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Leveraging Collaborative Virtual Environment Technology for Inter-Population Research on Persuasion in a Classroom Setting

Abstract

Immersive collaborative virtual environments (CVEs) allow us to interact with geographically distant others while experiencing social presence to a degree that goes far beyond text chatting or teleconferencing. Moreover, these environments provide this high level of realism within social contexts that are impossible in the physical world. Given these facts, CVEs provide behavioral researchers with an ideal platform to study social interaction both within and between geographically and culturally distinct communities. The study reported here leveraged these two unique capabilities of CVEs within a persuasive context by: (1) placing people who are seated in physically distal places into the exact same virtual world, and (2) structuring virtual space to maximize persuasion. Specifically, we report data from a study in which pairs of participants listened to a speaker deliver a persuasive passage within the same digital immersive virtual room. The individual members of each pair were separated by hundreds of kilometers, located at two different college campuses. Within the CVE, we digitally transformed the placement of participants' seats in the virtual classroom. Participants in the front of the classroom were more persuaded by the speaker and had more positive impressions of the speaker. Patterns in both persuasion and memory differed between campuses. Together these findings speak to the utility of wide range CVEs to maximize persuasion and demonstrate the viability of using CVEs for inter-site research.

1 Introduction

Collaborative virtual environments (CVEs) can bring geographically separated users from anywhere in the world into the same shared virtual space. Depending on the nature of the supportive technology, CVEs can be highly immersive 3D worlds in which users are perceptually surrounded by the synthetic environment. Moreover, the rendering of others' avatars (their digital representations) within that environment creates a strong sense of social presence for users (Benford, Bowers, Fahlen, Mariani, & Rodden, 1994; Blascovich et al., 2002). If individual users' physical movements are tracked, nonver-

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bal behavior can be rendered via their avatars, allowing for a relatively naturalistic form of digitally-mediated interaction.

Because CVEs can mimic physical world interactions, a variety of benefits over more traditional digitally-mediated communication emerge (Bailenson, Beall, Loomis, Blascovich, & Turk, 2005). Most obviously, CVEs provide interactants with an experience of shared space (Benford et al., 1994; Lombard & Ditton, 1997) and community (IJsselsteijn & Riva, 2003) with a greater degree of immersion than typical 2D platforms such as videoconferencing or text chatting provide (Schroeder et al., 2001). Perhaps more importantly, immersive CVEs in which users' nonverbal behaviors are tracked and rendered preserve critical communicative channels that are lost in more impoverished media. For example, the capability of immersive CVE technology for tracking and rendering gaze direction preserves a quite critical aspect of face-to-face interaction (Bailenson et al., 2005; Garau et al., 2003).

CVEs also enable the manipulation of social contexts in ways that are impossible in the physical world. Within CVEs, transformed social interactions (TSIs; Bailenson, 2006) can be used to augment CVE interactants' sensory abilities (e.g., by providing them with summary information regarding others' behavior within the scene; Bailenson et al., 2008), alter the situational context (e.g., by transforming the spatial or temporal structure of an interaction; see Zhang & Furnas, 2002), or strategically altering the appearance or behavior of users' avatars (Yee & Bailenson, 2007). Because these transformations can be applied to multiple users simultaneously, any or every interactant in a CVE can experience the ideal context for whatever the purpose of the world (e.g., learning, persuasion, social interaction).

In one study that utilized TSIs within a CVE (Bailenson et al., 2005), a pair of participants listened to a presenter deliver a persuasive passage. The presenter's gaze was manipulated such that in one condition each participant received a direct gaze from the presenter 100% of the time. Despite the fact that neither the speaker nor the participants in this study were aware of the TSI (i.e., "nonzero sum gaze"), the augmented gaze led to greater persuasion than in other conditions among female participants.

In a series of studies exploring the benefits of TSIs in an immersive educational CVE, researchers (Bailenson et al., 2008) manipulated a range of variables. In one experiment, they demonstrated that when instructors were given online feedback regarding the degree to which they were attending to every individual student in a class (a sensory augmentation TSI), those instructors were better able to distribute their attention evenly across the class than instructors who were not given the feedback. In another experiment, they manipulated the social environment by placing multiple agents (computer algorithm driven digital humans) in the class with the participants. When the agents behaved in a positive manner (e.g., attentive to the instructor) as opposed to a negative manner (e.g., distracted away from the instructor), participants learned more of the lecture's content.

Two additional studies in this series tested the effects of seat placement in the virtual classroom. In one study, participants' recall of the lecture's content was best when they sat in the center of the instructor's field of view. In a related study, participants learned more when they were placed (i.e., seated) virtually closer to the instructor (Bailenson et al., 2008). This corroborates early findings by Albert and Dabbs (1970), who also demonstrated that physical distance from a speaker influences attitude change. While these studies placed individual participants in the IVE, the possibility of placing all the students in a virtual class simultaneously in one of the ideal seats presents obvious potential benefits.

Collaboration is not the only benefit of CVEs. The mere fact that two individuals can simultaneously occupy the same virtual space provides researchers with the unique opportunity to place physically distant individuals in the same virtual environments; indeed, even in the same virtual space. This capability has been explored in a handful of empirical studies (Heldal et al., 2005; Schroeder et al., 2001; Steed, Slater, Sadagic, Bullock, & Tromp, 1999) in which researchers have placed geographically separated participants in virtual environments where they worked together on collaborative tasks. The researchers used these paradigms to examine the influence of technical platforms on interaction (Heldal et al., 2005) and on different aspects of co-presence (Schroeder et al.; Steed et al.).

But wide range CVEs can also be used for highly controlled inter-population research (Blascovich et al., 2002). Researchers can run participants from distant populations through the same study in parallel, trial by trial. As such, a single experiment can produce a highly controlled comparison between geographically different groups, allowing for uniquely powerful cross-validational work and/or intergroup comparisons. Despite this methodological power offered by the ability to place two participants in the same virtual space, wide range CVEs have not yet been tapped for comparative studies of this sort.

1.1 Overview of the Present Study

The present study further examined the utility of CVEs in lecture contexts. Specifically, we sought to replicate the findings concerning the benefits of placing participants near the speaker in a class. Moreover, we wanted to extend these findings in several ways. First, the original study (Bailenson et al., 2008) primarily measured the effects of speaker proximity on memory. Using a similar paradigm, the current study measured persuasability and audience members' impressions of the speaker. Given that placing participants closer to the speaker during a virtual lecture appeared to enhance their attention to the speaker, we hypothesized that the same transformation would lead to greater listener persuasion particularly if the speaker were delivering a strong argument. We also hypothesized that participants would feel more positively toward the speaker (and his or her message) given evidence from other literature that physical approach has positive effects on social attitudes (Kawakami, Phills, Steele, & Dovidio, 2007). By examining these questions, we hoped to add to the growing literature on persuasion in immersive collaborative IVEs (Bailenson et al., 2005; Guadagno, Blascovich, Bailenson, & McCall, 2007).

More importantly, we wanted to provide the strongest test possible of transformed social interaction. In previous work using a single participant in a virtual environment, we have demonstrated that putting a student in the "optimal seat" in the front and center of the virtual classroom resulted in more learning than putting that student in the back of the room. In the current study, we examined the effect of networking two people simultaneously into the optimal seat. In other words, given the effectiveness of the optimal seat for learning, and given the possibility of CVEs for allowing transformations of space, we examined using seat location as a gain factor for large group learning. This study is the first test of using CVEs to bend the spatial configuration of a classroom to maximize influence across users.

Finally, we were also interested in using a CVE not so much to create an interaction between two participants but to compare participant samples from two distinct populations who share the same virtual space. Specifically, we wanted to run one participant from each population during each experimental session within the same experimental environment so that we could make direct and highly controlled comparisons between the effects of our manipulation on the two samples. Along these lines, one goal of the current study was to use a CVE to test whether or not the influences of the given TSI would extend across two distinct academic populations and, more broadly, to demonstrate the utility of wide range CVEs for comparative research.

To accomplish these goals, we simultaneously placed pairs of participant listeners, one physically located at the University of California, Santa Barbara, and the other at Stanford University, into the same CVE in which they listened to an agent deliver a speech. We used a TSI to manipulate seat position such that in one condition (front-front) both participants' viewpoints were from the same front and center seat in the class. In this condition, from each participant's visual perspective, the other participant was sitting in the back of the room. In the other condition (front-back) one participant's viewpoint was placed in the front and center of the class and the other participant's viewpoint was placed in the back and center of the room. We predicted that participants in the front and center of the class would have better impressions of the speaker, would be more persuaded by the speaker's message, and would remember more of the speech's content, than participants in the back and center of the class.

2 Methods

2.1 Participants

Twenty female and 26 male undergraduate psychology students at the University of California, Santa Barbara (UCSB) and Stanford University were recruited for the study. Students were paid $10 or given class credit for their participation. Each experimental session used same-gendered pairs of participants with one student at UCSB and one at Stanford.

2.2 Materials and Apparatus

On both campuses the digital immersive CVE was rendered with a Virtual Research (Model V8) stereoscopic head mounted display (HMD) with about a 60 Hz refresh rate, a horizontal span of approximately 50°, and a vertical span of approximately 38°. All software was written in Vizard 2.5. Participants' head orientations were tracked by an Intersense© (model IS300) sensor.

The virtual environment was a class with relatively blank walls (see Figures 1 and 2). The speaker was represented via a virtual human-appearing agent whose apparent gender matched that of the participants. Each participant was rendered in the other participant's virtual world with a gender-appropriate avatar. Head rotations of each participant were tracked and these data were used to render the head motions on his or her avatar. Participants spoke to each other through speaker phones placed so that the audio came roughly from the direction of the other participant's avatar. The avatars and agent mouths moved when speaking proportionally to the amplitude of the sound input. Participants' worlds were networked through a control computer that was operated by the experimenter. Transitions from one stage of the experiment to the other were monitored and controlled via this computer.

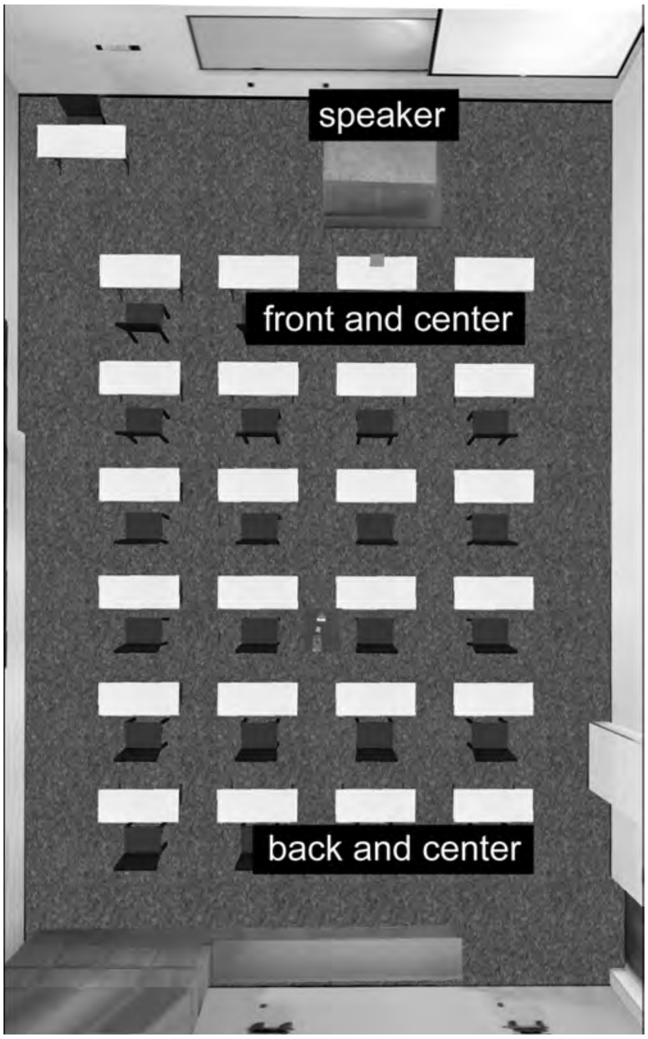

Figure 1. *Overview of classroom CVE. Depending on their condition, participants were either seated in the front and center or the back and center of the class.*

2.3 Procedure

When recruited, participants were asked to participate in a study about learning in IVEs. Upon arrival at the lab in their respective locations, participants completed a health screening questionnaire. The health screening was used to determine that the participants were able to participate in the experiment (i.e., they were not pregnant, epileptic, or highly susceptible to motion sickness). Participants were then told, "In the following study, you will put on a head mounted display and enter a virtual reality simu-

Figure 2. *Views from the back (top) and front (bottom) seats within the virtual classroom.*

lation. You will sit across from a lecturer who is teaching a lesson. Your job is to pay attention to the lecturer, and to learn as much as possible about the content of the lecture. We will be testing you later about specific information from the lesson."

Both participants then put on their HMDs and were placed in the same CVE. Participants were initially placed in a virtual desk with an "A" or "B" label. Text instructions facing the desk stated that the virtual speaker would use that letter to self-identify during the lesson. The participants were then instructed by the speaker to rotate such that they were facing each other's avatar. Participants were then asked to introduce themselves, starting with participant A. After speaking their names, the speaker asked participants to take turns nodding their heads and then to confirm that they saw the other participant nod. Following a brief warning, participants were then placed in their seats (at the front or back of the classroom) for the lecture.

Depending on the experimental condition, participants were either placed in a seat at the front and center of the room (2 virtual m from the speaker) or in a seat at the back and center of the room (9.5 virtual m from the speaker). Because a CVE can be transformed for multiple users simultaneously, it is possible for several students to sit in the same place in a virtual room while each user still believes that he or she is the only one in that spot. Hence, there were two conditions in this study—front-front and front-back. In the front-front condition, both participants (their viewpoints) were placed in the front and center seat. In this condition, however, the other participant's avatar was placed in the back seat such that each participant was led to believe that the other participant was sitting in the back. In the front-back condition, however, one participant was placed in the front and the other was placed in the back. In order to be sure that all participants saw where each other was apparently sitting, participants were asked to look around quietly to locate the speaker and then the other student when they were first placed in their seats.

After the participants were seated properly, the speaker started the first lecture. In this lecture, the speaker argued for the benefits of fever to health. Following this lecture, participants used a controller to answer questions about the content of the lecture. When both participants had completed answering all of the questions, they were placed again in seats facing each other. They were each asked if they could hear the speaker. The participants were asked to nod again and each confirmed that they saw the other participant nod. Following a brief warning, participants were then relocated to their seats at the front or back of the class for the second lecture. In this lecture, the speaker argued that the drive for profit compromises the integrity of the pharmaceutical industry. After this lecture, participants again answered another set of questions. At this point participants were taken out of the CVE and asked to complete a final questionnaire.

2.4 Measures

To measure persuasion, participants expressed their agreement/disagreement with statements about the arguments presented in the each of the lectures using a Likert scale ranging from "strongly agree" to "strongly disagree." There were two items for the first lecture and four items for the second lecture. Responses to statements contrary to the argument were reverse-coded and averaged together with the other responses to create a persuasion score for each lecture.

To measure impressions of the speaker, participants were asked to use a Likert scale to rate the degree to which a number of different traits described him or her (friendly, honest, credible, competent, sincere, trustworthy, warm, likeable, approachable, interesting, informed, and modest). The scale ranged from "strongly agree" to "strongly disagree." These ratings were then averaged to produce the impression score (Cronbach's $\alpha = .90$).

In addition to persuasion measures, participants also answered a series of multiple choice questions designed to assess their memory for the lectures' content. Participants received a score for the number correct of these per lecture.

3 Results

In examining the data, we were particularly interested in two variables: relative seat position in the class (our TSI)[1] and campus. To examine the effects of these variables on persuasion, we ran a two way ANOVA for each lecture with campus (Stanford or UCSB) and seat position (front or back) as fixed factors and with persuasion score as the dependent variable. While there was no effect of seat position on persuasion for the first lecture ($F(1,46) = 1.2$, $p > .25$, partial $\eta^2 = .02$[2]), there was a significant effect for the second lecture ($F(1,46) = 8.1$, $p < .01$, partial $\eta^2 = .06$) whereby participants in the front and center seat were significantly more persuaded by the message than participants in the back. Participants from UCSB were significantly more persuaded both by the first ($F(1,46) = 32.8$, $p < .001$, partial $\eta^2 = .43$) and second ($F(1,46) = 91.6$, $p < .001$, partial $\eta^2 = .65$) lectures. There was no interaction between campus and seat position for either lecture (ps > .5). For all of these tests, the persuasion measure was normally distributed and Levene's test of equality of variances was met.

We ran another set of ANOVAs to look at impressions of the speaker, again using campus (Stanford or UCSB) and seat position (front or back) as fixed factors. This analysis was not split by lecture because participants only rated the speaker once, after the lectures were both completed. Participants in the front seat had significantly more positive impressions of the speaker than participants in the back seat ($F(1,46) = 11.5$, $p < .01$, partial $\eta^2 = .21$). There was no effect of campus on speaker impressions and no interaction between campus and seat position (ps > .2). Again, this measure met Levene's test of equality of variances.

We ran two additional ANOVAs to examine memory for each lecture, once again using campus (Stanford or UCSB) and seat position (front or back) as fixed factors. There were no significant effects of seat position on memory for the first lecture ($F(1,46) < 1$, $p > .8$, partial $\eta^2 = 0.0$) or second lecture ($F(1,46) = 2.5$, $p = .12$, partial $\eta^2 = .04$). There were, however, significant effects of campus on learning for both the first ($F(1,46) = 6.3$, $p = .02$, partial $\eta^2 = .13$) and second ($F(1,46) = 8.7$, $p < .005$, partial $\eta^2 = .15$) such that participants at Stanford recalled more of the content of the lectures than at UCSB. Moreover, there was an interaction between campus and seat position for the second lecture whereby participants from UCSB were significantly more likely to benefit from sitting in the front than participants from Stanford (Figure 3; $F(1,46) = 4.0$, $p < .05$, partial $\eta^2 = .07$). Levene's test of equality of variances was met for the memory measures.

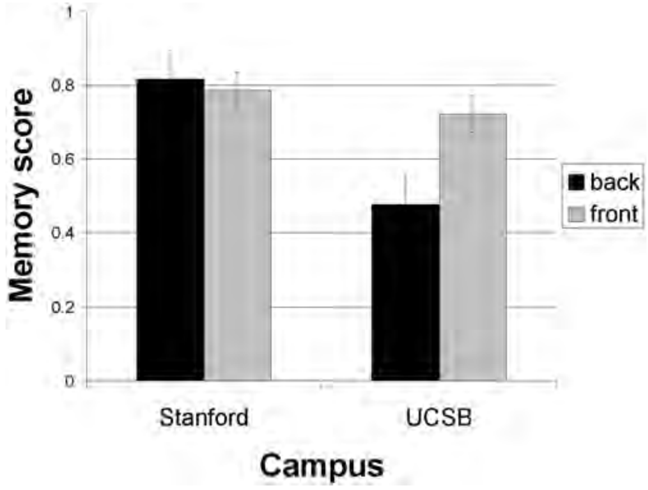

Figure 3. *Score on memory test by condition. Error bars based on standard error. The interaction between campus and seating position was significant such that participants from the UCSB laboratory benefited more from the optimal seat than participants at the Stanford laboratory.*

Finally, ANOVAs on the data of participants who were seated in the front of the room revealed no differences in impression, memory, or persuasion between participants whose paired-partners were seated in the front versus the back of the CVE.

1. Because participants always believed that the other participant was in the other seat, regardless of where the other participant was actually seated (participants in the front always believed that the other participant was in the back and participants in the back always believed that the other participant was in the front), it was not meaningful to compare data categorized by each pair's experimental condition (front/front versus front/back). We did not compare responses to the two lectures because the manipulation was the same for each participant for both lectures.

2. η^2 is a measure of effect size (Cohen, 1973).

4 Discussion

These findings extend previous work on TSIs in an educational setting (Bailenson et al., 2008). In the current study, participants on two different college campuses were brought together in a CVE where they listened to a speaker deliver a series of persuasive messages. Participants' seats in the environment were manipulated such that they sat relatively close to, or far from, the speaker. The data revealed that participants had more positive impressions of the speaker and were more persuaded by some of the speaker's arguments when they sat close to the speaker, even when two people were sitting in the optimal front seat simultaneously. As such, the current study offers further evidence that proximity manipulation is an effective TSI in CVEs.

The current study is particularly notable because it demonstrates that abstract ideas about transformations discussed in previous work (Bailenson et al., 2008) are effective in practice when scaled up to an actual networked social interaction. However, CVEs provide a double-edged sword. In one sense, "virtual is real" behaviors, such as relationships between seating proximity and learning, function in virtual spaces just as they do in physical spaces. On the other hand, via TSI, potential manipulations exist that are simply not possible in the physical world, such as having two people sit in the same seat simultaneously. When leveraging these two aspects of virtual environments, it is possible to create extremely powerful venues for social influence. This fact has obvious implications for the use of CVEs for distance learning where multiple learners might benefit from TSIs while participating in the same, live experience.

Interestingly, the influence of seat position on persuasion was only evident for the second of two lectures. There are several possible explanations for this fact. One possibility is that the content of the first lecture was less controversial than the second lecture. As such, participants may have been more universally receptive to the first, while the opinions relating to the second lecture may have been more labile and, as such, been more susceptible to the seating manipulation. A second possibility is that time may enhance the effects of seating distance on persuasion. Because the order of the two lectures was consistent across participants, it is impossible to disentangle order effects from effects driven by the specific content of the two lectures. Further research is necessary to disentangle this ambiguity.

In addition to manipulations of order, future research could also gather pretesting data on the given topics in order to eliminate the noise of individual differences in the response data. While the fact that the presented effects emerged with random assignment alone supports our hypotheses, pretesting would allow for a more sensitive measure of persuasion.

Significant differences in both persuasion and learning between participants from the two campuses used in this study demonstrate the utility of CVEs for inter-site research. Indeed, participants from one campus were persuaded more and learned less than the other. Moreover, the manipulation of seat placement used in this study only altered learning for participants from one of the campuses. If this study had been conducted using traditional research platforms, it would be more difficult to distinguish these differences in outcomes between sites from differences in the way the study was executed at the two sites. The present study overcomes many of those issues by conducting a multi-site study in the same virtual laboratory at the same time. In this sense, the current study shows that networked CVEs offer a method of comparing geographically or culturally distinct groups in a highly controlled (shared) environment without taking the members of those groups physically from their own locations. Moreover, this capability can be leveraged to examine how specific phenomena play out within entirely separate communities, allowing us to examine the cross-cultural validity of those phenomena. While the laboratories involved in the current studies were only hundreds of kilometers away from each other, it is easy to imagine running a similar study with participants in radically different locations (e.g., Bogota and Las Vegas).

Despite the fact that the environment used here networked two individuals, we focused more on exploring the methodological benefits of having multiple participants share a virtual space and made little use of the literally "collaborative" benefits of CVEs. Future work could make better use of social interactions within CVEs for inter-population research. Clearly, CVEs are an ideal platform for allowing individuals from different groups to interact, "face-to-face," in a controlled environment.

In sum, the study presented here adds to the literature on persuasion within IVEs while demonstrating the potential for using CVEs for inter-laboratory research on social behavior.

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