Effects of Social Priming on Social Presence with Intelligent Virtual Agents

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Abstract. This paper explores whether witnessing an Intelligent Virtual Agent (IVA) in what appears to be a socially engaging discussion with a Confederate Virtual Agent (CVA) prior to a direct interaction, can prime a person to feel and behave more socially engaged with the IVA in a subsequent interaction. To explore this social priming phenomenon, we conducted an experiment in which participants in a control group had no priming while those in an experimental group were briefly exposed to an engaging social interaction between an IVA and a nearby CVA (i.e. a virtual actor). The participants primed by exposure to the brief CVA-IVA interaction reported being significantly more excited and alert, perceiving the IVA as more responsive, and showed significantly higher measures of Co-Presence, Attentional Allocation, and Message Understanding dimensions of social presence for the IVA, compared to those who were not primed.

Keywords: Virtual Agent, Virtual Human, Social Priming, Social Presence, Co-Presence

1 Introduction

An intelligent virtual agent (IVA) can provide a flexible and versatile means to communicate verbal and spatial information with real humans. IVAs can be especially valuable when the presence of an actual human is not safe or feasible, such as in medical emergencies or military training. An IVA can be embedded not only in immersive virtual environments but also in the real world via augmented reality technologies to share the physical space with real humans [20]. For IVAs, it is desirable to facilitate a high sense of presence, co-presence, and social presence in order to elicit behavior in real humans that matches what can be observed between humans in the real world [9]. Lombard and Ditton define *presence* as the sense of non-mediation, which means that one can perceive presence via a technological medium if one can be oblivious to the existence of the medium [21]. There are many interpretations of the terms *social presence* and *co-presence*, e.g., see [7]. Goffman et al. indicate that *co-presence* exists when

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people sensed that they were able to perceive others and that others were able to actively perceive them [12]. Blascovich et al. define *social presence* both as a "psychological state in which the individual perceives himself or herself as existing within an *interpersonal* environment" (emphasis added) and "the degree to which one believes that he or she is in the presence of, and interacting with, other veritable human beings." [5, 6]. Harms and Biocca illustrated co-presence as one of several dimensions that make up social presence, and they evaluated the validity of their social presence measures with questionnaires [13]. While there is no universal agreement on the definitions of these terms, for the purpose of this paper we consider *social presence* to be one's sense of being socially connected with the other, and *co-presence* to be one's sense of the other person's presence.

Most previous research on interaction with IVAs focused on the perceived behavioral realism *while* directly interacting with the IVA. However, we believe that the observed behaviors *prior to* such direct interaction will have an important influence on the initial and perhaps lasting impression of the IVA. For example, there is evidence from psychology that perceptions of intelligence and disposition can be influenced by observations of a person's behavior prior to an interaction and an individual's apparent mood can be "contagious"—transferred to another person via implicit nonverbal behaviors [3, 8, 32].

In this paper, we explore the question of whether social presence can also be contagious. We use the word "Confederate" to indicate that the person is intentionally part of the experiment even though the participants may *not* think of that person as part of the experiment. Specifically, we used a *confederate virtual agent* or CVA. We present an experiment in which we test whether perceiving a socially engaging interpersonal discussion between an IVA and a CVA—i.e., exhibiting apparent social presence—can subsequently lead to the participant feeling increased excitement, alertness, and social presence with respect to the IVA.

This paper is structured as follows: Section 2 provides background information on IVAs, behavioral models, priming, and presence. Section 3 describes our experiment in which we analyze effects of an initial interaction between an IVA and a CVA on the subsequent perception of social presence with the IVA. Section 4 presents the results, which are discussed in Section 5. Section 6 concisely summarizes our experiment, the results, and presents our conclusions.

2 Background

While IVAs can be used as a replacement for real humans in certain situations, people usually do not treat an IVA exactly as they would treat a real human. For instance, in studies where medical students interacted with either an IVA or a real human pretending to have the same symptoms, participants appeared less engaged, sincere, and interested, and had a poorer attitude towards the IVA [30]. In an experiment with a computer graphics representation of an IVA, its advice was more rarely sought out compared to a physically present robot [25]. Often people treat IVAs as mere pixels instead of replacements for humans, even

when compared to robots that occupy a physical space. One explanation for this phenomenon is the low sense of presence, social presence, and co-presence induced by the IVA. In this paper we aim to increase the sense of social presence by exposing participants to a "social priming" *before* the interaction with the IVA.

Bailenson et al. studied participants' sense of co-presence in a multi-user shared immersive virtual environment while manipulating the non-verbal behavior of their virtual self-representations. The participants reported a higher sense of co-presence in a condition with head movement compared to the other conditions [1]. Garau et al. evaluated participants' responses, including presence, co-presence, and physiological signals, with respect to an IVA's degree of responsiveness. Their results did not show a significant relationship between perceived co-presence and the IVA's degree of responsiveness. However, they did suggest a link between higher levels of co-presence and participants who reported using computers less [11]. We took these findings into consideration while designing the study and analyzing the data.

While there are multiple possibilities for how the sense of social presence or co-presence of an IVA can be improved through modifications to its behavior *during* an interaction [2, 11, 15], the motivation for our work comes from exploring what could be done with the IVA *prior to* such a direct interaction.

Mood and even racial biases can be "contagious", i.e., transferred to other humans via implicit nonverbal behaviors [32, 35]. We wondered if exposure to a social presence priming could also be contagious. In general, *priming* can be seen as the incidental activation of a person's knowledge structure, which can lead the person to specific behaviors and attitudes [3]. It can affect social judgment [31], as well as goal-driven tasks, as Bargh et al. demonstrated by showing that primed participants performed comparatively better in an intellectual task [3]. Dijksterhuis and Bargh indicate that perception itself can prime or activate a behavioral tendency. Apart from perceiving observables of what is literally present, people make trait inferences and activate social stereotypes as forms of social perception that elicit the tendency to imitate in the social perceiver [10]. Qu identified three main elements in a conversation between a real human and an IVA: the surrounding environment, the virtual conversation partner, and the virtual bystanders [28]. Qu used images and videos to prime participants. Primed participants mentioned more keywords related to the priming content. Qu showed that priming with surrounding media content had a guidance effect in both the real world and the virtual world [29]. Similarly, we explore exposing our participants to a social priming and compare the effects on their social presence. Various studies have examined the concept of priming, some related to virtual reality [22, 27], but most of them explore the theory underlying the priming phenomenon. Researchers explored racial biases, gender, and IVA personality in virtual environments [23, 24, 26]. To our knowledge, there are no studies that use priming in the context of supporting social presence of an IVA.

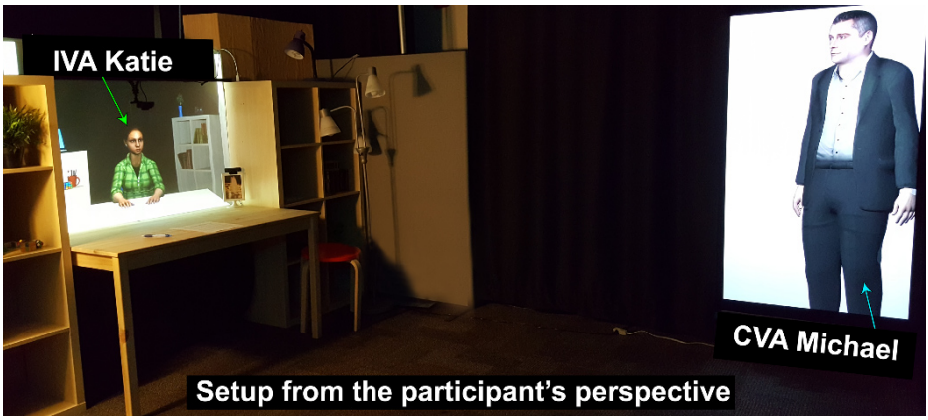

Fig. 1. Experimental setup: Participants were exposed to a brief conversation between the IVA (Katie) on the left and the CVA (Michael) on the right. The virtual elements in the scene were rendered from the participant's viewpoint.

3 Experiment

3.1 Material

We built a room-sized experimental setup (approx. 3m × 3.6m) where a virtual character was presented as sitting behind a shared physical-virtual desk between two bookshelves (see Fig. 1). We modeled and animated a 3D virtual character, named "Katie," in Autodesk Maya. Katie was designed with animations for facial expressions, speaking, and body gestures. She had a mostly neutral, serious, and polite demeanor during the interaction (i.e., designed to not be too warm or cold towards the participant). We then imported the model into Unity3D where we added a graphical user interface allowing an operator to trigger specific body gestures or pre-recorded phrases with corresponding speaking animations, in order to play a game of twenty questions and to carry out other limited responses as needed before or after the game. With this human-in-the-loop experimental setup, the operator pressed buttons behind the scenes to trigger Katie's responses. Katie's image was rear projected onto the screen behind the physical desk using an Optoma TW610ST projector. The participants were recorded using 5 Logitech c920 webcams (2 close ups and 3 wide angles) observing the space from different positions.The CVA, which we call "Michael," was presented on a Panasonic TC-P65VT30 screen.

3.2 Methods

We used a between-participants design for this experiment. To investigate the effect of social priming on social presence with an IVA we defined two groups: (i) *control group* and (ii) *social priming group*. Participants in both groups were asked to play a game of *twenty questions* with the IVA (Katie). Participants in

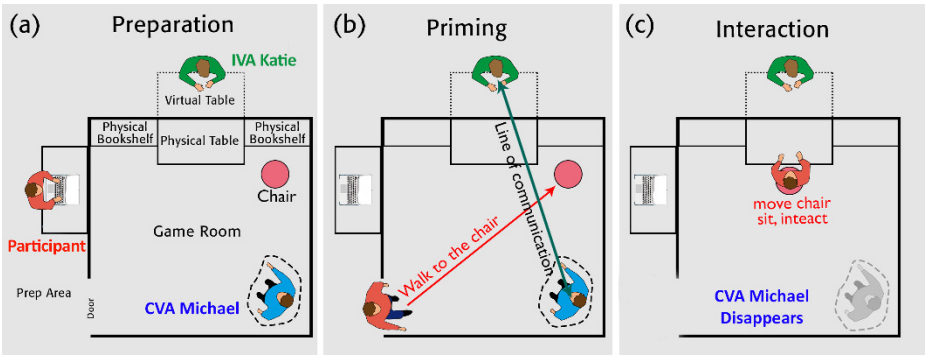

Fig. 2. Setup and procedure in the two experimental conditions. The dotted line around the CVA (Michael) indicates that he was there only in the social priming condition but not in the control condition. The other elements were the same in both conditions.

the social priming group perceived a short interaction between Katie and the CVA before they played the game. Participants in the control group were not primed with this social interaction before playing the game. Figure 2 illustrates the overall procedure which is comprised of three steps: (a) preparation, (b) priming (only for the social priming group), and (c) interaction with a twenty questions game.

In (a), before the participants entered the room, all participants read the informed consent and completed a demographics questionnaire. Then, the experimenter briefed them on the rules of the twenty questions game:

> *"You are going to play two games of twenty questions. During the first game, Katie has an object in mind that you have to guess; you can ask her questions that have YES or NO answers. During the game you cannot ask her open ended questions. You have a maximum of 20 questions to guess the object. In the second game, the same rules apply, except that Katie will ask you the YES or NO questions and you have to answer."*

Participants were asked to pick their object for the second game from a deck of cards before starting the interaction. They were asked to write down the answers to questions and to record the winner of each game during the interaction with the IVA. While individual interaction times might vary between participants due to the nature of the game (i.e., some people took more time to think before asking questions), the exposure times to the IVA were comparable across both groups.

In (b), the participants in the *social priming condition* saw Katie seated at the table and the CVA (Michael) standing in the corner of the room. They were then exposed to an interaction between Katie and Michael. Michael acted as if he had just finished a game with Katie. As soon as the participant entered, Michael looked at the participant, then at Katie, and said *"Oh, you've got visitors. I'll leave you two to play,"* then Katie and Michael exchanged phrases such as *"It*

was nice playing with you! Thanks for your time. See you later!" This short exchange constituted the social presence priming. Participants in the *control condition* were not exposed to this social interaction.

In (c), the participants then entered the room and interacted directly with Katie. Katie was seated at the table, and she initiated the conversation with phrases like *"Hello, how are you? Nice to meet you!"* and then moved on to playing the game. She ended the interaction with *"It was nice playing with you! Thanks for your time. See you later, bye!"*

During the experiment, participants were video recorded from multiple angles and observed for verbal and non-verbal behavior. Specifically, we observed whether the participants waited for the IVA and CVA to finish in (b), or if instead they walked straight to the chair, breaking the line of communication between Katie and Michael.

After completing the experiment, participants were asked to fill out a set of post-questionnaires including a social presence questionnaire [13], a presence questionnaire [36], an affective attraction questionnaire [14], and their subjective emotions state using Wilhelm's Mood Rating Questionnaire which consists of six questions (How did your interaction with the other player (Katie) make you feel: anxious, excited, tense, alert, in control, desire to leave the situation) [34]. Since we used a mixed reality setup rather than an immersive virtual environment (cf. [36]), we used a subset of the original questions, removing those inappropriate for our environment.

The exact questions for social presence dimensions are shown in Table 2 with *Co-Presence* being the degree the participant thinks he/she is not alone, *Attentional Allocation* is the amount of attention the participant allocates to and receives from the IVA, *Perceived Message Understanding* is the ability of the participant to receive a message from the IVA and for the IVA to understand their message, *Perceived affective understanding* is the ability of the participant to understand the IVA's emotional and attitudinal states and for the IVA to understand the participant's emotional and attitudinal states, *Perceived Affective Interdependence* is the extent to which the participant's emotional and attitudinal state affects and is affected by the emotional and attitudinal states of the IVA , *Perceived Behavioral Interdependence* is the extent to which a participant's behavior affects and is affected by the IVAs behavior [13]. The means for each dimension are computed by adding the scores for these questions and dividing by the total number of questions ($N = 6$). The social presence questions are on a 1 to 7 Likert scale. Questions marked with a star were inverted by negating the answer and adding 8. The individual questions from the *presence* questionnaires that showed significantly different answers are shown in Table 1.

3.3 Participants

58 participants (35 males and 23 females from multiple ethnicities) were randomly assigned to the control ($n = 29$) or social priming ($n = 29$) experimental group. Participants were recruited from our university community (students, employees, and alumni from various colleges within the university) via web postings

and email lists. Participants' experience with IVAs varied. Thirteen participants had never interacted with an IVA before, while the others reported varying familiarity with the concept of Virtual Humans (VH), from having encountered some sort of VH at some point, e.g. while playing video games, to four indicating being involved in some type of VH development at some point in their lives.

None of the participants had prior experience with the IVAs used in this experiment.

Table 1. Measurement for select Presence questions regarding Responsiveness, and Involvement that showed significant differences.

Responsive	How responsive were the other player (Katie) and her environment to actions that you initiated (or performed)?
Involved	How much did the visual aspects of the other player (Katie) and her environment involve you?

4 Results

4.1 Qualitative Results

In the social priming condition, most participants commented that they did not pay much attention to the CVA Michael. Fourteen participants acknowledged that they ignored Michael, with comments such as "I didn't pay him much attention," or "I completely ignored him." Five participants did not expect to see the CVA Michael and expressed being surprised or confused. Three participants felt that they "interrupted Katie and Michael's conversation." Six participants expressed positive reactions regarding Michael such as he was "friendly and heartwarming" and that he set the tone as "more realistic." and made participants "more excited," or put them "in a good mood."

Ten participants gave positive comments regarding the IVA Katie's friendliness and expressiveness such as saying she "was expressive" and that she gave off a "friendly vibe," and six participants gave comments suggesting improving the IVA Katie's emotions and expressiveness.

In the control condition, there were more mixed comments regarding the IVA Katie. Nine participants gave positive comments related to Katie's realism and character such as saying she was "very realistic and friendly" while 11 participants gave comments suggesting improvements for the IVA Katie's character, emotions and expressions such as "[she] could have been nicer and more friendly" and that she does not show much "emotion" or "her face doesn't show feeling" or they felt "a little distant" from her.

4.2 Quantitative Results

We decided to use non-parametric statistical tests to analyze the Likert scale ordinal data from the questionnaires [19] comparing the priming condition with

Table 2. Questionnaires for Social Presence including the following dimensions: CoPresence (CoP), Attentional Allocation (Atn), Perceived Message Understanding (MsgU), Perceived Affective Understanding (Aff), Perceived Emotional Interdependence (Emo), Perceived Behavioral Interdependence (Behv).

CoP-Q1	I noticed the other player (Katie).
CoP-Q2	The other player (Katie) noticed me.
CoP-Q3	The other player (Katie)'s presence was obvious to me.
CoP-Q4	My presence was obvious to the other player (Katie).
CoP-Q5	The other player (Katie) caught my attention.
CoP-Q6	I caught the other player (Katie)'s attention.
Atn-Q1*	I was easily distracted from the other player (Katie) when other things were going on.
Atn-Q2*	The other player (Katie) was easily distracted from me when other things were going on.
Atn-Q3	I remained focused on the other player (Katie) throughout our interaction.
Atn-Q4	The other player (Katie) remained focused on me throughout our interaction.
Atn-Q5*	The other player (Katie) did *not* receive my full attention.
Atn-Q6*	I did *not* receive the other player (Katie)'s full attention.
MsgU-Q1	My thoughts were clear to the other player (Katie).
MsgU-Q2	The other player (Katie)'s thoughts were clear to me.
MsgU-Q3	It was easy to understand the other player (Katie).
MsgU-Q4	The other player (Katie) found it easy to understand me.
MsgU-Q5*	Understanding the other player (Katie) was difficult.
MsgU-Q6*	The other player (Katie) had difficulty understanding me.
Aff-Q1	I could tell how the other player (Katie) felt.
Aff-Q2	The other player (Katie) could tell how I felt.
Aff-Q3	The other player (Katie)'s emotions were not clear to me.
Aff-Q4	My emotions were not clear to the other player (Katie).
Aff-Q5	I could describe the other player (Katie)'s feelings accurately.
Aff-Q6	The other player (Katie) could describe my feelings accurately.
Emo-Q1	I was sometimes influenced by the other player (Katie)'s moods.
Emo-Q2	The other player (Katie) was sometimes influenced by my moods.
Emo-Q3	The other player (Katie)'s feelings influenced the mood of our interaction.
Emo-Q4	My feelings influenced the mood of our interaction.
Emo-Q5	The other player (Katie)'s attitudes influenced how I felt.
Emo-Q6	My attitudes influenced how the other player (Katie) felt.
Behv-Q1	My behavior was often in direct response to the other player (Katie)'s behavior.
Behv-Q2	The behavior of the other player (Katie) was often in direct response to my behavior.
Behv-Q3	I reciprocated the other player (Katie)'s actions.
Behv-Q4	The other player (Katie) reciprocated my actions.
Behv-Q5	The other player (Katie)'s behavior was closely tied to my behavior.
Bhv-Q6	My behavior was closely tied to the other player (Katie)'s behavior.

the control condition. While it is common practice in some scientific disciplines to treat Likert-type scales as interval-level measurements [4], we avoid the discussion on whether parametric statistics can be a valid method for the analysis of non-parametric data [16, 17] by using non-parametric (MannWhitney U) tests.

Social Presence: We aggregated scores for the questions per category to cover all dimensions of social presence. We found a significantly higher social presence in the social priming condition for co-presence ($U = 256.0$, $p = 0.009$, $r = -0.664$), attentional allocation ($U = 288.0$, $p = 0.039$, $r = -0.662$), and perceived message understanding ($U = 276.0$, $p = 0.024$, $r = -0.527$). There was no significant difference for perceived affective interdependence ($U = 386.0$, $p = 0.596$, $r = -0.235$), perceived emotion interdependence ($U = 431.0$, $p = 0.876$, $r = -0.016$), and perceived behavioral interdependence ($U = 365$, $p = 0.391$, $r = -0.246$). Figure 3 shows the results for the dependent variables in the experiment.

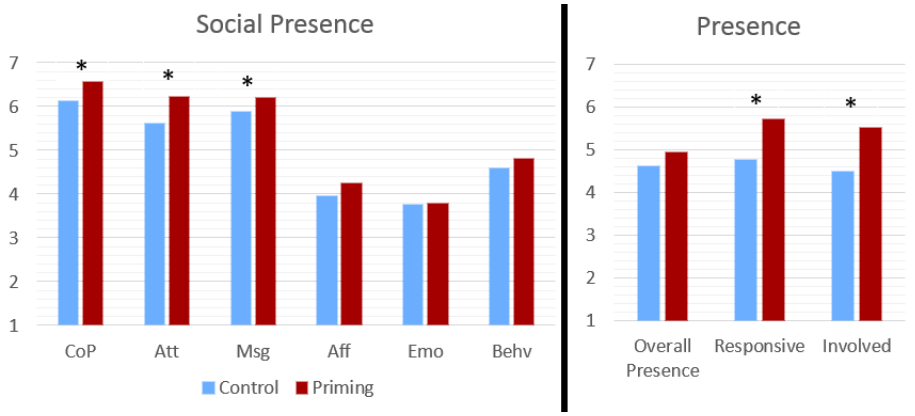

Fig. 3. Results for social presence dimensions (left) and for Presence (right). Star "*" indicates significant results

Mood Rating: Participants were asked to rate their interaction with the IVA Katie for the following Mood Ratings: anxious, excited, tense, alert, in control, and desire to leave the situation. The results show that participants in the social priming condition were more excited ($U = 294.5$, $p = 0.047$, $r = -0.572$) and more alert ($U = 267.5$, $p = 0.017$, $r = -0.651$) compared to those in the control condition. There was no significant difference for feelings of being anxious ($U = 385.5$, $p = 0.586$, $r = -0.182$), tense ($U = 371.5$, $p = 0.442$, $r = -0.134$), in control ($U = 415.0$, $p = 0.944$, $r = 0.000$), or desire to leave the situation ($U = 490.5$, $p = 0.208$, $r = 0.257$).

Presence: When comparing individual Presence questions, the results show that participants in the social priming condition perceived the IVA Katie as more responsive to their actions ($U = 278.5$, $p = 0.024$, $r = -0.641$) and that

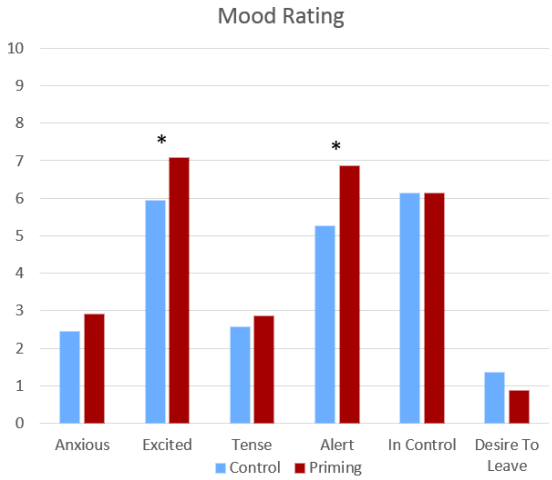

Fig. 4. Results for Mood Ratings. Star "*" indicates significant results.

they were more involved in the visual aspects of the IVA ($U = 254.5$, $p = 0.008$, $r = 0.772$). There was no significant difference for the presence (all $p > 0.05$), affect attraction (all $p > 0.05$), and virtual environment (all $p > 0.05$) questions.

5 Discussion

Overall, our results indicate that subtle social priming, by means of perceiving a short interaction between an IVA and a CVA, can result in a significant increase in social presence (specifically the co-presence, attentional allocation, and perceived message understanding dimensions of social presence), an increase in the sense of feeling more excited and more alert, an increase in the sense of feeling more involved in the visual aspects, and a perception of the IVA as more responsive compared to those who were not primed.

The results are particularly interesting as the social priming in our experiment was a rather short pre-scripted/pre-programmed conversation between our IVA and CVA. Indeed, because the IVA-CVA interaction occurs prior to, and independent of, the participant's interaction with the IVA, the IVA-CVA interaction can be pre-programmed and yet still look spontaneous. One could create a library of such short IVA-CVA vignettes to be invoked periodically when it appears that the circumstances are currently unlikely to yield direct human-IVA interaction. Such vignettes could then also be transferred to other characters and setups, without adding strict requirements in terms of space or interactivity.

Interpretation of the results within the social presence dimensions: We expected *Co-Presence* to be significantly different since Co-Presence is the degree the participant thinks he/she is not alone, and the fact of adding a CVA reinforces this idea. We also expected that the *Attentional Allocation* would be

higher as the CVA is expected to draw attention to the unexpected priming conversation. Given that the priming was designed to be the end of the previous player's game, it is possible that the increase in the *Perceived Message Understanding* came from the appearance that the IVA knows what she is doing since she played that game before and it was a pleasant experience for the CVA. We did *not* expect to see a significant change in the dimensions that are related to affect (*Perceived affective understanding*, and *Perceived Affective Interdependence*) as both the IVA and the CVA were designed to have a neutral, polite, and professional character (not too warm, not too cold). The means of the Control and Priming groups were almost identical. We did not design the priming in a way to intentionally affect the behavior (i.e., the CVA did not give a hint about the game, nor did he ask the participant to perform any specific action). We were not surprised that the *Perceived Behavioral Interdependence* was not significantly different. We did notice that *during* the priming, a few participants chose to wait while others chose to keep on walking but that change in behavior did *not* affect the results.

Interpretation of the Mood Ratings results: An argument can be made in either direction whether it is good or bad to be more Alert and more Tense. According to The Positive and Negative Affect Schedule (PANAS), "Excited" and "Alert" are classified as positive affects [33]. According to the Cognitive-Affective Theory of Learning with Media, the multimedia learning process is mediated by the learners mood, and positive mood has a facilitating effect on multimedia learning [18]. We conclude that using social priming can have a positive effect on the mood and possibly on learning using multimedia such as an IVA.

Are there other ways to prime social presence? Other stimuli might also be powerful social presence priming tools. For example, the IVA could exhibit "human-like" traits or characteristics, such as engaging in humor, referencing a recent real world event, or reacting to stimuli in the environment, showing awareness of the person and their surroundings. Likewise, it may be possible to strengthen (or weaken) the priming approach used in this study (e.g., making the perceived conversation appear more exciting). The CVA could engage in an unpleasant conversation such as scolding the IVA which could result in a positive priming (i.e., sympathize with the IVA) or negative priming (take sides with the CVA). Similarly, it may be possible to negatively prime participants if the confederate intentionally ignores the IVA. Future research directions may include experimenting with variations of other aspects of the IVA and CVA, such as attire, gender, or ethnicity as well as replacing the CVA with a real human confederate.

What are the long-term effects? We do not know how long the effects of social priming last or the effectiveness when the same priming situation is re-used multiple times. It may be the case that the effects stay until something else changes them or it could be the case that the effects fade over time and a reminder or "booster" may be periodically required, for which one could pseudo-randomly select one of multiple canned priming sequences. Social priming in this

way could be particularly useful to many applications employing IVAs because of its relatively low cost and independence with the actual direct interaction.

6 Conclusion

In this paper we presented a novel method to increase social presence with IVAs. It is generally believed that a higher sense of presence with an IVA has the potential to make applications such as training more effective, which can translate into increased performance in teams in a real environment [9]. Observing the behaviors of another human *prior to* interaction with that human can influence perceptions of that person's intelligence and disposition. To see if this effect could be used to increase the perceived realism of an IVA, we explored what we call *social presence priming*, where we exposed participants to an IVA participating in a seemingly spontaneous but actually pre-programmed socially engaging interaction with a confederate virtual agent *before* the participants interacted directly with the IVA. In the condition where the participants were socially primed, the co-presence, attentional allocation, and perceived message understanding dimensions of social presence were found to be significantly higher compared to the control condition. Participants also felt more excited and alert and perceived the IVA as more responsive. The results of this study are encouraging for the use of relatively low-cost social priming in existing and future IVA applications, since the proposed confederate virtual agents only need a limited functionality to complete a short canned interaction with the IVA.

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