Media Psychology, 10:1–22, 2007
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ISSN: 1521-3269 print / 1532-785X online
DOI: 10.108/15213260701300865

Virtual Humans and Persuasion: The Effects of Agency and Behavioral Realism

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Two studies examined whether participant attitudes would change toward positions advocated by an ingroup member even if the latter was known to be an embodied agent; that is, a human-like representation of a computer algorithm. While immersed in a virtual environment, participants listened to a persuasive communication from a digital representation of another student. The latter was actually an embodied agent (a computer-controlled digital representation of a human). Study 1 examined the extent to which gender of the virtual human, participant gender, and the agent's behavior affected attitude change. Results revealed gender-based ingroup favoritism in the form of greater attitude change for same gender virtual humans. Study 2 examined behavioral realism and agency beliefs; that is, whether participants believed the other to be an agent or an avatar (an online representation of an actual person). Results supported Blascovich and colleague's model of social influence within immersive virtual environments. Specifically, the prediction that virtual humans high in behavioral realism would be more influential than those low in behavioral realism was supported, but this effect was moderated by the gender of the virtual human and the research participant. Implications of these findings for the model are discussed.

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INGROUP FAVORITISM AND PERSUASION: THE EFFECTS OF AGENCY AND BEHAVIORAL REALISM

People are influenced more by similar others or members of their ingroups than dissimilar others or members of outgroups (e.g., Cialdini, 2001; Cialdini & Trost, 1998). For example, Brock (1965) demonstrated that salespersons who reported being similar to prospective customers on a dimension relevant to the prospective purchase (paint) were more effective sellers. Mackie, Worth, and Asuncion (1990) found that participants were more open to persuasion on a counter-attitudinal message when the communicator was a member of their ingroup. Guadagno and Cialdini (2007) reported that individuals highly identified with a communicator were more open to persuasion though, notably, the effect was moderated by the communication modality. Bailenson, Garland, Iyengar, and Yee (2005) demonstrated that a political candidate is more likely to receive a person's vote if he or she looks like that person (i.e., digitally morphed photograph combining the candidate and voter's faces).

This investigation examined how perceptions of a communicator's group membership and agency impact attitude change, specifically, whether people change their attitudes in accord with a position advocated by an apparent ingroup member even if that individual is known to be a computer-controlled agent. Research conducted by Nass and colleagues (Nass & Moon, 2000; Reeves & Nass, 1996) indicates that people often respond to computers socially, but the question of how people respond to computers that look and act human (i.e., virtual humans) has not been thoroughly addressed. Blascovich and colleagues (Blascovich, 2002; Blascovich et al., 2002) proposed a model of social influence within immersive virtual environments that predicts that people will be more influenced by virtual representations of humans to the extent that they exhibit behavioral realism and/or are believed to be avatars, that is, online digital representations of actual others.

Immersive Virtual Environments

A virtual environment is a synthetic representation of a natural or imagined environment (Blascovich et al., 2002; Biocca & Levy, 1995; Kalawsky, 1993; Lanier, 2001). Although virtual worlds have existed for millennia (Ijsselsteijn, 2004), modern digital technology has advanced them qualitatively and quantitatively. Digital virtual worlds can be two- or three-dimensional representations of a space (room, landscape, planet, etc.) containing objects (chairs, flora, oceans, etc.) and representations of humans. The latter can be online representations of actual persons (i.e., avatars) or computer algorithms simulating persons (i.e., agents). Individuals in an immersive virtual environment (IVE) are typically experience visual aspects of the virtual

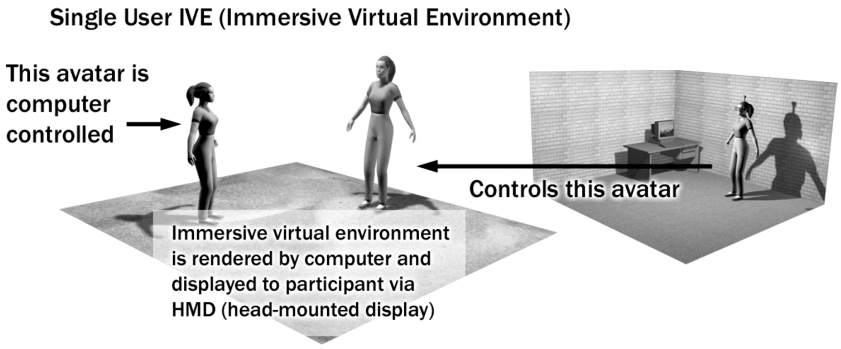

FIGURE 1 Single-user immersive virtual environment with computer-controlled agent.

world via computer controlled head-mounted displays (HMD) that project the world stereoscopically. See Figure 1.

For self-relevant social interactions involving conscious responses, Blascovich and colleagues (Blascovich, 2002; Blascovich et al., 2002) hypothesized an interaction between behavioral or communicative realism (the degree to which human representations and objects behave as they would in the physical world) and agency (the extent to which the participant believes they are interacting with another sentient human being) such that the higher the realism, the less perceived agency is necessary to achieve social influence, and vice versa. Thus, the more realistic the behavior of virtual human representations, and/or the more sentient they are perceived to be, the more they will influence individuals with whom they interact. At the extremes of perceived agency of virtual human representations are computer algorithm-controlled ones (i.e., agents) and human-controlled ones (i.e., avatars). Hence, equal levels of social influence require more realistic behaviors of agents than avatars.

Immersion, which occurs when the virtual environment perceptually envelopes an individual such that the individual perceives him- or herself to be interacting within that virtual environment rather than within his or her physical surroundings, is an important part of this process. People who are immersed feel a greater sense of social presence (the perception that one is really in the same environment with the other virtual humans) with both computer-controlled agents and human-controlled avatars than do individuals who are not immersed (Blascovich et al., 2002; Schroeder, 2002; Short, Williams, & Christie, 1976; Slater, Sadagic, Usoh, & Schroeder, 2000).

Social Influence in IVEs

Research examining social influence processes in IVEs has confirmed the effects described earlier. Bailenson, Blascovich, Beall, and Loomis (2003)

conducted studies examining interpersonal distance in IVEs. The first examined the impact of gender, agency, and behavioral realism (operationalized by gaze or no gaze behavior on the part of a virtual human) on the interpersonal distance that participants maintained from virtual others while traversing virtual space to view a series of letters attached to the virtual human's back. Results indicated that participants maintained greater interpersonal distance when they believed the virtual other was high in perceived agency (human-controlled) and when it was high in behavioral realism. The results revealed an interaction indicating that computer-controlled agents required realistic gaze to elicit social influence, but human avatars elicited social influence regardless of gaze behavior. Their second study examined violations of personal space. In this case, participants moved farther away from the virtual human when they thought it was an agent as opposed to an avatar who violated their personal space. Bailenson and Yee (2005) demonstrated that agents who were high in behavioral realism and mimicked the head movements of participants were more persuasive than agents who did not mimic (i.e., displayed other realistic movement behaviors).

Swinth and Blascovich (2001) examined conformity in a virtual blackjack game. Participants played blackjack in an immersive virtual casino together with two virtual humans. Agency was varied so that participants either believed they were playing with computer-controlled agents (low agency) or human-controlled avatars (high agency). The virtual players either consistently bet lower or higher in relation to participants' preestablished betting norms. Results indicated that participants conformed to the betting norms of the virtual humans, particularly when they perceived them as avatars.

Finally, Garau (2003), as well as Bailenson et al. (2005), reported that perceptions of social presence were lowest when there was a large mismatch between the behavioral realism and photographic realism the (i.e., appearance) of the computer-controlled agent. Specifically, the results from these studies indicate that when the behavioral realism of a virtual human is not in line with the photograph realism—by either being extremely realistic in behavior (i.e., acts human) but not appearance (i.e., does not look human) or being extremely unrealistic in behavior (i.e., does not act human) but realistic (i.e., looks human) in appearance—it can actually reduce the perception of being in a virtual environment with other sentient beings. Thus, behavioral realism may not always be more influential, particularly when there is an incongruity between the realism of virtual human behavior and appearance.

Gender Differences in Social Interaction in IVEs

Prior research has revealed that gender impacts perceiver perceptions of digital representations of humans. Specifically, effects of gender in some exper-

imental contexts have indicated that women are more sensitive to perceived agency. For instance, Swinth and Blascovich (2001) reported that women conformed more than men when they believed they were gambling in an IVE with other humans. Specifically, they found that men placed larger bets overall than women, but women conformed more than men, particularly when they believed they were interacting with avatars as opposed to agents. A second study replicated and expanded on this effect, demonstrating that both men and women conformed more to virtual humans of the same gender when no explicit expectations for agency were manipulated.

Other research indicates that women maintain greater interpersonal distance from avatars than agents, though men did not differentiate between the two (Bailenson et al., 2003) and that women yield more personal space to embodied agents who exhibit high behavioral realism than to agents who exhibit low behavioral realism (Bailenson, Blascovich, Beall, & Loomis, 2001). Thus, the results of prior research suggest that individuals respond differently to digital representations of humans as a function of agency and behavioral realisms, and that gender of the perceiver impacts this process.

Overview of the Present Research

We examined whether the results of prior research on social influence in IVEs generalize to persuasion contexts. In both the experiments here, participants listened to a virtual human's persuasive communication regarding the prospect of adopting a new security policy on campus. In Study 1, gender of the virtual human, participant gender, and behavioral realism of the agent were varied. Study 2 was a replication and expansion of the first study in which we also manipulated agency (i.e., agent vs. avatar).

STUDY 1

The purpose of this study was to examine the interaction between the gender of the virtual human and the gender of the participant. Gender was varied for two reasons: (a) because prior research indicates that men and women respond differently to virtual humans (Bailenson et al., 2001, 2003; Swinth & Blascovich, 2001), and (b) to explore whether gender differences in persuasion previously reported in text-based computer-mediated contexts (Guadagno & Cialdini, 2002; Guadagno & Cialdini, 2007) would occur in an IVE context. We varied behavioral realism expecting that virtual humans high in behavioral realism would be more influential than those low in behavioral realism. Participants were not told specifically whether the virtual humans with whom they interacted were agents or avatars.

Method

Participants. Participants were 65 (29 female, 37 male) undergraduates who either received course credit or were paid $5 for their participation. All were selected from a sample of the participant pool that had filled out measures of agreement, interest, and knowledge on the topic. Specifically, the population means and standard deviations on these measures are as follows: agreement ($M = -1.30$, $SD = 1.65$), interest ($M = 0.66$, $SD = 1.63$), and knowledge ($M = -0.85$, $SD = 1.78$). Thus, the population was generally opposed to, moderately interested in, and knew little about the topic of the persuasive communication. Participants who had completed the pretest measures were eligible to sign up for the experiment for credit or pay and, once they signed up, were randomly assigned to condition.

Design. The experimental was based a 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) between-subjects factorial design. Male and female participants were each randomly assigned to listen to a persuasive communication on proposed changes to university security policy from a virtual human (in actuality, an agent). In the high behavioral realism condition, the agent maintained mutual gaze with the participant by moving his or her head to maintain eye contact with the participant, blinked his or her eyes, and moved his or her lips in synch with the recorded persuasive communication. The low behavioral realism agent did not move his or her head, lips, and did not blink.

Dependent variables. To determine whether the behavioral realism manipulation was successful, we asked participants to rate the agent on a scale ranging from −3 (*strongly disagree*) to +3 (*strongly agree*) on the following four items: "The virtual person acted like a real person"; "The virtual person moved like a real person"; "I felt that the movement of the virtual person was controlled by a real person"; "I felt like I was interacting with a real person."

To assess participants' attitudes toward the security policy proposal, we asked them to rate the security card proposal on items adapted from a scale developed by Brinol and Petty (2003), ranging from −3 to +3 with the following anchor points: good/bad, foolish/wise, negative/positive, beneficial/harmful, effective/ineffective, and useful/not useful. Additionally, participants were asked to rate how much they agreed with a statement—"All students should have to carry ID cards for a new university-wide security system. These cards would be required for admittance into classes, the library, and any other public place on campus."—on a scale ranging from −3 (*completely disagree*) to +3 (*completely agree*). A series of additional measures assessed the participant's impression of the virtual human on a scale ranging from −3 (*Not at all* ____) to +3 (*Very* _____) on 13 dimensions adapted from Guadagno and Cialdini (2002): friendly, competent, warm, ap-

proachable, interesting, sincere, confident, honest, likeable, informed, credible, trustworthy, and modest.

Finally, to examine whether perceptions of social presence varied as a function of the extent to which the agent displayed realistic behavior, we added the following four items adopted from Swinth and Blascovich (2001): "I felt like other person could see me"; "I felt like the other person was watching what I did"; "I felt like the other person knew I was there"; "I felt like the other person was looking at me."

To ensure that there were no differences in perceptions of the quality of the presentation based on the voices of the male and female agents, we asked participants to rate the quality of the presentation on a scale ranging from 1 (*very low*) to 9 (*very high*).

Apparatus. The IVE technology used is described in detail in Bailenson et al. (2001) and is illustrated in Figure 2. Using this system, it is possible to create an IVE in which participants experience appropriate sensory input. The participant saw and heard a computer-generated visual and auditory rendering of the virtual world; when he or she turned his or her head or moved, the rendition changed accordingly. The orientation and location of a participant's head was tracked by a three-axis orientation (yaw, pitch, and roll) and position sensing system. For this study, the IVE was a simple room.

Procedure. Participants were told that the purpose of this study was to receive feedback from students on a potential change to campus secu-

FIGURE 2 A participant wearing an HMD in the experiment.

FIGURE 3 The male and female virtual humans.

rity policy, one that would require them to carry an identification card that they would need to access the campus grounds and facilities. Each participant was told they were going to listen to another student's opinion on the topic while in an IVE. The other student was actually an agent (a computer-controlled digital representation of a human) that was either male or female. See Figure 3 to view the models of the virtual humans.

The virtual human's persuasive communication contained a series of strong arguments in favor of the security card proposal adapted from Brinol and Petty (2003). We translated the original communication from Spanish to English, edited the content to fit the specifics of our University, and added an opening and closing paragraph.

The male and female virtual humans were selected from a sample that were pretested and found to be slightly above average in ratings of perceived attractiveness, friendliness, likeability, and intelligence—the range of means was from 4.5 to 5.5 depending on item on a scale of 1 (*Not at all* ____) to 9 (*Extremely* _____). A series of independent sample t-tests comparing the ratings for the male and female virtual humans on the aforementioned dimensions revealed no significant differences between the two agents on any of these dimensions (all p's $> .25$). Additionally, the pretest data on these two faces indicated that there were no gender differences in participants' ratings of the virtual humans.

After listening to the persuasive communication, participants filled out a computer-based questionnaire, using RiddleMeThis as our data collection tool (Loewald & Guadagno, 2004). The computer-based questionnaire included the dependent measures listed earlier. On completion of the questionnaire, participants were debriefed and dismissed.

Results

Behavioral realism manipulation check. The four items measuring perceptions of behavioral realism formed a reliable composite, $\alpha = .72$. A 2

(virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) analysis of variance (ANOVA) on the composite revealed a main effect for behavioral realism, $F(1, 58) = 19.51$, $p < .01$, $\eta_p^2 = .252$. An examination of the means revealed that participants rated the high behavioral realism virtual human higher than the low behavioral realism virtual human on behavioral realism ($M = -1.28$, $SD = 0.83$ vs. $M = -2.26$, $SD = 0.93$). It is noteworthy that both means were far below the scale midpoint of zero.

Attitude change. To determine participants' attitudes toward the proposal, we formed a composite of the attitude items by averaging them together, $\alpha = .85$. A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) analysis of covariance (ANCOVA) with pretest attitude toward the topic as the covariate revealed a gender of the virtual human by participant gender interaction indicating that participants experienced more attitude change when the virtual human was the same gender as they were, $F(1, 57) = 5.45$, $p < .05$, $\eta_p^2 = .087$. See Figure 4 for a breakdown of the adjusted means. Additionally, Table 1 reports pre- and posttest mean attitude toward the security card proposal. Men and women did not differ in their pretest attitude towards the topic.

Trait ratings. We conducted a Principal Axis Factor Analysis with Varimax rotation on the 13 trait ratings of the virtual human and the analysis revealed two distinct factors. We formed a composite of the traits on these two factors by averaging them. The first factor, which we refer to as "likeability," contained the following traits: friendly, warm, approachable, interesting, sincere, confident, likeable, trustworthy, modest, $\alpha = 0.89$. The second factor, which we refer to as "credibility," contained the following traits: competent, honest, informed, credible, $\alpha = 0.83$.

A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) ANOVA on the like-

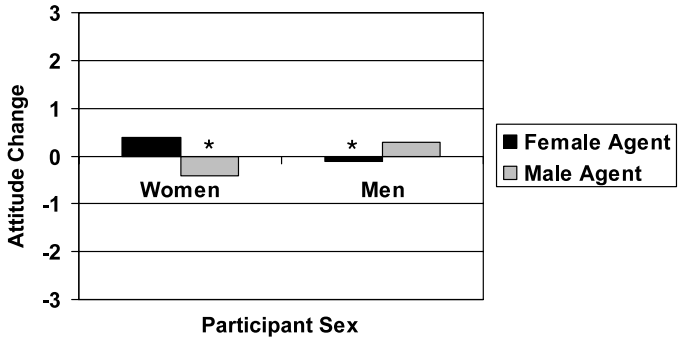

FIGURE 4 Study 1: Adjusted means for gender of the virtual human by participant gender interaction in attitude change. $^*p < .05$.

TABLE 1 Preexperimental and Postexperimental Raw Means and Standard Deviations on Participants' Attitude Toward the Topic of the Persuasive Communication

		Raw agreement with the message			
		Preexperiment		Postexperiment	
Study	Participant gender	*M*	*SD*	*M*	*SD*
Study 1	Women	−2.66	0.48	0.00	0.84
	Men	−2.46	0.51	0.13	1.14
Study 2	Women	−0.51	1.84	0.80	1.29
	Men	−0.89	1.75	0.43	1.20

ability composite revealed a main effect of gender of the virtual human indicating that participants rated the female virtual human as more likeable than the male ($M = 0.43$, $SD = 0.77$ vs. $M = -0.05$, $SD = 1.13$), $F(1, 58) = 4.48$, $p < .05$, $\eta_p^2 = .071$. Again because we made predictions concerning same- and cross-gender influence attempts, we examined the means for this measure broken down by gender of the virtual human and participant gender, which revealed that this main effect was driven by the women who showed an ingroup favoritism effect ($M_{\text{same gender agent}} = 0.69$, $SD = 0.67$ vs. $M_{\text{opposite gender agent}} = 0.22$, $SD = 0.79$), $F(1, 62) = 6.28$, $p < .03$, whereas the men did not ($M_{\text{same gender agent}} = 0.06$, $SD = 1.28$ vs. $M_{\text{opposite gender agent}} = -0.21$, $SD = 0.89$), $F(1, 62) = 0.26$, *ns*.

A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) ANOVA on the credibility composite revealed a marginal interaction between participant gender and gender of the virtual human in the predicted direction, $F(1, 62) = 2.90$, $p < .10$, $\eta_p^2 = .048$. Women showed an ingroup favoritism effect ($M_{\text{same gender}} = 1.44$, $SD = 0.59$ vs. $M_{\text{opposite gender}} = 0.53$, $SD = 1.28$),

TABLE 2 Means and Standard Deviations for Liking, Credibility, and Presentation Quality Broken Down by Participant Gender and Gender of the Virtual Human

		Gender of the virtual human			
		Woman		Man	
Dependent variable	Participant gender	*M*	*SD*	*M*	*SD*
Agent liking	Women	0.69*	0.67	0.22*	0.79
	Men	−0.21	0.89	0.06	1.28
Agent credibility	Women	1.44*	0.59	0.53*	1.28
	Men	0.91	0.66	0.93	1.39
Presentation quality	Women	6.07*	1.25	4.31*	2.09
	Men	5.30	1.89	5.51*	1.89

*$p < .05$.

$F(1, 62) = 5.37, p < .03$, whereas the men did not ($M_{\text{same gender}} = 0.93$, $SD = 1.39$ vs. $M_{\text{opposite gender}} = 0.91$, $SD = 0.66$), $F(1, 58) = 0$, *ns*. See Table 2 for the breakdown of means by gender of the virtual human and gender of the participant on the two trait composites.

Social presence. The social presence measures formed a reliable composite, $\alpha = .92$. A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) ANOVA on the social presence composite revealed a significant main effect for behavioral realism, $F(1, 58) = 4.48, p < .05, \eta_p^2 = .072$, indicating that participants experienced more social presence when behavioral realism was high as opposed to low ($M_{\text{high BR}} = -0.95$, $SD = 1.7$ vs. $M_{\text{low BR}} = -1.76$, $SD = 1.45$). There were no significant effects for gender of the participant or virtual human on this measure.

Presentation quality.[1] A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) ANOVA revealed a main effect of gender of the virtual human indicating that participants rated the presentation quality of the female virtual human as higher than that of the male ($M_{\text{female agent}} = 5.72$, $SD = 1.64$ vs. $M_{\text{male agent}} = 4.79$, $SD = 1.99$), $F(1, 55) = 4.16, p < .025, \eta_p^2 = .074$. Because we made predictions concerning same and cross gender interactions, we examined the means for this measure by gender of the virtual human and participant gender, which revealed that this main effect was driven by the women who showed an ingroup favoritism effect ($M_{\text{same gender agent}} = 6.07$, $SD = 1.25$ vs. $M_{\text{opposite gender agent}} = 4.306$, $SD = 2.09$), $F(1, 59) = 6.54, p < .02$, whereas the men did not ($M_{\text{same gender agent}} = 5.30$, $SD = 1.89$ vs. $M_{\text{opposite gender agent}} = 5.51$, $SD = 1.89$), $F(1, 59) = 0.17$, *ns*. This suggests that the manipulation check may have not operated as expected and is instead a reflection of the overall trend toward ingroup favoritism. See Table 1 for the breakdown of means by gender of the virtual human and gender of the participant on the measure of presentation quality.

Discussion

The results of this study indicate that persuasive social influence in IVEs functions differently from other forms of computer-mediated communication (Guadagno & Cialdini, 2002, 2007). Specifically, women in this study did not display less attitude change than did men as has been reported in prior research examining gender differences in attitude change in emailed persuasion attempts. Instead, in the absence of explicit expectations as to the agency of a computer-controlled virtual representation of a human, men and women both exhibited an ingroup favoritism effect, displaying more attitude

[1]Data were missing for 2 participants on this measure.

change when the communicator was a virtual human of the same gender as the participant. This effect was greater for women in this study, possibly due to the fact that women identify more strongly with their gender than do men (Cameron & Lalonde, 2001; Guadagno, Dimov, Bailenson, Beall, & Blascovich, 2004).

Additionally, it appears that the high behavioral realism manipulation was not sufficiently realistic to produce the predicted effect. As hypothesized, participants did rate the high behavioral realism agent as more behaviorally realistic and higher in social presence than the low behavioral realism agent; however, this did not produce more attitude change. The second study attempted to replicate and expand on these findings by examining the impact of perceived agency on the persuasion process.

STUDY 2

In the second experiment, we sought to replicate and expand on Study 1 by examining whether agency impacted attitude change. We hypothesized that virtual humans perceived to be human controlled (i.e., avatars) would be more influential than those perceived to be computer controlled (i.e., agents). Participants were given explicit information about the agency of the virtual human. Additionally, in the high behavioral realism condition, the virtual human made and broke eye contact with the participant in a manner that was more behaviorally realistic than constantly establishing mutual gaze. As in Study 1, the gender of the virtual human and the gender of the participants were varied. All other aspects of the virtual human and the IVE were identical to Study 1.

Method

Participants. Participants were 174 (89 female, 85 male) undergraduates who either received course credit or were paid $5 for their participation.

Design. The experimental was based on a 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) × 2 (agency: high vs. low) between-subjects factorial. All participants were randomly assigned to condition. The virtual humans' appearance and voices were identical to Study 1. The high behavioral realism was more interactive than in the first study: The virtual human only tracked the gaze of the participant within a 15-degree field of view and broke and reestablished eye contact at random intervals: The low behavioral realism was identical to Study 1. To manipulate agency, participants in the low agency condition were told they were interacting with a computer-controlled agent and participants in the high agency condition told that they were interacting with a human-controlled avatar.

Dependent variables. We used the same dependent variables as in Study 1.

Procedure. The procedure was identical to that reported in Study 1 except for the agency manipulation. Participants in the agent condition were told that the virtual person was a computer-controlled agent, not a real person. Participants in the avatar condition were told the virtual person was another research participant. To reinforce this manipulation, participants saw a mixture of live video of themselves and prerecorded video of the virtual others. As participants walked into their lab room, they saw video displaying live footage of their movements on one fourth of a computer screen. The other three quarters of the computer screen displayed prerecorded footage of two confederates who were settling into other lab rooms and the third fourth of the screen displayed white noise.

Results

Behavioral realism manipulation check. The four items measuring perceptions of behavioral realism formed a reliable composite, $\alpha = 87$. A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) × 2 (agency: high vs. low) ANOVA on the composite revealed a main effect for behavioral realism indicating that the high behavioral realism virtual human was perceived as higher than the low behavioral realism virtual human, $F(1, 158) = 65.05$, $p < .001$, $\eta^2 = .29$ ($M_{\text{high BR}} = -0.90$, $SD = 1.23$ vs. $M_{\text{low BR}} = -2.23$, $SD = 0.96$). It is important to note that, although the mean for the high behavioral virtual human was higher than the high behavioral realism virtual human in Study 1, it was still below the scale midpoint of zero.

This analysis also revealed a main effect for agency, indicating that participants who believed the virtual human was human controlled rated it as higher in behavioral realism as compared to participants who believed the virtual human was computer controlled, $F(1, 158) = 6.9$, $\eta_p^2 = .042$, $p < .01$, ($M_{\text{human perceived agency}} = -1.36$, $SD = 1.29$ vs. $M_{\text{computer perceived agency}} = -1.79$, $SD = 1.25$). Finally, there was additionally a significant four-way interaction on this measure, which will not be discussed further because this interaction was not interpretable.

Attitude change. Table 1 reports pre- and posttest mean attitude toward the security card proposal. As can be seen in the table, men and women who participated in this study did not differ in their pretest attitude toward the topic. As in Study 1, the attitude measures formed a reliable composite, $\alpha = .89$. A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) × 2 (agency: high vs. low) ANCOVA on the composite of attitude measures with pretest attitude toward the topic as a covariate revealed two significant effects. First, there was a significant gender of the virtual human by perceived agency interaction,

$F(1, 155) = 3.70$, $p = .05$, $\eta_p^2 = .023$, indicating that for male virtual humans, there was more attitude change when participants believed he was an agent than when participants believed he was an avatar ($M = 0.98$ vs. $M = 0.45$). When the virtual human was female, there was no significant difference based on perceived agency, although it trended toward more attitude change when participants perceived the virtual human to be human controlled than computer controlled ($M = 0.86$ vs. $M = 0.63$).

Second, there was a significant three-way participant gender by virtual human gender by behavioral realism interaction, $F(1, 155) = 4.72$, $p < .05$, $\eta_p^2 = .03$. See Figure 5 for a display of the adjusted means by condition. Post hoc interaction contrasts indicated that male participants reported more attitude change in the high behavioral realism condition when the agent was male than female, $t(164) = 1.09$, $p < .05$. No other post hoc contrasts probing this interaction were statistically significant. Thus it appears that the ingroup favoritism effect only occurred for male participants when the virtual human was high in behavioral realism.

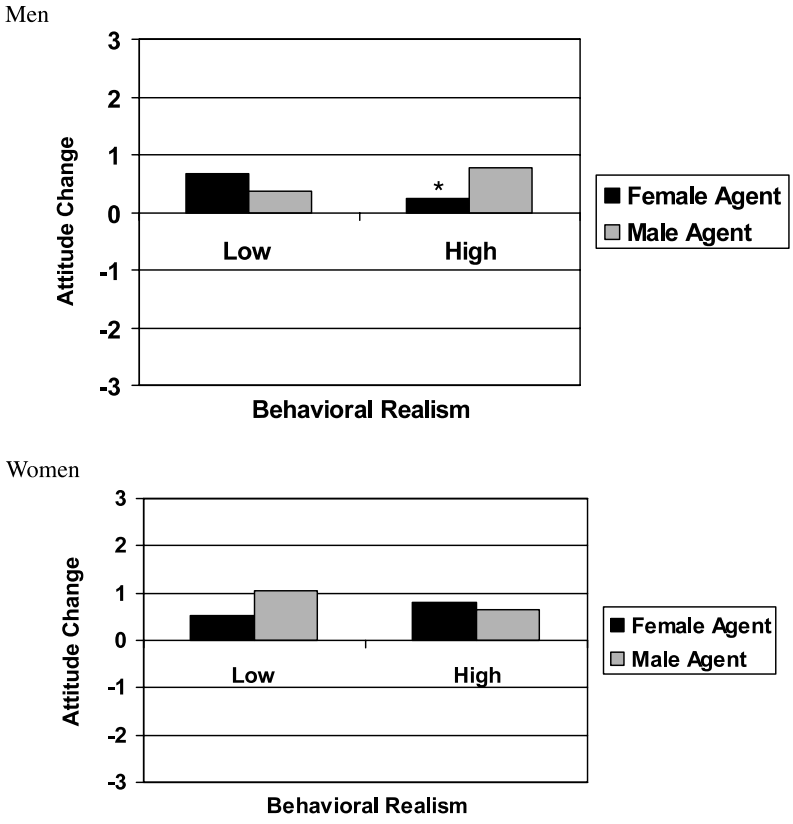

FIGURE 5 Study 2: Adjusted means for three-way gender of the virtual human by participant gender by behavioral realism interaction in attitude change. $^*p < .05$.

Trait ratings. The same items used in Study 1 were averaged to form two reliable composites: liking, $\alpha = .90$, and credibility, $\alpha = .81$. A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) × 2 (agency: high vs. low) ANOVA on the liking composite revealed a significant main effect for gender of the virtual human indicating that the female virtual human was rated as more likeable than the male, $F(1, 158) = 6.29$, $p < .02$, $\eta_p^2 = .038$ ($M_{\text{female}} = 0.73$, $SD = 1.08$ vs. $M_{\text{male}} = 0.34$, $SD = 0.94$). This was qualified by a significant gender of the virtual human by perceived sentience interaction, $F(1, 158) = 5.40$, $p < .05$, $\eta^2 = .033$. Simple effects tests revealed that when participants believed they were interacting with a computer, there was no difference in liking for the virtual human based on its gender ($M_{\text{female}} = 0.57$, $SD = 1.05$ vs. $M_{\text{male}} = 0.53$, $SD = 0.88$). However, when participants believed that they were interacting with a human-controlled avatar, participants rated the female agent as more likeable than the male agent ($M_{\text{female}} = 0.88$, $SD = 1.11$ vs. $M_{\text{male}} = 0.14$, $SD = 0.97$).

A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) × 2 (agency: high vs. low) ANOVA on the credibility composite revealed no significant effects.

Social presence. The social presence measures formed a reliable composite, $\alpha = .95$. A 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) × 2 (agency: high vs. low) ANOVA on the social presence composite revealed several effects. First, as in Study 1, there was a main effect for behavioral realism, $F(1, 158) = 43.91$, $p < .001$, $\eta_p^2 = .217$, indicating that participants in the high behavioral realism condition reported experiencing more social presence than those in the low behavioral realism condition, ($M_{\text{high BR}} = -0.15$, $SD = 1.78$ vs. $M_{\text{low BR}} = -1.76$, $SD = 1.52$). Next, there was a main effect for agency indicating that participants who believed they were interacting with an avatar reported more social presence than participants who believed they were interacting with a computer agent ($M_{\text{human}} = -0.60$, $SD = 1.82$ vs. $M_{\text{computer}} = -1.31$, $SD = 1.80$), $F(1, 158) = 8.54$, $p < .01$, $\eta_p^2 = .051$. Finally, there was a significant gender of the virtual human by perceived agency interaction, $F(1, 158) = 9.61$, $p < .01$, $\eta_p^2 = .057$. Simple effects tests revealed that participants reported feeling more social presence with the female virtual human when they thought she was an avatar human as opposed to an agent ($M_{\text{human}} = -0.19$, $SD = 1.88$ vs. $M_{\text{computer}} = -1.60$, $SD = 1.77$), $F(1, 172) = 12.99$, $p < .001$. However, there was no difference in social presence ratings when the virtual human was male ($M_{\text{human}} = -0.97$, $SD = 1.71$ vs. $M_{\text{computer}} = -1.03$, $SD = 1.8$), $F(1, 172) = 0.03$, *ns*.

Presentation quality. The 2 (virtual human gender: male vs. female) × 2 (participant gender: male vs. female) × 2 (behavioral realism: high vs. low) × 2 (agency: high vs. low) ANOVA on participants ratings on the quality of the presentation revealed no significant effects. This suggests that, in this

study, the manipulation check did not interact with any of the independent variables and instead operated as expected by demonstrating that there was no difference in the quality of the presentation based on the voice of the virtual humans.

Discussion

The results of this study indicate that when perceived agency is explicitly manipulated, other factors impact an individual's receptivity to a persuasive communication from an agent. Specifically, it appears that, as in prior research (Bailenson et al., 2003; Swinth & Blascovich, 2001), the gender of the audience interacts with perceived agency and behavioral realism to produce differential levels of attitude change, possibly due to differences in men and women's expectations for interacting with virtual humans as evidenced by gender differences in computer gaming experience (Lucas & Sherry, 2004). It is noteworthy to point out that an ingroup favoritism effect did reveal itself in this study as well, but this effect interacted with other independent variables producing a more narrow ingroup favoritism effect. Specifically, men in this study showed an ingroup favoritism effect when the behavioral realism of the virtual human was high.

One interpretation of these data is that there was no ingroup favoritism effect when participants were given explicit expectations about the agency of the virtual human. An examination of the attitude change data broken down by the full design reveals that it was affected by perceived agency. Women reported the most positivity toward the message in the high behavioral realism, female virtual human, high agency condition ($M = 1.30$), whereas men reported the most positivity in the high behavioral realism, male virtual human, low agency condition ($M = 1.02$). It appears that there is an ingroup favoritism effect but it is moderated by participant's beliefs about virtual humans.

Another interpretation of these results is that there may be a relationship between expectations for interacting with a computer versus a human and a man versus a woman. It may be that men and computers are both expected to be competent relative to women and humans, which are both expected to be warm. In support of this notion, there is evidence in the stereotyping literature that men are perceived as more competent than women whereas women are perceived as more warm (Fiske, Cuddy, Glick, & Xu, 2002). This could also be the case for virtual humans who are agents versus avatars. The finding that the female virtual human was perceived to be more likeable than the male, particularly when participants believed themselves to be interacting with another agent, support this interpretation and generally indicates that the social influence effects with virtual humans is moderated by level of perceived agency, behavioral realism, *and* the gender of the virtual human. The finding that participants reported experiencing more social presence

with the female virtual human than the male when they believed they were interacting with another human also support this interpretation. This is particularly interesting given that all aspects of the interaction with the virtual human were identical except that one virtual human appeared to be male and the other female. Thus, it appears that participants' preexisting existing expectations for the men and women and computers and humans impact the impressions formed of a virtual human and the level of social influence that occurs. Future research should further address this relationship.

Finally, as in Study 1, the measures of social presence and the behavioral realism manipulation check indicated that the behavioral realism manipulation was successful at producing higher levels of social presence. Also, agency beliefs interacted with behavioral realism such that participants who thought they were interacting with a human perceived the virtual human to be higher in behavioral realism and experienced more social presence than when they thought they were interacting with a computer.

GENERAL DISCUSSION

These results illustrate how important agency is for interactions with virtual representations of humans in IVEs. Specifically, the results of Study 1 suggest that social behavior in IVEs functions differently from other forms of computer-mediated communication such as e-mail (Guadagno & Cialdini, 2002, 2007) and that in the absence of explicit information about the nature of a virtual human, men and women both show an ingroup favoritism effect most likely because they are making decisions based on the similarity heuristic (Cialdini, 2001). Thus, participants were more persuaded when the virtual human was the same gender as they were. The results of Study 2 indicate that an individual's responses to virtual representations of humans vary in part by behavioral realism and perceived agency but that is not the whole picture: gender interacts with these variables. In this case, only men in the high behavioral realism condition showed greater persuasion when interacting with a virtual human of the same gender when they believed him to be an agent. Thus it appears that participants show an ingroup favoritism effect when the nature of the virtual human is unknown (Study 1) or when there is a match between the expectations and experiences of the participant and what they are told about the nature of the virtual human (Study 2). That is, in Study 1, participants were more swayed by the persuasive arguments of a virtual human that matched their gender than one who did not. In Study 2, the relationship was more complex. Specifically, the gender of the virtual human interacted with perceived agency in a way that suggests that participants were in part swayed by preexisting expectations based on the nature (human vs. computer) and gender of the virtual human. For instance, the male virtual human was more persuasive when it was perceived

to be computer than human, whereas the opposite trend occurred for the female virtual human. As stated earlier, these differences may be due to participants' expectations for interacting with a computer being more consistent with masculine stereotypes (e.g., competent), whereas expectations for interacting with a human are more consistent with feminine stereotypes (e.g., warm). This is certainly one aspect of this research that should be addressed in future work.

Additionally, the gender differences reported may be a reflection of gender differences in interaction with virtual humans in online contexts such as games and online communities (Lucas & Sherry, 2004; Yee, 2006). Women and men have different goals and engage in different activities while interacting with virtual humans. Specifically, women engage in more social interaction and cooperative activities than men. Women spend also less time in virtual environments than do men. These differences may lead men and women to form different expectations about interacting with virtual humans. Future research should explicitly examine this issue by measuring expectations about and experience with virtual humans and environments in their participants.

These results may also be explained by gender differences in attention to nonverbal behavior. Much research has indicated that women are more sensitive to nonverbal cues than are men (Hall, 1978). Additionally, in research on social interaction in IVEs, many studies have found that men and women respond differently to manipulations of behavioral realism (e.g., Bailenson et al., 2003; Bailenson et al., 2005; Swinth & Blascovich, 2001), with women responding more strongly to such manipulations than men. Thus, it may be possible that women are more sensitive to the realism of the nonverbal behavior. Although a virtual human may be more or less realistic in behavior, we are not yet at the point where technology will enable us to create a virtual human that behaves exactly like a human. Thus, for women, a virtual human that is high in behavioral realism may violate their expectations about nonverbal behavior leading them to resist persuasion. This may be why there was only an ingroup favoritism effect for men but not women in Study 2. Furthermore, although we did find differences between the high and low behavioral realism virtual humans across both studies, we also found that the high behavioral realism agent was not perceived as particularly high in behavioral realism. In both studies, the means for the high behavioral realism condition were below the scale midpoint of zero. Future research should continue to seek to refine the behavioral realism of virtual representations of humans and seek to further understand the mechanisms that determine when men and women will respond differently to agents and avatars.

The findings in terms of social presence and behavioral realism are consistent with Blascovich and colleague's (Blascovich, 2002; Blascovich et al., 2002) social influence model of immersive virtual environments. Participants in both studies experienced more social presence when behavioral realism

of the agent was high as compared to low. Additionally, in Study 2, the finding that individuals rated the virtual human higher in behavioral realism and experienced more social presence when they believed the virtual human to be an avatar rather than an agent is strong support for the model.

Limitations of this Research

One limitation of this research is that we examined this issue with only one male and one female virtual human rather than several virtual humans. So, although we pretested the photographs used for the virtual humans and found no differences between them on key variables related to persuasion, it remains an open question as to whether these results would generalize to other faces. We recommend that future research in this area employ more than one virtual human of each gender. An additional limitation to the generalizability of this work concerns the persuasive communication—specifically that we used just one topic for persuasion. Future work should examine these issues using a wider range of topics.

Implications of this Research and Future Directions

Overall the results of this research provide further support for Blascovich and colleagues' (Blascovich, 2002; Blascovich et al., 2002) model of social influence in immersive virtual environments and suggest that certain aspects of the model may need to be revised. Specifically, although higher levels of behavioral realism and the perception that one is interacting with a sentient being do produce more social presence, it does not necessarily mean that more social influence will occur. In this research, it appears that two additional factors impacted the social influence process: the gender match between the human research participant and the virtual human and perception that virtual human that was the high behavioral realism condition was not very realistic in behavior. Thus, we would recommend that future revisions of the model take gender into account. Additionally, we recommend that future work continue to refine the realism of behavior exhibited by virtual humans.

Furthermore, Blascovich and colleagues' (Blascovich, 2002; Blascovich et al., 2002) model would predict a positive relationship between the behavioral realism of virtual humans and the impressions formed by human observers such that the more realistic the behavior of a virtual human, the more influential they are. However, there are two issues that must be considered. First, it is important to recognize that the behavioral realism of a virtual human is distinct from the photographic realism of a virtual human. That is, a virtual human may look human but not act very human or may not look human but act very human. Second, when there is a mismatch between the appearance and behavior of a virtual human, social influence processes

may actually decrease because of the uncanny valley (Mori, 1970). The uncanny valley is a theoretical perspective in robotics, which predicts that, as a robot becomes more human in appearance and movement, the emotional reaction of human observers will transition from positive to repulsion then back again. Applied to social interactions with virtual humans in immersive virtual environments, this suggests that the uncanny valley occurs when a virtual human looks human (is high in photographic realism) but does not act human enough (is not quite right in behavior). This is a topic that has not been investigated empirically but merits empirical investigation on future work.

ACKNOWLEDGMENTS

The research presented in this article was supported by the following grant: National Science Foundation ITR IIS 0205740. Some of the findings reported here were initially presented at the April 2005 meeting of the Western Psychological Association in Portland, Oregon. We thank Ariana Young, Michelle Denni, Nicole Ferraro, Pamela Luna, and Lauryn Cederbloom for their valuable assistance with data collection and Kim Swinth, Tonio Loewald, and Ariana Young for their insightful feedback on this manuscript.

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