Transformed Social Interaction, Augmented Gaze, and Social Influence in Immersive Virtual Environments

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Immersive collaborative virtual environments (CVEs) are simulations in which geographically separated individuals interact in a shared, three-dimensional, digital space using immersive virtual environment technology. Unlike videoconference technology, which transmits direct video streams, immersive CVEs accurately track movements of interactants and render them nearly simultaneously (i.e., in real time) onto avatars, three-dimensional digital representations of the interactants. Nonverbal behaviors of interactants can be rendered veridically or transformed strategically (i.e., rendered nonveridically). This research examined augmented gaze, a transformation in which a given interactant's actual head movements are transformed by an algorithm that renders his or her gaze directly at multiple interactants simultaneously, such that each of the others perceives that the transformed interactant is gazing only at him or her. In the current study, a presenter read a persuasive passage to two listeners under various transformed gaze conditions, including augmented gaze. Results showed that women agreed with a persuasive message more during augmented gaze than other gaze conditions. Men recalled more verbal information from the passage than women. Implications for theories of social interaction and computer-mediated communication are discussed.

Looking directly into the eyes of another person is one of the most potent nonverbal signals humans possess. In face-to-face interaction in the nondigital world, humans are limited by physics: We can only make direct eye contact with a single person at a time. This limitation, however, does not apply to certain types of computer-mediated communication. The goal of this research was to examine effects of the augmentation of a presenter's gaze in a collaborative virtual environment (CVE), such that each audience member experiences his or her direct gaze simultaneously without knowledge that such augmentation is taking place.

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Positive Effects of Eye-Gaze in Interaction

There is little doubt that directing one's eyes towards another person has noticeable consequences, documented by much behavioral research (see Kleinke, 1986, or Segrin, 1993, for a thorough review). For the purposes of the present discussion, it is useful to break the positive effects of eye gaze into two classes: coordination–regulation and immediacy–arousal. It is important to note that these categories are not exhaustive; they have been chosen instead to provide a useful framework for the current study.

The direction of eye gaze provides information for the regulation and coordination of conversation. Eye gaze functions as a direct proxy for a person's attention (Breed, 1972; Kelly, 1978). Consequently, people in an interaction use gaze direction to assist in providing context for ambiguous speech (Rutter, 1984). Furthermore, eye gaze works as one of the primary nonverbal cues to regulate conversation (Argyle; 1988; Kendon, 1977), such that direction and duration of eye gaze acts as cues for turn yielding, intention to speak, and speech encoding.

Additionally, gaze functions on a more emotive level, causing arousal and perceptions of immediacy (Anderson, Guerrero, Buller, & Jorgensen, 1998; Mehrabian, 1967) for gaze recipients. Patterson's (1976) intimacy–arousal model suggests that when Person A exhibits an intimate behavior (e.g., eye gaze) towards Person B, then person B's arousal level increases. Patterson did not exclusively define arousal physiologically; however, subsequent research has indicated that gaze increases heart rate, (Wellens, 1987), galvanic skin response (Strom & Buck, 1979), and the magnitude of electroencephalogram responses (Gale, Kingsley, Brookes, & Smith, 1978). Interpreting physiological data is complex, and many studies have failed to find a relationship between various measures of arousal and gaze (e.g., Patterson, Jordan, Hogan, & Frerker, 1981). Nonetheless, there is some evidence that people who receive eye gaze from another person may become aroused.

Either as a consequence of changing the flow of the conversation due to turn taking structure, or as a consequence of arousal, there is ample evidence that a person who uses direct eye gaze gains advantage in terms of social influence. In a meta-analysis of nonverbal cues and social influence, Segrin (1993) reported that for every single study that manipulated gaze (i.e., gazing confederates versus nongazing confederates), there was more social influence in the high gaze condition than the no-gaze condition. Furthermore, on average this manipulation accounted for about 20% of the variance in the data across studies. For example, directing gaze at others (compared to looking away from others) makes for more persuasive presenters (Burgoon, Dunbar, & Segrin, 2002; Morton, 1980), better salespeople (Bull & Robinson, 1981), and more effective teachers (Fry & Smith, 1975; Ottenson & Ottenson, 1979; Sherwood, 1987).

Theories of gaze and conversational regulation would argue that the use of eye gaze, by managing the expectations of others during the conversation, increases a speaker's credibility and persuasive abilities (Kendon, 1979). Theories of immediacy and arousal would argue that the use of eye gaze should cause the receiver to reciprocate with intimacy and consequently receive persuasive messages more positively (Patterson, 1976). Furthermore, theories of expectancy violation would predict that if arousal resulting from a nonverbal cue (e.g., extensive eye gaze) violates an expectation, and that arousal is labeled positively under a given context, then high amounts of social influence would result from that arousal (Burgoon, 1983).

One issue that warrants discussion is gaze avoidance. When a person clearly avoids the direct gaze of others, he or she is seen by the others as transmitting avoidance-oriented emotions such as embarrassment, sorrow, and disgust (Burgoon, Coker, & Coker, 1987; Kleinke, 1986; Rutter, 1984). The evidence on gaze aversion as an accurate deception cue is mixed; however, most people tend to associate gaze aversion with deception (Bond Jr., Omar, Pitre, Lashley, Skaggs, & Kirk, 1992). In the current study, we do not directly manipulate gaze aversion. It is worthwhile to point out, however, that avoiding gaze should decrease social influence, just as increasing gaze should increase social influence.

Collaborative Virtual Environments and Transformed Social Interaction

Immersive collaborative virtual environments are communication systems in which multiple interactants share the same three-dimensional digital space despite occupying remote physical locations. In a CVE, immersive virtual environment technology monitors the movements and behaviors of individual interactants and renders those behaviors within the CVE via avatars, or dynamic digital representations that are often human in appearance. These digital representations are tracked naturalistically by optical sensors, mechanical devices, and cameras. The avatars are constantly redrawn for each user during interaction; as a result, unique possibilities for social interaction emerge (Blascovich, Loomis, Beall, Swinth, Hoyt, & Bailenson, 2002; Loomis, Blascovich, & Beall, 1999).

Unlike telephone conversations and videoconferences, the physical appearance and behavioral actions of avatars can be systematically filtered in immersive CVEs idiosyncratically for other interactants, amplifying or suppressing features and nonverbal signals in real-time for strategic purposes. Theoretically, these transformations should impact interactants' persuasive and instructional abilities. Previously (Bailenson, in press; Bailenson & Beall, in press; Bailenson, Beall, Loomis, Blascovich, & Turk, 2004), we outlined a theoretical framework for such strategic filtering of communicative behaviors called transformed social interaction.

This theory explicates a number of spatial, temporal, and visual parameters that interactants can utilize during conversations.

This theory delineates three dimensions for transformed social interactions. Transformations of *sensory abilities* complement human perceptual abilities. For example, "invisible consultants" can be rendered either as algorithms or human avatars who are only visible to particular members of a CVE. These consultants can either provide real-time summary information to selected interactants regarding either the attentions and movements of other interactants (information which is automatically collected by the CVE) or of themselves. For example, teachers using distance learning applications can receive warnings concerning students who clearly are not paying attention or can utilize automatic registers that ensure they are spreading their attention equally towards each student.

Transformations of *situational context* change the spatial or temporal structure of a conversation. For example, the spatial arrangement of the CVE (e.g., a meeting room) can be optimally configured for each independent user in the CVE. For example, every single student in a class of 20 can sit directly in front of the virtual blackboard, and perceive the rest of the students as sitting behind or to the sides of him. Furthermore, by altering the flow of rendered time in a CVE, users can implement strategic uses of "pause" and "rewind" during a conversation in attempt to increase comprehension and productivity.

Self representation transformations involve the strategic decoupling of the rendered appearance or behaviors of avatars from the actual appearance or behavior of the human driving the avatar. Hence, rendering avatars of users can deviate from the actual state of the user. For example, it could be the case that some students learn better with teachers who smile while some learn better with teachers who have serious faces. Consequently, in a CVE, the teacher can be rendered differently to individual students, with his or her facial expressions tailored idiosyncratically for each student in order to maximize attention and learning.

An exploratory study conducted previously (Beall et al., 2003) implemented a transformation of self representation labeled *augmented gaze*, which allows mutual gaze to be unconstrained by the limits of physical person-to-person contact. As described above, because the immersive CVE must be rendered individually for each interactant, it can be rendered differently to each one. Consequently, a given interactant's gaze can appear to be directed toward more than one person simultaneously. Furthermore, recipients are very likely to assume that they are the sole recipient of that mutual gaze. Nass, Robles, and Wang (in press) refer to this machine-generated gaze as "apparent attention." The exploratory study featured three interactants in an immersive CVE. One of the interactants, the presenter, led a discussion concerning designated topics with two listeners while gaze transformations took place. The study demonstrated that: (a) participants were unaware of the presenter's augmented gaze and (b) participants directed their attention (i.e., looking direction) more towards the presenter when under augmented gaze conditions than natural gaze conditions.

To our surprise, despite transformed social interaction's interference with nonverbal cues, the interaction suffered only slightly in terms of interactivity and responsiveness. In fact, the presenter was subjectively perceived by our participants as hyperresponsive, because he or she dedicated (according to the subjective reports of the listeners) large amounts of nonverbal resources to each of them. In sum, the gaze ability of the presenter was doubled, but at little if any cost in terms of interactivity within the conversation.

Theories of Interactivity

A fundamental principle of successful human interaction is the concept of responsiveness in conversation (Cappella & Pelachaud, 2002). For conversation and interaction to function properly, a degree of contingency among the actions of the various interactants is required.

In early research on verbal and nonverbal behavior, Kendon (1970) closely analyzed filmed interactions in slow motion, and recorded every "minimally perceptible change" in gesture. These meticulous analyses revealed three kinds of synchrony. First, the change points in the movement of different body parts of the same individual coincided. Second, these changes in different body parts correlated with speech changes for that individual. The third type was *interactional synchrony:* the correlation of change points across individuals in an interaction. Kendon found that this synchrony occurred from the subsyllabic level to the word level. Furthermore, he argued that interactional synchrony impacts credibility, persuasion, and trust in interactions by managing expectancies among participants (Kendon, 1979). In essence, synchrony results when people's behaviors are strategically contingent upon one another.

Synchrony, however, may not be so crucial in computer-mediated communication. More recent work (Burgoon, Bonito, Bengtsson, Cederberg, Lundberg, & Allspach, 2000) demonstrated that interactive, face-to-face, human partners were not rated as having more credibility than noninteractive computer interfaces on a number of different measures. According to those authors, features that create a potential for interactivity are only useful if they increase personal involvement as well as mutual connection between the user and the interface. For example, in types of interaction in which the user is primarily intended to receive information, synchronous interactivity may not increase the amount of involvement of the receiver. Instead, there should be an optimal matching between the level of interactivity in the interface and the desired amount of active behaviors by the user.

These findings by Burgoon and colleagues shed light on the predictions for the current work. On the one hand, transformed gaze should theoretically interfere with synchrony; the presenter's head movements are no longer contingent on the movements of the two listeners, but rather only on one participant at a time. By overriding even a single aspect of nonverbal behaviors (gaze direction) while letting the other ones such as voice intonation and verbal information proceed naturally, transformed gaze might present a major obstacle for interactional synchrony. If the goal of the interaction is to have the listeners behave passively as information receivers in the discussion, then the reduction of interactivity may actually be a more effective interface. In fact, certain levels of interactivity in interfaces can be counterproductive and distracting, especially given the subjective variability that exists across users in terms of assessing personal involvement with an interface (Burgoon, Bonito, Bengtsson, Ramirez Jr., Dunbar, & Miczo, 2000).

In the current work, the loss in synchrony should not translate into a loss of personal involvement, due to the fact that the goal of the interaction is for the listeners to receive information, not necessarily to contribute information. Consequently, the clear benefits from the increased gaze, in terms of immediacy and arousal of the augmented gaze, should provide an interactant with a powerful tool to substantially increase the amount of attention he or she can elicit from the listeners.

Our previous work examining eye gaze[1] in CVEs consistently demonstrated gender differences (Bailenson, Blascovich, Beall, & Loomis, 2001, 2003): women responded more to eye gaze manipulations in CVEs than men. In those studies, female participants adjusted their personal space behavior more to mutual gaze than did male participants. One potential explanation for this effect centers on women's ability to communicate nonverbally. As Hall (1984) pointed out in a literature review of nonverbal behaviors, women tend to be more skilled than men at both transmitting and receiving nonverbal messages. Other studies examining computer-mediated persuasion have also demonstrated similar gender effects (Guadagno & Cialdini, 2002). Consequently, in the current study, we examine our data by gender.

Persuasion and Transformed Gaze

One way to frame the two categories of gaze effects on persuasion is by utilizing the elaboration-likelihood model of Petty and Cacciopo (1986). According to this model, people processing a persuasive message utilize either the central route (i.e., dedicate cognitive resources toward actually working through the logical strengths and weaknesses of an argument) or the peripheral route (i.e., analyze the message only in terms of quick heuristics and surface features).

In terms of gaze coordinating turn-taking behavior, one way to explain an increase in persuasion would be along the central route: By having a more successfully managed conversation in which multiple speakers are expertly coordinated, the listeners are more likely to encode and analyze information properly from the persuasive topic. On the other hand, in terms of immediacy and arousal, because gaze conveys a degree of liking from the sender to the receiver, a speaker utilizing high amounts of gaze would be able to increase his or her persuasive abilities regardless of how the listener processes the information by activating the "liking route" of peripheral persuasion (e.g., Chaudhuri & Buck, 1995).

Overview and Hypotheses of Study

In the study reported here, we investigated whether or not listeners would show more agreement with a presenter implementing augmented gaze than with other presenters. This study was similar to the exploratory study conducted by Beall et al. (2003). In that study, however, we did not find any differences in persuasion. Consequently, in the current work, the passages read by the presenter were altered to allow for examination of participants' agreement. Via pretesting, we developed passages that allowed for either an increase or decrease in agreement from the normative agreement of our participant population.[2] Furthermore, we ran more participants in the current study to provide more statistical power for hypothesis testing.

We formulated four hypotheses:

H1: Augmented gaze would increase agreement of listeners to the presenter's message compared to the natural gaze condition and the reduced gaze condition, as previous research has demonstrated that eye gaze increases persuasion (Segrin, 1993).

H2: Similar to H1, augmented gaze should increase memory for the material presented compared to the natural gaze condition and the reduced gaze condition, given that previous research has demonstrated that instructor gaze increases learning (Sherwood, 1987).

H3: Compared to the natural gaze condition, augmented gaze and reduced gaze would decrease participants' ratings of the presenters' social presence, the degree to which participants regarded the presenter's avatar as sentient and aware of the interaction (e.g., Blascovich et al., 2002; Heeter, 1992; Lee, 2004; Lombard, Reich, Grabe, Bracken, & Ditton, 2000; Rice, 1993; Short, Williams, & Christie, 1976).

Transformed gaze should be seen as unresponsive (Cappella & Pelachaud, 2002) and in violation of the normal expectancies of a multiple-person interaction (Burgoon, Stern, & Dillman, 1995); accordingly, participants should rate such presenters as having lower social presence than other presenters.

H4: Participants would not detect transformed gaze explicitly.

It may be argued that transformed social interaction, in general, as well as augmented gaze, would not be an effective strategy if interactants in a given discussion do not believe that the verbal and nonverbal behaviors they are seeing have actually occurred. One can imagine a "slippery slope," in which the use of transformations becomes so prevalent during computer-mediated communication that the interaction loses all practical function and meaning. Consequently, studying the human ability to detect transformed behavior is a uniquely interesting theoretical and applied question at the present time.

METHOD

Design

We selected for one between-participants variable, participant gender (in a given session, the presenter and both participants, as well as their three avatars, were either all male or all female) and manipulated another, presenter gaze condition (natural, augmented, or reduced). In the natural condition, the presenter's avatar veridically displayed his or her head movements. In the augmented condition, the presenter's avatar directed his or her gaze toward each of the two listeners 100 percent of the time. In the reduced condition, the presenter's avatar gazed down at his or her computer monitor 100% of the time (see Figure 1). The augmented and reduced gaze conditions were implemented by transforming the veridical head movements of the presenter by scaling the magnitude of those movements down by a factor of 20 (e.g., if the presenter moved her head 20 degrees left, the participants would see a 1 degree movement), and by recentering the effective straight-ahead position of the presenter's head such that the presenter's eyes were looking directly at the eyes of each listener (augmented) or directly down at the computer screen (reduced). Scaling down the actual movements provided slight head movements, which prevented the presenter from appearing frozen. The presenters and the listeners were always blind to the transformations. Presenters were encouraged to use head movements in order to engage the participants.

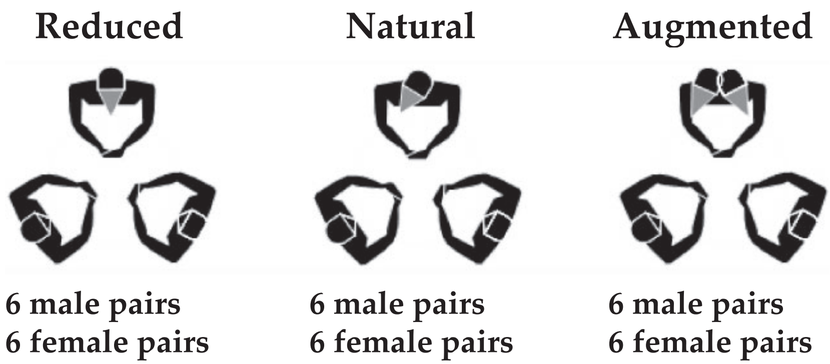

Figure 1. An Illustration of the Three Different Gaze Conditions

In all three conditions, the two listeners' head movements were rendered veridically. Furthermore, all three avatars blinked (randomly according to a computer algorithm based on human blinking behavior) and exhibited lip movements driven in real time by the amplitude of the sound of each interactant's speech as measured by a small microphone placed near the mouth. Other than lip movements, head movements, and eye blinks, there were no other behaviors exhibited by the participants' avatars (i.e., no changes in facial expressions). There were three male presenters and two female presenters (all confederates), each of whom were randomly cycled across the three gaze conditions approximately an equal number of instances.

Materials and Apparatus

The immersive, three-dimensional virtual room contained a round table around which the three avatars were seated (see Figure 2). Participants could see the other avatars as well as their own torsos (if they looked straight down). The technology used to render the immersive CVE is described in detail in Bailenson, Beall, and Blascovich (2002). Figure 3 depicts a person wearing the head-mounted display (HMD) and an intercom device. The HMD contains a separate display monitor for each eye (50 degrees horizontal by 38 degrees vertical field-of-view with 100% binocular overlap) and the graphics system renders the virtual scene separately for each eye (in order to provide stereoscopic depth) at approximately 60 Hz. In other words, as a participant moved his or her head, the system redrew the scene 60 times a second in each eye in order to reflect the appropriate movements. Using an inertial tracking system

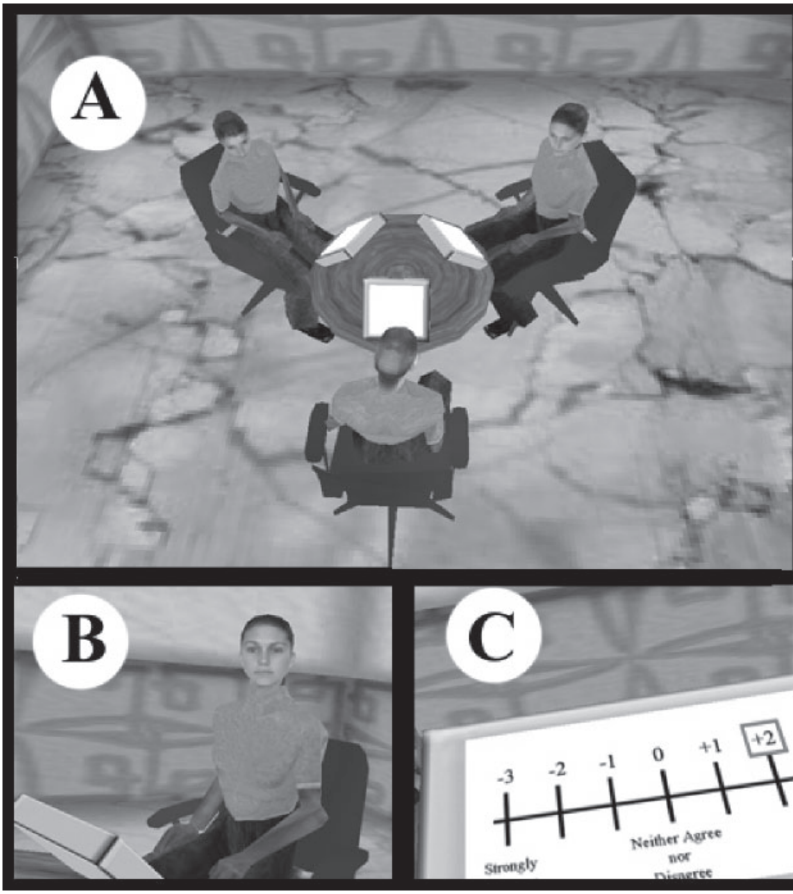

Figure 2. Visual Scenes from the Virtual Conference Room
NOTE: Panel A depicts a bird's eye view of the virtual conference room with three female avatars in it. Panel B depicts an avatar close-up. Panel C shows one of the Likert-type response screens used on each computer monitor.

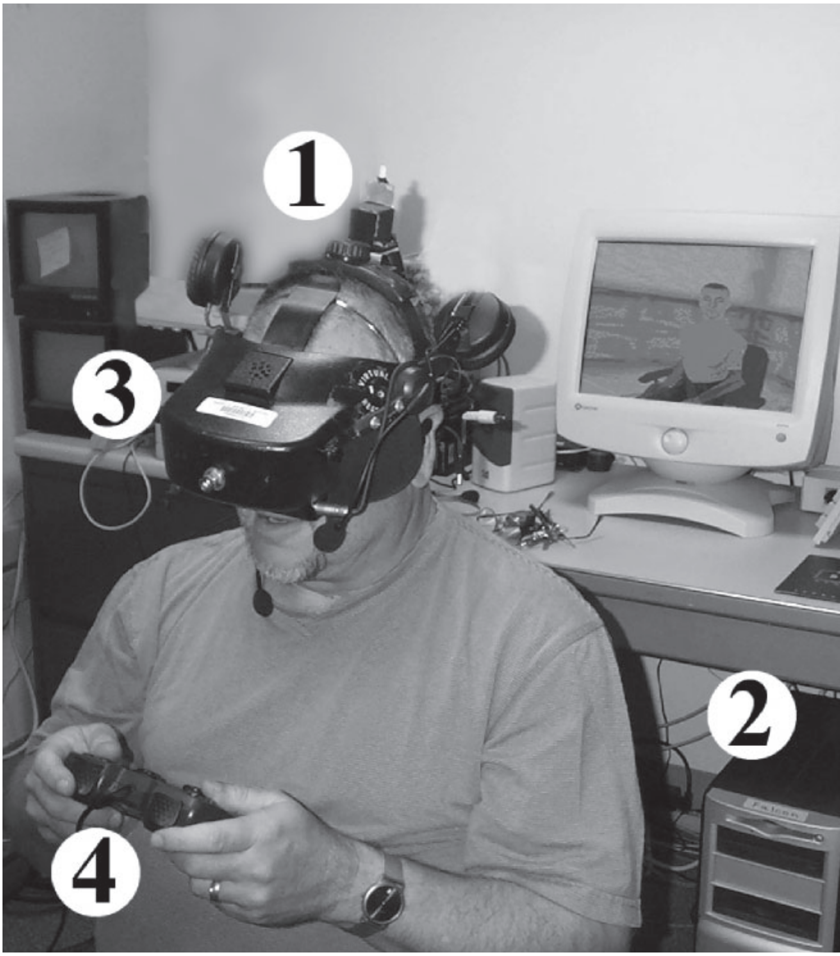

Figure 3. A Depiction of Our CVE System
NOTE: The components are:
1. orientation tracking sensor
2. image generator
3. HMD with intercom device
4. game pad input device.

for orientation with low latencies (i.e., the delay between a user's movement and the system's detection of that movement was less than 40 ms), it was possible for participants to experience realistically dynamic visual input. The full duplex intercom system (i.e., one that allows interactants to talk and listen at the same time) integrated into the HMD provided natural audio communications among interactants. Participants often describe the experience as "being inside a movie."

Participants

Participants were recruited from an introductory psychology class for pay or for experimental credit. There were 12 participants in each of the six between-participants conditions resulting from crossing participant gender and gaze condition for a total of 72 participants.[3] Participants' ranged in age from 18 to 25, with a mean of 19.61 ($SD = 1.38$).

Power Analysis

Given the sample size of 72, the experiement had a statistical power of .22 and .85 to detect small ($t = .10$) and medium ($t = .25$) effects at 1 degree of freedom. For tests with 2 degrees of freedom the corresponding power values were .24 and .92 (Cohen, 1987).

Procedure

Participants did not meet each other or the presenter in vivo. An experimenter escorted each participant into his or her separate room and read the following paragraph:

> In this experiment, we are testing Shared Virtual Environments. These are virtual reality conferences where three people can meet in the same virtual room. This is very similar to a videoconference, except instead of seeing a video feed of the other people, you will see virtual reality representations of them. When you move in a shared virtual environment, the other people in the virtual room see your movements exactly when you do them. In the current study, each of three people will sit in their own physical room. However, all three will appear in the same virtual conference room. The purpose of the current study is to test out how smoothly an interaction can flow in a virtual conference room. One of the people is the presenter. He or she will lead the discussion, and will ask you certain questions to keep you engaged in the discussion.

The two participants then received instructions regarding use of the HMD, the integrated intercom, and the game pad used to record responses during the experiment session. Once immersed in the virtual conference room, the presenter (i.e., a confederate) addressed the two participants in the virtual world. The presenter facilitated introductions and demonstrated the manner in which the immersive CVE functioned. Specifically, the presenter pointed out the nature of real-time head movements by instructing one participant to move his or her head around and made sure that the other participant noticed the real-time movement. During this introductory phase, the presenter's head movements were always rendered veridically to ensure that participants were aware of the fact that the presenter could move his or her head in the CVE before transforming those movements. In addition, the presenter pointed out how the avatars' mouths moved in correspondence to their real-time mouth movements during speech and instructed participants how to use the game pad to answer Likert-type scale response questions (from –3 to +3) on the virtual computer screen in front of them.

Finally, once participants adjusted to the CVE, the appropriate gaze condition commenced and the presenter read the persuasive passage. The passage was broken up into four sections, each taking about 20 seconds to read. After the presenter completed each section, he or she facilitated a discussion concerning that section for a period of approximately 90 seconds. The purpose of the discussion periods was to ensure that participants were exposed to the gaze manipulation for a minimum period of time (a total of approximately 8 minutes for the entire passage). This procedure was chosen for two reasons. First, by keeping the same 20-second passages constant, we attempted to keep content as uniform as possible across participants. Presenters were trained to elaborate on the content of the 20-second passage without bringing in new information. Second, pretesting demonstrated that the amount of head movements was much higher in an informal discussion period than in a formal presentation. We were interested in the effect of eye contact via head movements, so a design that encouraged as many head movements as possible was important. In some ways, this presentation style is similar to a teaching scenario in which the instructor presents information and then encourages discussion to ensure that the students properly encoded that information before moving on to the next point.

After the passage was read, the presenter verbally administered three Likert-type scale agreement questions and three multiple choice memory questions about the passage. Participants responded using the game pad depicted in Figure 3 to move the cursor depicted in Panel C of Figure 2. The passage and questions appear in Appendix A.

After completing the agreement and recall questions, participants removed the HMDs and completed a pen-and-paper scale. The scale gauged social presence and appears in Appendix A. Next, participants estimated the percentage of time that the presenter looked at him or her, at the other participant, and at neither. These questions were spaced across pages and mixed with distractor questions concerning time estimations and other percentage questions in order to discourage automatic complementary responses for the three presenter gaze responses. Finally, they wrote three paragraphs (at least five sentences each), one about the presenter, one about the other participant, and one about the conference in general.

Measures

Presenter Gaze Estimation

Participants estimated the amount of time that the presenter looked at them, the other participant, and at neither. Each estimate was made on a scale of 0–100%. This measure was used as a manipulation check to demonstrate that participants noticed more gaze in the augmented condition.

Agreement

The agreement measure was the degree to which participants agreed with the statements summarizing the passage. The three agreement responses concerning the main points of the passage (depicted in Appendix A) were averaged into a single agreement score (minimum agreement = -3, maximum agreement = 3, Cronbach's alpha = .72). This measure was used to test H1.

Memory

A single score was calculated to measure participants' memory for passage information by averaging responses (1 for correct, 0 for incorrect) of the three multiple-choice questions (shown in Appendix A). Higher scores indicate greater memory. The restricted range of this score based on averaging three nominal values; because of this, we implemented an Arcsine Transformation (Hogg & Craig, 1995) on the data, and analyzed both the transformed and the raw scores. This measure was used to test H2.

Social Presence

A single score was calculated to measure how much the participants felt that the presenter was aware of the participants, as well as how real the presenter's avatar behaved during the interaction by averaging the responses (listed in Appendix A). Higher scores indicate more social presence. Cronbach's α was .77 for this scale. This measure was used to test H3.

Explicit Augmented Gaze Detection

In the open-ended paragraph about the presenter, two independent coders, blind to the experimental condition, analyzed the text and looked for instances in which the participant explicitly detected the augmented gaze (i.e., either of the participants realized that they were not seeing "real gaze" behaviors, or suspected that more than one person received gaze simultaneously). For example, the coders looked for any wording concerning the redirection of head movements, fake or artificial gaze, or nonverbal tampering. This measure was used to test H4.

RESULTS

Presenter Gaze Estimates

Participant estimates of the percentage of presenter gaze quantified their awareness of the presenter's gaze behavior and were used as a manipulation check for the various gaze conditions. An ANOVA[4] was performed with participant gender and gaze condition as between-participants variables, gaze direction (toward the participant answering the question versus towards the other participant[5]) as a within-participants[6] variable, and percent time as the dependent variable. There was a main effect of gaze direction, such that participants estimated they received more of the presenter's gaze (M = 44.67 %, SD = 27.05 %) than did the other participant (M = 27.44 %, SD = 19.83 %), $F(1, 60) = 19.40$, $p < .001$, $\eta^2 = .24$. Even though there was an overall bias across the three gaze conditions such that participants overestimated gaze at themselves, this main effect was largely driven by the predicted interaction between gaze condition and gaze direction, $F(2, 60) = 6.47$, $p < .005$, $\eta^2 = .17$. As Figure 4 depicts, participants in the augmented gaze condition perceived more gaze directed toward themselves than toward the other participant. This disparity was much larger in the augmented condition than it was in the other two gaze conditions. There were no significant main effects for gender [$F(1, 60) = 1.38$, $\eta^2 = .02$] or gaze condition [$F(2, 60) = .72$, $\eta^2 = .02$]. Neither the interaction between gender and gaze condition [$F(2, 60) = 1.10$, $\eta^2 = .03$] or between gender and gaze direction [$F(1 ,60) = .93$, $\eta^2 = .00$] were significant. Finally, the three-way interaction was not significant, $F(2 ,60) = .23$, $\eta^2 = .05$.

In sum, participants generally perceived that they received more gaze from the presenter than did the other listener in their group regardless of the actual gaze condition. This effect, however, was most apparent in the augmented condition in which the presenter actually did look at them constantly.

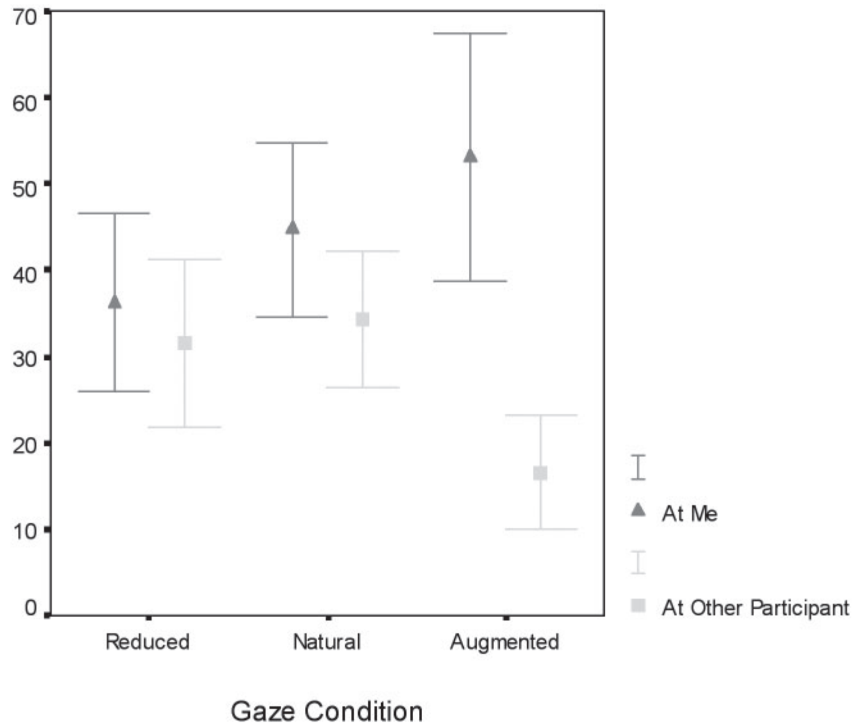

Figure 4. The Average Participant Estimation of the Percentage of Time the Presenter Looked at Himself or Herself Versus the Other Participant by Gaze Condition

Agreement

Figure 5 depicts mean agreement across participant gender and gaze conditions. An ANOVA was performed with gender and gaze condition as between-participants independent variables and agreement score as the dependent variable. There was a main effect of gaze condition, $F(2, 60) = 4.86$, $p < .05$, $\eta^2 = .14$, with Dunn's test for planned comparisons (using an α of .05) indicating that agreement in the augmented condition ($M = .21$, $SD = 1.23$) was significantly higher than either the natural condition ($M = -.55$, $SD = 1.17$) or the reduced condition ($M = -.74$, $SD = 1.23$). As Figure 5 shows, however, there was also an interaction between gender and gaze condition, $F(2, 60) = 3.23$, $p < .05$, $\eta^2 = .10$, such that female participants demonstrated higher agreement in the augmented gaze condition than the other gaze conditions, while males did not show a reliable difference between conditions. In addition, there was a main

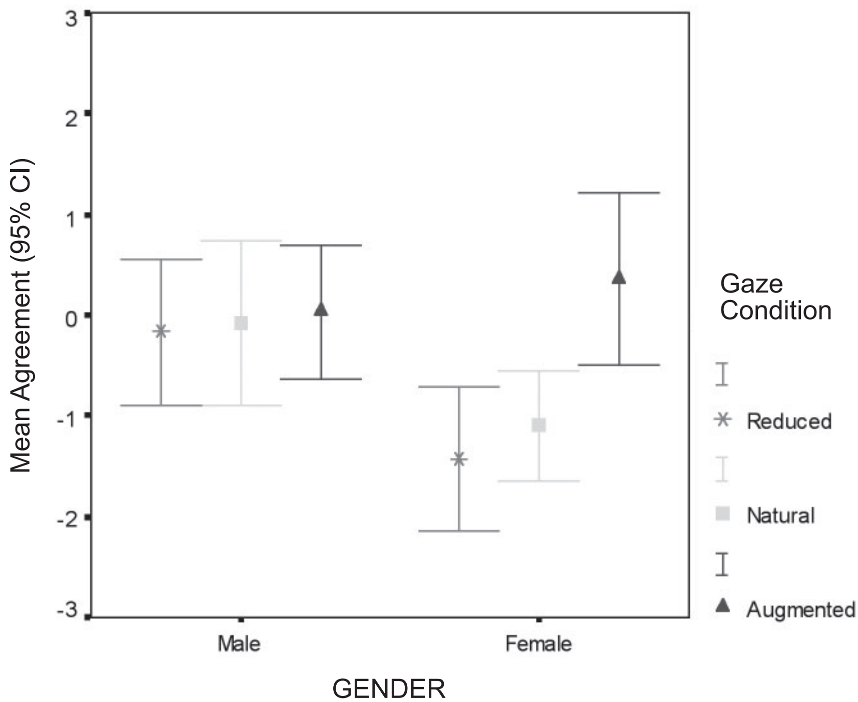

Figure 5. Mean Agreement Scores Across Participant Gender and Gaze Condition
NOTE: Positive scores indicate agreement.

effect of gender $F(1, 60) = 5.59$, $p < .05$, $\eta^2 = .09$, such that female participants agreed less overall than males. In sum, women were less persuaded than men as a group. Women in the augmented gaze condition, however, were more persuaded than women in the other gaze conditions.

Memory

The pattern of results for the data transformed using Arcsine and the raw data were identical; consequently, for simplicity we report inferential statistics using the raw scores. An ANOVA was performed with gender and gaze condition as independent variables and memory score as the dependent variable. There was a main effect of gender, $F(1, 60) = 5.78$, $p < .05$, $\eta^2 = .09$, with male participants scoring higher ($M = .30$, $SD = .15$) than females ($M = .20$, $SD = .20$). Men's memory scores were significantly above chance (.25), $t(33)=2.09$, $p < .05$ whereas women's scores did not differ from chance $t(31) = 1.44$. There was no significant main effect of condition [$F(1, 60) = .93$, $\eta^2 = .00$], or interaction ($F(2, 60) = 2.60$, $\eta^2 = .08$).

Social Presence

This section examines the average scores of the social presence questions (listed in Appendix A). Figure 6 demonstrates the means across participant gender and gaze condition. An ANOVA was performed with gender and gaze condition as independent variables and social presence as the dependent variable. There was a main effect of condition, $F(2, 60) = 9.17$, $p < .001$, $\eta^2 = .23$, with Tukey's HSD ($\alpha = .01$) indicating that participants in the augmented condition ($M = -.21$, $SD = .43$) reported lower scores than either the natural condition ($M = .14$, $SD = .35$) or the reduced condition ($M = .21$, $SD = .45$). Furthermore, there was an interaction between gender and gaze condition, $F(1, 60) = 3.13$, $p < .051$, $\eta^2 = .09$. As Figure 6 illustrates, only in the natural gaze condition did female participants report higher presenter social presence than male participants. There was no main effect of gender [$F(1, 60) = 3.05$, $\eta^2 = .05$].

Explicit Transformed Gaze Detection

There were zero instances in which the participants explicitly detected that the human gaze had been tampered with, as judged by either coder. We ran a power analysis that computed the maximum probability for dichotomous event *P* that would include zero at the two-tailed, .05 alpha level. *P* was slightly less than .10, demonstrating that it was extremely unlikely for people to detect the transformed gaze.

DISCUSSION

Summary of Findings

In the current study, H1 predicted that participants would be more persuaded (i.e., demonstrate higher agreement with the presented passage) in the augmented condition than in the other two conditions. This hypothesis was supported for female participants, but not for male participants. The fact that men did not demonstrate an increased persuasion response to the augmented gaze behavior is consistent with previous findings concerning gender and the utilization of gaze cues, both in immersive virtual environments (Bailenson et al., 2001; 2003) and in physical environments (Mulac, Studley, Weimann, & Bradac, 1987). The current study, however, cannot rule out the possibility that we simply did not have a large enough sample size to detect differences among male participants. One potential explanation is that male participants

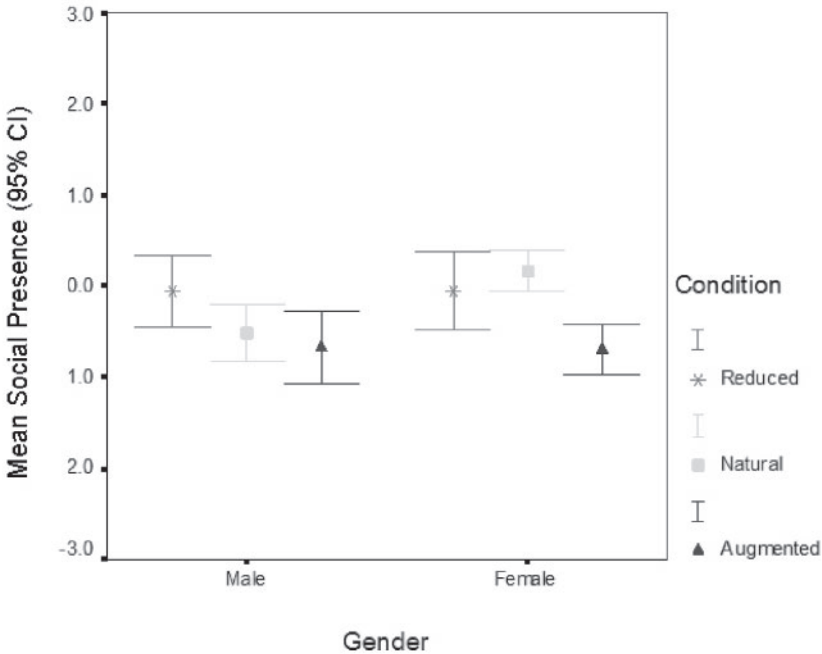

Figure 6. Mean Social Presence Scores Across Participant Gender and Gaze Condition
NOTE: Positive scores indicate higher social presence.

may have focused primarily on the verbal content of the message. This explanation is supported by (a) better recall of males for the actual content of the message on recall Question 2 than females and (b) smaller differences in agreement and social presence ratings by gaze condition among men than women. On the other hand, women may have focused primarily on the head movements of the presenters. This explanation is supported by (a) female participants' lower recall for the verbal content of the message on recall Question 2 than males and (b) higher degree of agreement and lower ratings of social presence in the augmented condition than the other conditions.

The behavior of participants in this study suggests a distinction between low level responses (i.e., automatic, unintentional, and implicit actions) and high level responses (i.e., planned, intentional, explicit actions). On an explicit level, participants reported in the social presence ratings that the presenter was unresponsive and unaware in the augmented condition (H3). This finding makes sense, considering that the augmented gaze never strayed from the participant's face *ever* during the reading of the passage, even when the presenter was verbally addressing the other participant. The fascinating result of this study is that despite reporting the clearly problematic aspects of the presenter in the 100% augmented gaze condition on an explicit level in terms of responsiveness, female participants were still persuaded by the visual input of augmented eye gaze on a low, implicit level. In other words, even though on some level female participants were well aware that the presenter's behavior was not socially appropriate (Williams, Cheung, & Choi, 2000), they were still persuaded most after receiving the high amounts of eye gaze.

Gaze, especially in the context of CVE design, has traditionally been viewed as a necessary tool for conversation to function. Head and eye movements serve to facilitate turn-taking, interest, agreement or disagreement, and many other conversational signals that are substantial in regulating face-to-face interactions. These signals are by no means essential. For example, conversations function quite well via telephone. In the current study, however, these signals were not merely removed; rather, they were arbitrarily transformed, stripping away the interactive, responsive function of otherwise realistic gaze behavior. Given this drastic transformation, the results are quite striking. Not only did the conversations flow quite well with augmented gaze, but participants did not detect that the veridicality of gesture had been breached (H4), as demonstrated by their lack of explicit augmented gaze detection after the session. Part of the reason for this lack of detection has to do with the low level of interactivity utilized in the interaction context in the CVE: A speaker presenting to listeners does not elicit as much turn taking and synchrony as other types of contexts (Burgoon et al., 2002). Most notably, at least with female participants, presenters were most able to accomplish their conversational goal (i.e., persuade the participants) when these conversational signals were drastically transformed in the augmented condition.

Implications for Communication Theories and Practice

These findings have implications for theories of computer-mediated communication and nonverbal behavior. Work by Walther (Walther, 1996; Walther & Burgoon, 1992) described how interactions conducted via digital representation in chatrooms can be hyperpersonal (i.e., more intimate, salient, and intense than face-to-face interaction). The reasons Walther provided to explain hyperpersonal interaction center largely around the verbal content and presentation of the message itself. The current findings extend the notion of hyperpersonal interaction to the nonverbal realm; using transformed social interactions, speakers can make themselves more persuasive than face-to-face conversational physics would allow. Moreover, previously discussed work by Cappella and Pelachaud (2002) rightly point out the importance of responsiveness in effective interaction. The current findings indicate that, at least in CVEs, people have a more inclusive definition of a responsive gesture (i.e., they will tolerate a less responsive representation during interaction) than thought previously. This is also consistent with work examining responsiveness and interactivity in other types of mediated contexts (Burgoon et al., 2002).

Moreover, the study results have implications for real-world applications. We did not find significant facilitation of memory in the current study (i.e., H2 was not supported); however, the potential for augmented gaze to assist instructors in distance learning CVEs remains an intriguing possibility. Instructors should be able to provide students with more "personalized" nonverbal attention via augmented gaze as well as other transformed social behaviors. On a less positive note, augmented gaze may turn out to be an attractive strategy for advertisers, salespeople, politicians, and others who seek to gain influence. In the current study, participants were not able to detect the transformed gaze. As CVEs become more widespread, however, hopefully people will become more aware of the possibilities of misuse of rendered representations. Furthermore, it should be possible to develop algorithms to detect augmented gaze and other forms of transformed social interaction (Bailenson et al., 2004).

Limitations and Future Directions

The current research has a number of limitations. Most notably, our sample size was smaller than most studies on persuasion. Given the low power of many of our statistical tests, there may have been differences between our conditions that we did not detect. Moreover, the manipulation of eye gaze was limited to head orientation in the current study, in that participants moved their heads with eyes always facing straight ahead. A more effective manipulation would be to manipulate both head direction and eye direction. Similarly, in future studies we will implement a more appropriate measure of gaze aversion. In the current study, the presenters looked at the computer screen while they spoke. Consequently, their gaze behavior was likely attributed to task performance (i.e., having to read words on the computer screen), and listeners likely did not draw many negative social inferences from the behavior. A more effective manipulation of gaze avoidance would be to manipulate eye direction (as opposed to head orientation) such that a speaker oriented his or her head towards a listener while actively moving his or her eyes away from that listener (Adams & Kleck, 2005). This manipulation would likely demonstrate that reduced gaze decreases social influence compared to natural gaze.

Along similar lines, eye gaze is just one small cue that contributes to assessments of immediacy and discourse coordination. A more thorough study should examine a fuller set of nonverbal cues (e.g., hand gestures, facial expressions, interpersonal distance, and intonation). In addition, the length and specificity of the current persuasive argument (relatively short passages of only a single thematic topic), as well as the way in which the argument was presented (a series of verbal passages repeatedly interrupted by discussion), certainly do not generalize to all types of persuasive situations.

The topic of the current passage—reduced prison sentences—could also be responsible for our current gender effects. One explanation for the memory difference would be that men may have remembered more than women about the content of the conversation because of more prior knowledge concerning crime and criminals. Alternatively, women, who may feel more vulnerable to violent crime, might be more personally involved in the potential outcome of the message. Furthermore, the presentation method of the argument clearly limits the generalizability of this study, and future research should definitely examine transformed social interaction in all types of persuasive contexts. Moreover, virtual reality simulations currently are limited in that the equipment is expensive and cumbersome. In the past few years, however, the improvements in such technology has accelerated drastically (Blascovich et al., 2002), while costs have decreased dramatically, and there is no reason to suspect that this trend will change.

In sum, the current study demonstrates a powerful social interaction strategy: using computer mediated communication, speakers can augment their normal nonverbal behavioral abilities with transformed social interaction. Providing mutual gaze to many people at once should be an extremely effective interaction strategy. The current data are far from conclusive; however, the findings do suggest that augmented gazers increase their social influence without being detected by their audience. Future work should examine the possibilities and ramifications of using augmented gaze and other transformations in media.

APPENDIX

Stimulus Passage and Social Presence Scale

Section I

The Michigan Department of Corrections has come up with a sensible plan to reduce prison overcrowding safely. The department's plan—called the Conditional Reintegration Program—would permit carefully selected inmates to finish the last several months of their sentences on electronic monitoring, or at halfway houses with 24/7 security coverage.

Section II

That would save roughly 1,300 prison beds this year, when Michigan's prison population will surpass 50,000 and reach capacity. Even with added staff to run the new program, the plan would save more than $16 million a year. Inmates in the program must work and pay the state rent, as well as taxes.

Section III

The Department of Corrections would closely supervise the inmates, who will continue to be classified as prisoners. Any slip-up would send them back to an institution. The program poses no danger to the public. Inmates selected, from minimum-security prisons only, would be close to parole. Certain violent offenders would be excluded.

Section IV

Besides saving money, the new program also would help inmates readjust to society. They'd work, save money, pay child support and take on everyday responsibilities, increasing their chances of staying out when they get out. The debate on this measure—as with any on crime and punishment—will no doubt get emotional. But the new governor and Legislature should listen to reason and approve this sound, money-saving idea.

Agreement Questions

1. Carefully selected inmates should be able to finish their sentences outside of prison.
2. Conditional Reintegration would save money without any significant safety risks.
3. Prisoners would have a better chance of being rehabilitated after their sentence with the Conditional Reintegration Program.

Memory Questions

1. According to my presentation, how many prison beds would the Conditional Reintegration Program save? (a) 1,200 (b) 120 (c) 1,300 (d) 130
2. According to my presentation, the Conditional Reintegration Program would save___ dollars ___? (a) 160 million, in total (b) 16 million, in total (c) 60 million, per year (d) 16 million, per year
3. According to my presentation, which of the following is NOT a benefit of the Conditional Reintegration Program? (a) Inmates would be able to work. (b) Inmates could live with their families. (c) Inmates could pay child support. (d) Inmates could save money.

Social Presence

The presenter was good at making eye contact with me.
The presenter should have given me more eye contact.
The presenter had no idea where I was looking during the conversation.
I felt that the presenter did not look enough at me.
The presenter spent too much time looking at the other conversant.
The presenter and I interacted very smoothly.
The presenter and I were "in tune" with each other in terms of nonverbal gestures.

NOTES

1. In previous work (Bailenson & Yee, in press; Bailenson, Beall, & Blascovich, 2002; Beall et al., 2003), as in the current study, we argued that gaze can be expressed by both head and eye movements. Head and eye direction are highly correlated; as a result, head pose can be used to approximate attentional focus. We use the term gaze to describe head direction only, while we acknowledging that having avatars that do not move eyes from side to side is problematic.

2. The agreement statements were pretested along with a number of other statements in a psychology class (n = 163). The mean of each of the three agreement statements were between 1 and -1 (*SDs* < 1.10) on a Likert-type agreement scale between -3 and +3.

3. Due to equipment failure, data were lost from three groups (six participants): one from female-reduced, one from female-natural, and one from male-augmented.

4. Due to our relatively small sample size it is important to note that, for all ANOVAs conducted in this paper, we tested for violations of sphericity and homogeneity of variance. For every analysis, the assumptions were met.

5. We did not include estimations by participants of "the presenter looking at neither of the two interactants" in this ANOVA in order to prevent the two levels of the within-participants variable from being perfectly complementary.

6. There is a risk that treating each participant as an independent observation is problematic, because participants could potentially hear one another and see one another's head movements. Each participant, however, did experience their own version of the virtual world drawn to their local machine, and there was very little interaction between the two participants. Nonetheless, the current study is limited by this potential nonindependence, and in future work with a larger sample size we plan on using group as the unit of observation.

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