Exploring the Impact of Environmental Effects on Social Presence with a Virtual Human

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Abstract. We explore how and in what ways the surrounding environment can be an important factor in human perception during interactions with virtual humans. We also seek to leverage any such knowledge to increase the sense of Social/Co-Presence with virtual humans. We conducted a user study to explore the influence of environmental events on social interaction between real and virtual humans in a Mixed Reality setting. Specifically we tested two different treatments to see the effects on Social/Co-Presence: (i) enhanced physical-virtual connectivity/influence via a *real* fan blowing on *virtual* paper, and (ii) the virtual human's corresponding *awareness* of the environmental factor as she looks at the fan and holds the fluttering paper. While a statistical analysis for the study did not support the positive effects of the two treatments, we have developed some new insights that could be useful for future studies involving virtual humans.

Keywords: Virtual humans, Social presence, Co-presence, Physical-virtual connectivity, Environment-aware behaviors, Plausibility.

1 Introduction

One's sense of *Social/Co-Presence (So/Co-Pres)* with a virtual human has been considered as an important measure of how the virtual human is perceived. The concepts of Co-Presence and Social Presence could be described as how one perceives the other's presence as a sense of "being together," and how much they feel "socially connected," respectively. Harms and Biocca considered Co-Presence as one of several sub-dimensions that embody Social Presence [3], and Blascovich et al. defined Social Presence as a "psychological state in which the individual perceives himself or herself as existing within an **interpersonal environment**" (bold added) [2]. In a broad sense of Presence, Slater introduced an important concept, called *Plausibility Illusion (Psi)*. Psi "refers to the illusion that the scenario being depicted is **actually occurring**," that "requires a credible scenario and plausible interactions between the participant and objects and virtual characters **in the environment**" (bold added) [5]. Considering the definitions addressed above, we expect that the plausibility of the context and the surrounding environment where the social interaction takes place could be important factors in the resulting sense of So/Co-Pres with virtual humans.

In this paper, we discuss an experiment aimed at investigating the effects of the following possible influences on So/Co-Pres with a virtual human in a

mixed reality (MR) environment: (i) the enhanced physical-virtual connectivity via environmental objects—a physical fan and a virtual fluttering paper, and (ii) the virtual human's awareness of them. The results did not show statistically significant effects on the sense of So/Co-Pres in terms of the influences, but we developed some insights that could be useful for future studies involving virtual humans.

2 Preliminary Experiment

We designed a between-subjects study with three different groups: (i) Control, (ii) Physical-to-Virtual Influence (PVI), and (iii) Environment-Aware Behavior (EAB). For all groups, participants had a conversational interaction (a simple practice job interview) with a virtual human in a mixed reality environment— the virtual human was rear-projected on a screen. For the PVI group, a virtual paper on the table in front of the virtual human appeared to flutter as a result of the physical fan that was located next to the participant during the interaction. The physical fan blowing the virtual paper was chosen as a subtle environmental event to strengthen the connection between physical and virtual spaces, and potentially influence the sense of So/Co-Pres. In the EAB group, the virtual human would additionally occasionally exhibit attention toward the fan's effects by looking at it or holding the virtual paper to stop the fluttering. For the Control group, the paper did not flutter and the virtual human never demonstrated any awareness of the physical fan. The three groups are briefly described in Fig. 1. We hypothesized that the level of So/Co-Pres for each group would be different, e.g., Control $<<$ PVI $<$ EAB. We expected the virtual human's gaze direction changes and paper-holding gesture might be less significantly influential as compared to the fluttering paper. 31 undergraduate/graduate students (Control: 10, PVI: 10, and EAB: 11; 9 females and 22 males; mean age: 22.35, SD: 3.36, range: 18–29) were paid 15 USD for participating in the study. To measure the participants' sense of So/Co-Pres, we used two different Social Presence questionnaire sets from Bailenson et al. [1] and Harms and Biocca [3] (7-level Likert-scale).

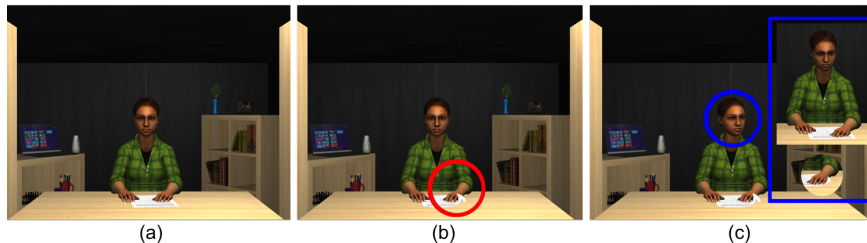| Group	Physical Fan	Virtual Paper Fluttering	Virtual Human's Awareness Behavior
Control	ON	NO	NO
PVI	ON	YES	NO
EAB	ON	YES	YES

Fig. 1. Experimental Groups. (a) Control, (b) PVI (red circle: fluttering virtual paper), and (c) EAB (blue circle: looking at the fan, blue rectangle: holding the paper gesture).

3   Results & Discussion

A previous experiment examined whether the sense of So/Co-Pres could be increased by a peripheral environmental object, a "Wobbly Table" [4]. In that experiment, a visually aligned wobbly table spanning a physical-virtual environment, in which a real human and a virtual human could sit across from each other, was used as a subtle environmental event. In this study, we were curious whether just observing the fluttering virtual paper—a much less direct experience than the "Wobbly Table"—would still have an impact on So/Co-Pres. We had expected to see positive effects on So/Co-Pres for the PVI and EAB groups; however, the results did not show any supporting evidence. While there were slight differences, no statistically significant differences were observed in either Social Presence questionnaire among the three groups (One-way ANOVA; $F(2, 28) = 0.590$, $p = 0.561$ for Bailenson's Social Presence and $F(2, 28) = 0.426$, $p = 0.657$ for Harms and Biocca's Social Presence in Fig. 2). Based on brief discussions with participants after the study, we have some possible explanations for the lack of significant differences.

GROUP	Mean	SD	N		GROUP	Mean	SD	N
CONTROL	4.780	0.520	10		CONTROL	5.111	0.635	10
PVI	4.560	0.759	10		PVI	4.922	0.386	10
EAB	4.891	0.797	11		EAB	4.939	0.477	11
(Bailenson et al.'s Social Presence)					(Harms and Biocca's Social Presence)			

Fig. 2. Descriptives for Social Presence responses.

Ignorance of Fan/Paper. We had wanted our fluttering virtual paper and fan wind to be peripheral (not central) to the experience, but they may have been *too* subtle—many participants were not consciously aware of the effects. Even those who were conscious of the effects seemed to pay little or no attention to them. Furthermore, based on discussion with the participants, our job interview scenario may have encouraged participants to narrowly focus on the virtual human, thus minimizing the potential influence of any environmental effects. Similarly, it seems that the novelty of the virtual human could have exacerbated the inattention to the environment and related effects.

Physical-Virtual Connectivity. We had originally considered the *absence* of movement of paper as *implausible* in the presence of the fan, and intended to use that implausibility to measure the effect of the physical-virtual effect (real fan affecting virtual paper). However in retrospect we realize that non-movement of the paper is entirely *plausible*—the fan might or might not affect paper on a nearby table, and therefore the treatment was potentially ineffectual for our intended purpose. In other words, none of the groups (Control, PVI, and EAB) might have seen anything "wrong" with the paper's behavior.

Environment-Aware Behaviors. Compared to the direct involvement of the human participant in the wobbly table movement [4], the fluttering virtual paper and fan wind were unrelated to the participant's actions. This could have made the virtual human's reactive nonverbal behaviors to the fan/paper irrelevant to the participants, counter to what we intended, and could have contributed to the lack of a positive association with So/Co-Pres in this setup. If the virtual human's awareness behaviors *were* a direct response to the real human's

actions, or if the awareness was temporarily made central to the conversation, there could be an increase in So/Co-Pres. In fact, based on user comments, the fact that the virtual human did *not* change the conversation in any way related to the effects was perhaps implausible, emphasizing a perceived autonomous nature of the virtual human, and thereby negatively effecting So/Co-Pres.

Experimental Measures. In attempting to understand why we did not see the expected effects, we came to realize that existing Social Presence questionnaires do not currently consider the aspects of the surrounding environment where the social interaction takes place but rather they mainly focus on the interactivity/connectivity between two or more interlocutors. Given that several definitions of So/Co-Pres indicate that the environmental aspects could be important, adding questions about the environment (or more generally the social context) could potentially provide a more accurate measure.

4 Conclusions

We conducted a user study investigating the effects of the environment and virtual human awareness of the environment on So/Co-Pres. Despite the lack of significant results, we obtained some insights from the study, which could be useful for designing more effective virtual humans or related studies. Given that we still believe the environment and awareness behaviors of the environment can increase So/Co-Pres with virtual humans, we will keep exploring the related effects. As a next step, we will consider more appropriate interaction scenarios and (im)plausible treatments that could encourage noticeable effects. Also, we are planning to run a conceptually similar study in an augmented reality setting, where the real and virtual are "equalized" (less distinct).

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