilities, often depending upon the role they are designed to play in a scenario. Critical to the success of virtual humans is the extent to which they behave realistically in a social interaction (16,17). Therefore, depending on the nature of the interaction, virtual humans can range from passive observers to interactive conversation partners with simulated emotions. In addition, virtual humans vary in the extent to which their actions are directly controlled by a computer versus a human. Means of control, as well, depends primarily upon the design and goals of the virtual encounter.

There are many ways in which employing IVEs and virtual humans could become an important extension of simulation methodology for studying health care communication. The first objective of this report is to review existing studies that use IVEs and virtual humans as tools to conduct experimental research to elucidate causal relationships and mechanisms in the medical encounter. The second objective is to discuss benefits and challenges of using these tools for future research.

2. Methods

A literature review was performed to identify the current body of experimental studies that employ IVEs as a method to study elements of health care communication and interaction. This review focused on work that uses IVEs as a research method. This distinction is made in accordance with Fox and colleagues' taxonomy (18) which distinguishes IVE-related research based on whether it uses IVE platforms as a method, studies IVEs an object, or studies virtual worlds with the intent of applying them to real-world uses (e.g., training).

The primary literature search was accomplished using Scopus to query the English-language medicine and social sciences literature. Several search terms of various configurations were entered simultaneously including: virtual, simulated, analog, computer*, digital, patient; doctor, physician, medic*, clinic*; communication, encounter, visit, and interact* (asterisks indicate wildcards i.e., unspecified characters). Resulting articles published since 1995 were hand searched for relevance. In addition, references sections were examined and authors of related articles were contacted for discovery of any relevant unpublished work.

3. Results

In the area of health care communication, IVEs were by far most commonly studied with the aim of developing tools to train medical, nursing, pharmacy and other professional students in clinical skills and communication. For example, several studies tested the efficacy of IVE simulations for training students in clinical communication (19–21), and compare IVEs to interactions with standardized patients (12,22,23). A smaller number of studies have investigated the nature of the interactions clinician-trainees have with virtual patients (24,25) and have explored ways of sensitizing trainees to patient experiences (26,27). IVEs hold a great deal of promise in this research area, and this is an important area for development. However, development of IVE tools for communication training is beyond the scope of the current review.

Use of IVEs as a method for health care communication research was far less common than exploration of their potential for training. The paucity of literature in this area was clearly demonstrated by the literature search. The search described above resulted in four published articles. These articles stem from two unique research projects. The first project examines the impact of physician characteristics and behavior on health care communication, whereas the other examines patient characteristics. Research from both perspectives is indeed possible using IVE tools.

The earliest research to employ virtual humans as a tool to conduct health care communication research was performed by Schmid Mast, Hall, and Roter (28,29). This work examined the effects of provider gender and communication styles (caring and dominance) on patient perceptions, satisfaction, behavior. University student participants acted as analog patients in interaction with a virtual human physician. Participants viewed the virtual clinic on a computer monitor and interacted verbally with the doctor. Throughout the interaction participants were fed information about their hypothetical symptoms on which to base their conversation with the virtual doctor. Schmid Mast and colleagues' work demonstrated that gender dyad combinations and communication style interactively determined patient satisfaction, and that each communication dimension independently elicited different dimensions of patient behavior. Though the virtual environment used in these studies was not fully immersive, it did allow naturalistic interaction with a virtual doctor. Therefore, it illustrates use of virtual humans in ways that confer research benefits for experimental work in health care communication.

In the second set of articles, Persky and Eccleston (30,31) used an IVE to examine medical students' behavior and attitudes toward a virtual patient and assess recommendations made for the patient's care. This work investigated the impact of the patients' body size (i.e., obesity) on interpersonal bias and clinical behaviors. It also examined the use of genetic causal explanations for obesity as a potential means of bias reduction. Medical students were immersed in the virtual clinic by wearing a head-mounted display. They were able to move through the clinic environment using natural physical movements like walking. Medical students' communication and nonverbal behaviors were tracked and recorded by the virtual environment apparatus. The study revealed that medical students exhibited more bias-related attitudes against an obese than a non-obese version of the same virtual patient. They also made less visual contact with the obese patient during the encounter. Providing students with information that implicates genetics in causing obesity improved some attitudes toward the obese patient. However, provision of this information also reduced rates of health behavior-related referrals and recommendations.

4. Discussion and Conclusion

4.1 Discussion

4.1.1 Advantages of Employing IVEs—The studies performed by Schmid Mast and colleagues and by Persky and Eccleston illustrate the major advantages of using IVEs for experimental health care communication research. In both projects, because participants interacted with virtual humans, the researchers were able to manipulate elements of the interaction that are immutable and impossible to disentangle in the real world. Schmid Mast and colleagues isolated and explored the effects of physician gender, level of caring in communication, and level of dominance in communication, three variables that are typically confounded in real humans. By disentangling these factors, they were able study their individual and interactive contributions. It would not have been possible to cleanly demonstrate these relationships based on natural human conversations. Persky and Eccleston employed a virtual human in order to portray a patient as obese or not, while holding all other characteristics, communications, and behaviors constant. They were therefore able to demonstrate that the patient's weight elicited biased reactions from medical students in isolation from other factors that can be confounded with weight in real human patients (32,33).

On a more general note, essentially any experimental manipulation is possible in IVEs (13,14). For health care communication research, this is particularly powerful with respect to individuals' personal and social characteristics. Researchers have complete control over virtual clinicians' and virtual patients' physical characteristics (e.g., appearance, race, gender; (30,34–36)). Researchers can also control nonverbal behavior, holding it constant between individuals or situations, or disentangling verbal from nonverbal behavior (37).

The work reviewed here also illustrates another benefit of IVEs and virtual human research tools. As previously discussed, in research there is typically an inherent tradeoff between mundane realism and experimental control. In general, the more an experimental situation approaches real life, the less control experimenters have over the environment. When experiments are conducted in IVEs, however, they can be situated in realistic environments where, by the very nature of the technology, every element is tightly controlled (13,14). In Schmid Mast and colleagues' work, all of the virtual physician's verbal and nonverbal behaviors were pre-programmed and thus completely controlled, even while these behaviors occurred within a visible clinical environment. Virtual environments that are fully immersive, as in Persky and Eccleston's work, retain experimental control but elevate the mundane realism of the scenario as the virtual clinic environment becomes totally enveloping and can feel increasingly authentic.

Finally, Persky and Eccleston's work illustrates a third advantage associated with immersive virtual research environments: integrated behavioral measurement opportunities. Nonverbal behaviors are an extremely important area of health care communication research, however, these behaviors can be difficult and time-intensive to code and quantify (38). In IVEs, physical behavior forms the basis of system operation because the digital content that makes up virtual environments is rendered in accordance with users' body position. Therefore, it becomes a rather simple matter to unobtrusively record and automatically analyze behaviors such as visual gaze and interpersonal approach distance. By employing these measures, Persky and Eccleston were able to demonstrate that medical students' visual gaze was affected by patient weight.

4.1.2 Challenges for Practical Implementation—Given the potential benefits illustrated by existing work, it is important to explore issues and challenges relevant to use of IVEs as a tool for future studies. Key among these is the validity of using IVEs to study real world processes and application of research findings to real clinical communication.

There are several lines of work that address these issues. First, researchers who develop IVEs to serve real-world training and clinical purposes have shown that experiences in IVEs do translate to behavior in real environments. For example, IVEs have repeatedly been shown to be a successful tool for conducting exposure therapy to treat patients with specific phobias or anxiety (39,40). In addition, the IVE training literature demonstrates that systems with virtual patients can successfully train student clinicians to perform clinical tasks and communicate with real patients (23,41). Comparisons of virtual patient training simulators with standardized patient actors generally show that virtual patients elicit the same communication content from students. Virtual patients also elicit similar nonverbal behaviors and expression of empathy, though these reactions may be qualitatively different on some dimensions (22,24).

Research has also specifically validated use of IVEs as an experimental tool. Several studies have demonstrated that individuals behave similarly between experiments conducted in IVEs and in those conducted in real settings (15). Many real-life social processes have been shown to occur in IVEs (34,42–44). Additional work as to the direct applicability of IVEs for health care communication research would be beneficial. The existent evidence, however, does suggest that findings from research applying IVE tools to health care communication can be applicable to real-life encounters.

Although this report has primarily focused on advantages, IVE tools are not a panacea for health care communication research. There are several challenges to their implementation that warrant consideration. Of foremost importance for this area are technical limitations related to the act of communication. Creating spontaneous, naturalistic interpersonal interaction with virtual humans requires high quality voice recognition, artificial intelligence schemes, and large databases of recorded phrases to drive communication. This has limited the extent to which a successful, unscripted verbal give-and-take can occur with virtual humans. The studies presented in this review constrained communication scenarios such that the social exchange could seem psychologically natural even though it was not truly naturalistic. There are several strategies for constraining conversations to achieve these ends. Researchers can implement a closed-ended, turn-taking conversational structure (e.g., a virtual patient communicates all of his concerns and symptom information, and the clinician participant responds afterwards). Alternatively, researchers can feed participants information from which to build communications that work within a scripted interaction. Other strategies include having a research assistant select contextually appropriate conversational responses on the fly, and having a research confederate directly voice the virtual patient or clinician in the interaction. Some research groups involved in development of clinical training IVEs are working to improve the accuracy of naturalistic, conversational virtual humans based on voice recognition (20,45,46). It is likely that such systems will be ready for experimental work in the near future. It is worth noting, however, that more naturalistic communication introduces variability back into the interaction. There may therefore be research questions for which constraining conversational interactions would still be the preferred approach.

IVEs present additional challenges related to resources. Perhaps the most obvious issue is the cost of building IVEs and acquiring the necessary hardware. The cost of IVE systems has continued to decrease to being within the reach of many institutions. They can run on off-the-shelf computers, however, the other hardware varies substantially in type, quality, and cost. In terms of software, there are commercially available virtual environments for more common applications (e.g., psychotherapy), however, more novel applications typically require custom programming. Cost and time required for programming depend upon the scope of the project and the skill and experience level of the programmer. Software packages designed for creating IVEs are continually becoming more functional and user friendly. Therefore, with the high rate of computing power expansion and software sophistication these costs will likely continue to diminish. On the positive side, once an experimental scenario is created, it can be used for as many iterations as desired, replicated in any facility with the required equipment, and altered for use in future work. Two recent papers describe the practicalities of incorporating IVE tools into experimental research programs (15,18).

One final challenge associated with IVEs is the frequent temptation to use novel tools for their own sake. It is important to recognize that most research questions can be sufficiently addressed by traditional research tools. The challenges described here underscore the importance of using IVE tools only where they bring clear benefit to the questions under study.

4.2 Conclusion

The work performed thus far only begins to scratch the surface of what is possible. Rapid progress is being made in increasing the quality and believability of virtual humans and their capabilities for authentic interpersonal interaction (46,47). IVEs can also enable novel explorations of several important constructs in health communication research. For example, the process of perspective-taking can be studied by allowing clinicians to literally take the perspective of a virtual patient in a clinical encounter (27). Furthermore, use of IVE research tools can be combined with other assessments that would be impractical to add to actual clinical encounters. For example, research has shown that participants' physiological responses can be assessed in IVEs without disrupting the virtual experience (48). These and other capabilities have the capacity open new avenues for future research programs.

Experimental methods are indispensible for establishing causal relationships and mechanisms that drive communication processes. IVE research tools can pave the way for innovative experimental research that has been previously unimaginable. Use of IVEs as a tool for health care communication research is in its infancy. Given their potential, however, IVEs will likely prove to be an important addition to the array of tools available for advancing our understanding of communication in health care.

4.3 Practice Implications

Use of IVEs and virtual human methods might be reasonably expected to grow in the future, given that they confer several potential advantages for experimental research in health communication (49). These digital tools are also likely to become increasingly relevant and important as training and even medical encounters themselves move toward computerized platforms (i.e., telemedicine). Indeed use of IVE tools for experimental studies and their application to training and clinical care can be overlapping research domains. Experimental findings can inform strategies for effective training simulations or practice interventions. Likewise, developments in these applications can illuminate new research questions for experimentalists to address.

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Figure 1.

Illustration of immersive virtual environment equipment. A) Head-mounted display; B) Tracking Cameras; C) tracking and rendering computers