Effects of Agents' Embodiment and Robot Anxiety Scale on Social Priming

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Abstract: In this study, we focus on the priming effect that would affect the social relationships among the agent, robot, and human because the opportunities to converse with robots and agents are increasing. This research investigated the effect of embodiment of the priming agent on the perception of social presence of the primed agent. The preliminary results did not support our hypothesis that "the social presence of the primed agent becomes higher when the embodied robot primes than when the virtual agent primes." However, the results indicated that there is a dichotomy in the perceived social presence between the participants' groups when we divide them according to their anxiety level toward robots. This indicates that the priming effect on the social presence of the primed agent is different depending on the embodiment of the priming agent and people's anxiety toward robots.

1 INTRODUCTION

In recent years, our daily lives widely include humanoid robots and virtual agents equipped with conversational ability. Robots and agents help humans as receptionists, museum guides, and even as job interviewers. Because of their ability to converse with humans, they can affect the social relationship between the humans, agents, and robots. In this study, we focus on the priming effect that would affect the social relationships among the agent, robot, and human. Priming effect is a phenomenon in which giving prior information influences a person's later judgment (Bargh, et al. 1996). Priming effect occurs among humans in everyday life. Because the opportunities to converse with robots and agents are increasing, we believe it is important to investigate the effect of priming on the social relationships among humans, humanoid robots, and agents.

As agents and robots have different embodiments, the amount of potency (i.e., perceived extroversion, perceived self-confidence, and presence) from them is different. Furthermore, their different embodiments may affect not only their potency but also their social presence. In other words, robots and agents would affect our behavior or relationship with other humans (de Greef et al. 2001). Daher et al. tackled this issue by using two agents, namely, a priming agent and a primed agent for the experiment. They examined the impact of priming on the perceived social presence of the primed agent judged by human participants. Their result indicated that the priming by the agent affected the human perception of the social presence of the primed agent (Daher et al. 2017).

Researchers in human-agent interactions and human-robot interactions have reported people's different behaviors and attitudes to collocated robots, remote robots projected on the display, and virtual agents that performed the same task. Some researchers report that they evaluated robots to be more social, reliable, and competent than a virtual agent in a mutual task (Pan et al. 2016, Powers et al. 2007), while such difference was not found in a simple greeting interaction (Bainbridge et al. 2008). Another research showed that an embodied robot is more reliable than a robot projected on the display (Kiesler et al., 2008). Therefore, it is necessary to verify Dahers' findings by using other embodiments, i.e., collocated robots, instead of virtual agents.

The purpose of this study is to verify whether the embodiment of the priming agent affects the social presence of the primed agent. We will follow the

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experimental procedure of Daher et al. 2017 and add a humanoid robot to the priming side.

2 EXPERIMENT

2.1 Hypothesis and Experimental Conditions

From the related research (de Greef et al. 2001, Daher et al. 2017, Kiesler et al. 2008), we formed the hypothesis that "the social presence of the primed agent becomes higher when the embodied robot primes than when the agent primes." The experimental conditions are the robot condition where the robot primes the participant about the game-playing agent, the agent condition where the virtual agent (different from the game-playing agent) primes the participant about the game-playing agent, and the control condition where there is no priming before the game. We conducted the experiment as a between-subject design.

The experiment in this study follows the procedure in (Daher et al. 2017), where the participants play two games of twenty questions with the game-playing agent. Twenty questions is a game in which one side asks the opponent a question that should be answered with a yes or no, and then guesses what the opponent has in mind. Fig. 1 shows the experimental scene of (Daher et al. 2017). A life-sized agent (right) gives priming on another agent (left) that plays twenty questions with the participants.

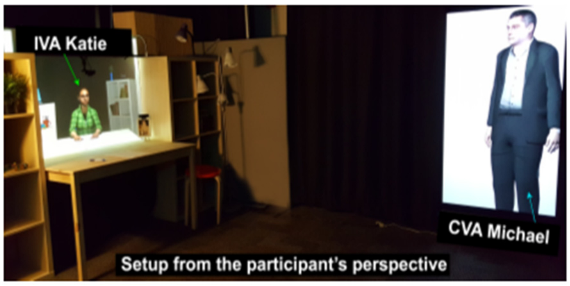


Figure 1: Experimental scene of (Daher et al. 2017).

2.2 Experimental Environment

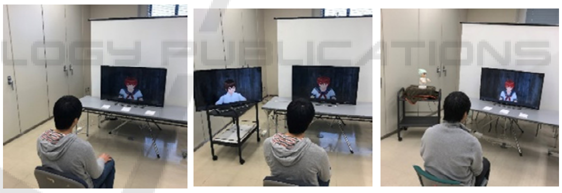
We developed a female agent who plays the game with the participants and a male agent who performs priming before the game using Unity5.2.1f1 and C#. Fig. 2(a) shows the male agent, and Fig. 2(c) shows the female agent who plays the game. The robot used for the experiment is CommU, a social conversational robot made by Vstone Inc. Fig. 2(b) shows the robot's appearance. We used Java to control the robot motions and dialogues during the game.

In this experiment, the male agent (shown in Fig. 2(a), priming agent) or the humanoid robot (shown in Fig. 2(b), priming robot) give priming information to the participants about the female agent (shown in Fig. 2(c)). The female agent plays the game with the participants.

The distance between the participant and the primed agent or the robot was set to 90 cm, which is defined as an individual distance between acquaintances by Hall (Hall 1966). Fig. 3(a) shows the experimental settings under the control condition, Fig. 3(b) shows the agent condition, and Fig. 3(c) shows the robot condition.

(a) (b) (c)

Figure 2: The agents and the robot's used in the experiment. (a) priming agent, (b) priming robot, (c) primed agent (game-playing agent).



(a) (b) (c)

Figure 3: Three experimental conditions. (a) control condition, (b) agent condition, (c) robot condition.

2.3 Experimental Procedure

In total, 43 Japanese university students of age group 19 to 24 years (36 men and 7 women) participated in the experiment. We should consider the participants' anxiety level towards robots because we use a robot in the experiment and the existence of the robot might affect the effect of priming. Therefore, we asked the participants to answer the questionnaire on robot anxiety scale (RAS) (Nomura et al. 2006) before we started the experiment. RAS consists of three categories, namely, robot's conversational ability anxiety (i.e., the robot may not understand complex stories), robot behavior characteristics anxiety (i.e., what kind of behavior the robot performs), robot dialogues anxiety (i.e., whether one's utterance is understood by the robot). The questionnaire has 11 questions and answers with a 6-point Likert scale.

In cases of robot and agent conditions, the participants hear a conversation between the robot or the priming agent and primed agent before they start a game. The intention of this conversation is to tell the participants that the priming robot or the agent had been playing the game with the primed agent just before the participants' turn and they really enjoyed the game. When the participant enters the room to play the game, he sees the priming agent saying, “I really enjoyed the twenty questions game with you. It was really interesting and you are very good at guessing what I had in mind." The priming conversation lasts about 15 seconds. In the case of the control condition, the game starts without priming (thus there is no priming agent or robot situated in the experimental room as shown in Fig. 3(a)) after the instruction of the experiment. We conducted the experiment in a between-subject design, thus each participant experienced only one condition.

The twenty questions game proceeds as follows. The participant and the agent select one out of nine creatures (from a list given during the instruction) without telling the others. In the first turn, the participant asks the primed agent questions and the agent answers with a yes or no, and the participants guess the animal that the primed agent has in mind. The roles are reversed in the second turn. The participant answers the questions from the agent, and the agent guesses the animal the participant has in mind. Examples of dialogues with the agent include, "Is it a four-legged animal?" "Does it swim?" and "Does it run fast?"

After the twenty questions game, each participant answers a questionnaire on the social presence of the primed agent that they have finished playing the game with. This questionnaire is composed of questions about the social presence of humans defined in Harms et al. 2004.

The experimental procedure is as follows:

1) The participants receive instructions about the experiment and answer the RAS questionnaire.
2) They enter a separate room for the twenty questions game.
3) Only one of the three conditions is assigned to each of them: the robot condition, the agent condition, or the control condition. In case of conditions for receiving priming (the robot condition and the agent condition), the participants hear a conversation between the priming robot or agent and the primed agent as they enter the other room. In the control condition, the participants immediately go to step 4.
4) They play twenty questions game with the game-playing agent two times.
5) They move to the original room where they were instructed before the game, and they answer the questionnaire on the social presence of the game-playing agent.

2.4 Questionnaires

Answers to the RAS questionnaire were rated with a 6-point scale (1: I do not feel anxious at all – 6: I feel very anxious). Table 1 shows the questions from the RAS questionnaire. Because we assume that one’s anxiety level towards robots would affect the priming effect from the robot, we divided the participants into two groups according to their RAS scores. The average RAS score of the 43 participants was 39.1. We categorized 20 participants whose scores were higher than 39.1 as high RAS group and 23 participants whose scores were lower than 39.1 as low RAS group.

Although we assigned a similar number of participants to each condition, the number of participants in the two RAS groups was not even. The number of participants who were assigned the agent condition was 14 (high RAS group: 6 participants, and low RAS group: 8 participants), who were assigned the robot condition was 14 (high RAS: 4, low RAS: 10), and who were assigned the control condition was 15 (high RAS: 10, low RAS: 5).

Table 1: RAS questionnaire (Nomura et al. 2006).

Anxiety toward Communication Capability of Robots	Robots may talk about something irrelevant during conversation.
	Conversation with robots may be inflexible.
	Robots may be unable to understand complex stories.
Anxiety toward Behavioral Characteristics of Robots.	How robots will act.
	What robots will do?
	What power robots will have?
	What speed robots will move at?
Anxiety toward Discourse with Robots	How I should talk with robots.
	How I should reply to robots when they talk to me.
	Whether robots understand the contents of my utterance to them.
	I may be unable to understand the contents of robots’ utterances to me.

The social presence questionnaire was rated on a 7-point scale (1: I do not agree at all – 7: I agree very much). The questionnaire consists of 6 categories: Co-Presence (CoP) that measures the sense of being with the other party, Attentional Allocation (Atn) that measures the degree of attention paid to the other party, Perceived Message Understanding (MsgU) that measures the degree of understanding of the other party's thoughts, Perceived Affective Understanding (Aff) that measures the degree of understanding of the other party's feeling, Perceived Emotional Interdependence (Emo) that measures the degree of being influenced by the other party's feelings, and Perceived Behavioral Interdependence (Behv) that measures the degree of being influenced by the other party's behaviors. Table 2 shows questions from the social presence questionnaire adopted from Harms et al. 2004.

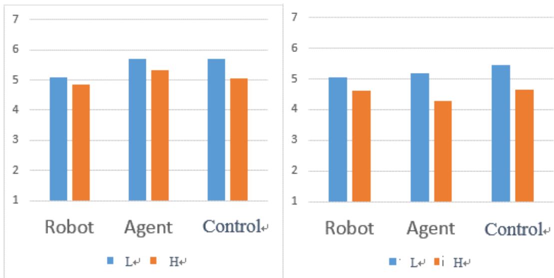
Table 2: Excerpted questionnaire on social presence (Harms et al.2004).

Co-presence (CoP)	I noticed (my partner). (My partner) noticed me. (My partner's) presence was obvious to me.
Attentional Allocation (Atn)	I was easily distracted from (my partner) when other things were going on. (My partner) was easily distracted from me when other things were going on.
Perceived Message Understanding (MsgU)	My thoughts were clear to (my partner). (My partner's) thoughts were clear to me.
Perceived Affective Understanding (Aff)	I could tell how (my partner) felt. (My partner) could tell how I felt.
Perceived Emotional Interdependence (Emo)	I was sometimes influenced by (my partner's) moods. (My partner) was sometimes influenced by my moods.
Perceived Behavioral Interdependence (Behv)	My behavior was often in direct response to (my partner's) behavior. The behavior of (my partner) was often in direct response to my behavior.

3 RESULTS

We conducted a one-way ANOVA for the social presence questionnaire with the priming factor. Consequently, the main effect was seen in the priming factor in MsgU (F=4.555, p=<.01). The control condition was rated significantly higher than the robot condition. In addition, the main effect was seen in the priming factors in Emo (F=5.625, p=<.01). The control and the agent conditions were rated significantly higher than the robot condition. The main effects of priming factors were not observed in the other four social presence categories.

To investigate whether human anxiety against robots affects the priming effect, we conducted a one-way ANOVA with the RAS factor. Fig. 4(a) shows the results of the social presence CoP ratings and Fig. 4(b) shows the results of the Atn ratings by the two RAS groups. As a result, the main effect was seen in the RAS factor in the categories CoP (F=4.182, p=<.05) and Atn (F=9.281, p=<.01). The low RAS group rated CoP and Atn significantly higher than the high RAS group. For the other categories, there were no main effects among the RAS factor.



(a) (b)

Figure 4: (a) CoP and (b) Atn scores made by the two RAS groups.

We also conducted a two-factor ANOVA for the priming factor and the RAS factor. Fig. 5, 6, and 7 show the questionnaire results of MsgU, Emo, and Aff respectively. As a result, there were significant interactions between the priming factor and the RAS factor in MsgU (F=4.389, p=<.01), Aff (F=7.467, p=<.01), and Emo (F=5.502, p=<.01).

In the low RAS group, they rated MsgU significantly lower in the robot condition (F=4.553, p=<.05) and the agent condition (F=4.553, p=<.01) than in the control condition. They rated Aff significantly lower in the robot condition than in the agent condition (F=7.202, p =<.01) and the control condition (F=7.202, p=<.01). They rated Emo significantly lower in the robot condition than in the control condition (F=3.801, p=<.01).

In the high RAS group, they rated MsgU significantly lower in the robot condition than in the agent condition (F=3.828, p=<.01) and the control condition (F=3.828, p=<.05). They rated Emo significantly lower in the robot condition (F=5.177, p=<.01) and the control condition (F=5.177, p=<.01) than in the agent condition. There was no significant difference between the priming conditions in the evaluation of the RAS high group in Aff.

In the Behv category, which indicates whether the behaviors of the primed agent affect the participants, there were no significant differences in the main effects or interactions on/between priming factor and RAS factor.

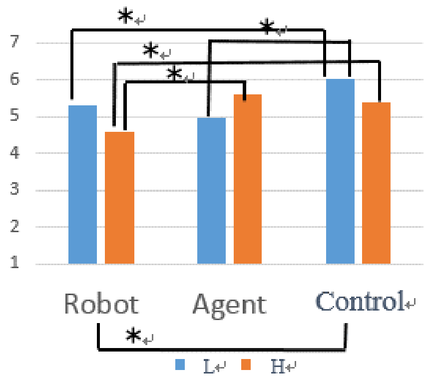


Figure 5: MsgU scores made by the two RAS groups.

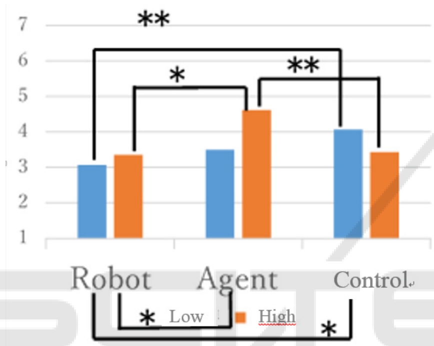


Figure 6: Emo scores made by the two RAS groups.

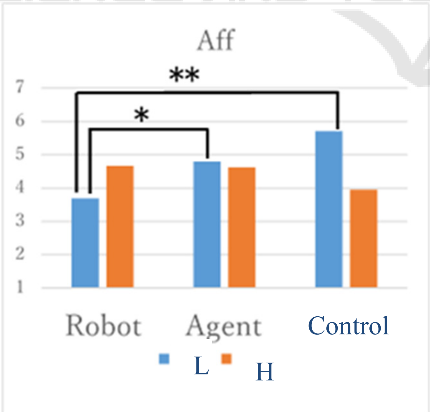


Figure 7: Aff scores made by the two RAS groups.

In summary, the main effects of the priming factor were seen in MsgU and Emo. The embodiment on the priming side affected a part of the social presence of the primed agent. However, contrary to the hypothesis, evaluations of the social presence of the primed agent became significantly higher when there was no priming and no physical embodiment on the priming side. Moreover, CoP and Atn showed the main effects of the RAS factor. The low RAS group rated the above categories as significantly higher than the high RAS group.

In terms of interactions between the priming factor and the RAS factor, the low RAS group rated the robot condition as the lowest and the control condition as the highest in MsgU, Emo, and Aff categories, while the high RAS group rated the control condition and the agent condition as significantly higher than the robot condition in the above categories.

4 DISCUSSION

The embodiment on the priming side affected two categories in the social presence of the primed agent. There were no significant differences in the other social presence categories among the priming conditions. The hypothesis that "the social presence of the primed agent becomes higher when the embodied robot primes than when the agent primes" was not supported. On the contrary, the social presence of the primed agent was perceived lower when the robot primed than when the virtual agent did and when there was no priming. We interpret the reason for this result as follows: 1) the experimental environment where the embodied robot interacted with the virtual agent emphasized the different embodiments of the robot and the agent, 2) the robot size is 307(H) ×180(W) ×130(D) mm, and it is smaller than the agent, which is displayed on the 40 inch screen. 3) Thus, it decreased the believability and credibility of the robot and the game environment itself where the robot and the agent play the twenty questions game.

CoP and Atn ratings showed the main effects between the RAS groups. The above scores were rated significantly higher in the low RAS group than the high RAS group. This result suggests that we can apply the high RAS group's negative and anxious attitude toward robots to the virtual agent.

The interactions between the priming factor and the RAS factor in MsgU, Emo, and Aff indicate that there is a tendency that the low RAS group rated the robot condition as the lowest and the control condition as the highest in the above categories, while the high RAS group rated the control condition and the agent condition as significantly higher than the robot condition.

We interpret these results as follows: The low RAS group can perceive high social presence of the game-playing agent without any priming, because of their nature of having low anxiety toward robots. They perceived the unnaturalness of the experimental environment where the robot played the twenty questions game with the virtual agent and have opinions about it. Thus, their ratings in the categories of MsgU, Emo, and Aff, which measure one's effort to understand the other party's thoughts, feelings, and moods, decreased. In other words, priming by the robot resulted in decrease of the social presence of the game playing agent for the low RAS group.

The high RAS group has high anxiety against robots. This might have led to their low social presence ratings in the robot condition. However, their social presence ratings of the game-playing agent were as high as the ones in the control condition or even higher. Thus, they perceived higher social presence from the game-playing agent when the other agent gave priming information.

In summary, the overall results suggest that the social presence of the primed agent becomes higher when the other agent performs the priming for the high RAS group, while the social presence of the primed agent becomes lower when the robot performs the priming for the low RAS group. One of the limitations of this experiment is that the number of participants assigned to each condition and RAS group is not even and there are a limited number of participants. Further experiment should gather a larger number of participants.

In terms of other limitations, further research should use a life-sized agent and robot. Daher et al. 2017 used a life-sized agent for the priming agent, and they implemented an animation of it leaving the spot soon after it gave the priming information to the participant. The robot and agent used in this experiment were not life-sized, and we did not implement animations such as leaving the place; therefore, the actual perceived presence of the robot or agents was lower than the experimental setting in Daher et al. 2017. Hence, there is a possibility that the priming effect would be more noticeable if life-sized robot and agents were used. Moreover, the embodiment of the primed side should be considered in a further experiment. This experiment used a virtual agent for the primed side, but a further experiment should switch the primed side from the agent to the robot.

5 CONCLUSION

This research investigated the effect of embodiment of the priming agent on the perception of social presence of the primed agent. The preliminary results did not support our hypothesis that "the social presence of the primed agent becomes higher when the embodied robot primes than when the virtual agent primes." However, the results indicated that there is a dichotomy in the perceived social presence between the participants' groups when we divide them according to their anxiety level toward robots. This indicates that the priming effect on the social presence of the primed agent is different depending on the embodiment of the priming agent and people's anxiety toward robots. Thus, we should consider the effects of the embodiment of the agent and people's attitude toward robots on the social presence of agents.

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