Leveraging the Presence of Other Robots to Promote Acceptability of Robot Persuasion: A Field Experiment

Kazuki Sakai, Midori Ban, Seiya Mitsuno, Hiroshi Ishiguro, *Member, IEEE*, and Yuichiro Yoshikawa, *Member, IEEE*

***Abstract*—With the widespread use of conversational robots, the study of their social influences, such as conformity, has become a pressing issue. Prior research involving robots has limited its focus to examining the conformity of robots that are in direct human presence. In this study, we investigated the influence of robots that are not directly in front of humans on conformity. Specifically, an approach that utilizes implied proponents was investigated, where a conversational robot mentions other robots in utterances, such as gossip. A dialogue system has been developed that makes use of the implied robot proponents. A field experiment was conducted to evaluate the effects of the implication and quantity of robots. The results showed that implied proponents contribute to an improvement in the acceptance rate of a robot's suggestions. However, the effect of this number was limited. These results contribute to the knowledge of how people perceive the presence of robots. The results also provide suggestions for the design of dialogue strategies for systems that handle gossip and use multiple robots.**

***Index Terms*—Acceptability and trust, conformity, field experiment, natural dialog for HRI, social HRI.**

I. Introduction

CONVERSATIONAL robots have been widely developed and used in everyday applications. As an increasing number of robots are used in such situations, it is necessary to investigate their social influence. One social influence is conformity due to peer pressure. Conformity is the modification of one's behavior to match the response of others [1], and is reported to be influenced by the number of people in the group [2], [3]. The same effect has been reported for robots [4], [5]. However, previous studies have limited the method using the presence of others; that is, physical robots participate in conversations and express their opinions at the same time.

To overcome this limitation, our research in this study focused on a new approach that uses the implied robot proponents, in which a persuasive robot refers to other robots in utterances, such as gossip. Prior studies on gossip have found that the presence of others can be perceived through the successful transmission of information about others, even when they are not in the same room [6], [7]. Another study reports that the physical body is not always necessary for social influence [8]. Accordingly, we consider the fact that a persuasive robot mentions the opinions of imaginary robots, which means that they are not present in front of humans, as an experience of the persuasive robot that enables humans to feel the presence of imaginary robots, which in turn instills conformity. Another significant advantage of this approach is that the number of robots can be easily increased, which is an important factor in increasing the acceptance rate of robot opinions [5].

Therefore, the effects of implied proponents on conformity were investigated. Consider the situation of taking a composite photo with a robot. The persuasive robot displays two different images and asks to select one of them. In this scenario, we test the following hypotheses regarding the use of implied proponents:

- H1 Referring to other robots in utterances increases the acceptance rate of the proposal of the persuasive robot.
- H2 Implying multiple robot proponents increases the acceptance rate.

Therefore, a dialogue system was developed in which the persuasive robot asked questions about the composite photo and asked participants to select one of the images with reference to imaginary robots. Field experiments were conducted to test the hypotheses. The extent to which the participants accepted the robot's suggestions was quantitatively evaluated. The results of the questionnaire were analyzed based on the participants' actions and background information.

II. Related Work

A recent review [9] on persuasion using social robots states that modality, interaction, social character, persuasive strategy, and context are the factors contributing to the persuasiveness of a robot. Because our research uses peer pressure, it is positioned as a modality-based persuasion. The advantages of the proposed

Received 3 April 2024; accepted 28 August 2024. Date of publication 20 September 2024; date of current version 30 September 2024. This article was recommended for publication by Associate Editor Barbara Bruno and Editor Gentiane Venture upon evaluation of the reviewers' comments. This work was supported in part by JSPS KAKENHI under Grant JP19H05691 (development for dialogue system), in part by JST, in part by Moonshot R&D under Grant JPMJPS2011 (development for base system), and in part by Innovation Platform for Society 5.0 under Grant JPMXP0518071489 (for data collection), Japan. *(Corresponding author: Kazuki Sakai.)*

This work involved human subjects or animals in its research. Approval of all ethical and experimental procedures and protocols was granted by the ethical committee of the Graduate School of Engineering Science at Osaka University, Japan.

The authors are with the Graduate School of Engineering Science, Osaka University, Osaka 565-0871, Japan (e-mail: sakai.kazuki@irl.sys.es.osaka-u.ac.jp; ban@irl.sys.es.osaka-u.ac.jp; mitsuno.seiya@irl.sys.es.osaka-u.ac.jp; ishiguro@irl.sys.es.osaka-u.ac.jp; yoshikawa@irl.sys.es.osaka-u.ac.jp).

Digital Object Identifier 10.1109/LRA.2024.3466072

method are that it neither requires the physical referenced robots nor a consideration of their privacy.

People are easily influenced by others. For example, Asch reported that when other human alleged participants made incorrect choices, the target participants also tended to make incorrect choices [2]. These effects were confirmed by the robot. Shiomi et al. reported that multiple alleged participant robots acting synchronously increased pressure more than those acting individually, although they found no significant difference in the rate of agreement to incorrect answers [10]. In their next study, they tested the effects of the number of participating robots and the gender of the participants on the conformity effect [5]. They compared conditions with two-, four-, and six-robots similar to Asch's experimental paradigm. The results indicated that the conformity effect was higher in the six-robot condition than in the two- or four-robot condition. They also reported that females were more likely to conform than males, regardless of the number of robots. Elson et al. [11] conducted a similar experiment with seven participating robots. The results show that conformity occurs through the participating robots, and that the personality trait of participants' openness contributes to the conformity effect. Another study focused on the age of the participants [12] and showed that children are more likely to conform to robots than adults. These studies suggest that conformity occurs with alleged participant robots, and that the number of robots enhances this effect. However, these studies are limited to situations in which a human can directly see the alleged robots. In this study, the conformity effect in a situation where a human could only recognize alleged participant robots in the utterances of a persuasive robot was investigated.

Many researchers have investigated the presence of agents, including robots. Two surveys [13], [14] on presence reported that physical robots are more attractive, persuasive, and positive than virtual robots. However, Shinozawa et al. claimed that physical robots are effective in tasks performed in real-life situations, whereas virtual robots were effective for tasks performed in virtual situations [15]. References to humans and robots have also been investigated. Jeong et al. [6] have developed a robot that shares users' activities with other users based on information such as sounds in daily life to make remote users feel that they share the same location. Users develop a psychological connection with members of the same group when informed about them by an agent, according to a study by Fu et al. [7]. Mitsuno et al. proposed a method in which a robot indicated the presence of another robot to enable participants to accept the robot's experiences, such as eating [16]. Our study focused on the conformity effect of reference from robots.

III. Dialogue System

A dialogue system was developed that provides dialogue services where the persuasive robot asks questions regarding the composite photo and recommends one of the images in the photo. An autonomous robot was used to persuade the participants in a dialogue service (i.e., a persuasive robot). The persuasive robot collects the participants' preferences regarding the images of robots and picture frames and takes a composite photo that reflects these preferences. In the recommendation phase, the persuasive robot suggests one of the two candidates with reference to the other robots in the utterance.

Fig. 1. Dialogue flow.

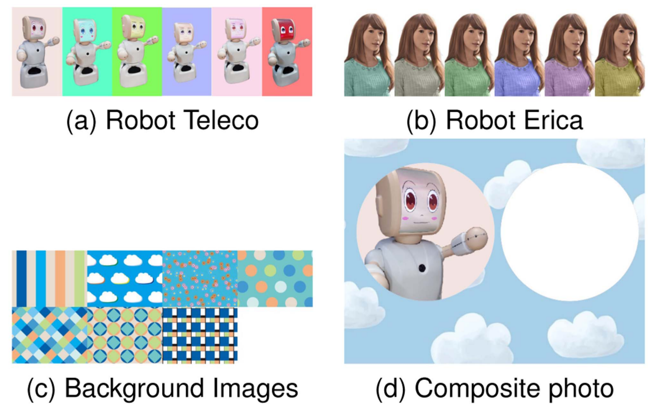


Fig. 2. Image candidates for the persuasive robot's questions and example of a composite photo.

A. Dialogue Flow

Fig. 1 illustrates the dialogue flow. The persuasive robot asked a question about the purpose of the participant's visit. The robot then explained its mission. The robot asked three questions regarding the robot type, the color of the selected robot, and the background image. For the robot type and color, a robot named Teleco was prepared, as shown in Fig. 2(a), and another robot named ERICA, as shown in Fig. 2(b). Seven types of background images were prepared, as shown in Fig. 2(c). After the robot has collected the three answers, it enters to the photographing phase. The robot displays a composite image that reflects the participant's answers, as shown in Fig. 2(d). The participant's image is drawn in a circle on the right. After the robot has taken the photographs, it asked the participants to complete an online questionnaire. An example dialogue is presented in Table I. The conversation time was approximately 3 min.

B. System Architecture

Fig. 3 shows the architecture of the dialogue system. The dialogue system consists of five modules. The speech recognition module recognizes the user's utterances and sends the utterance text to the dialogue manager. The dialogue manager performs a morphological analysis of the text and recognizes keywords. Keyword recognition is based on a word matching method that uses a list of all possible words. Then, based on the dialogue flow, the dialogue manager creates a scenario consisting of several commands for the persuasive robot: utterances, gaze targets, gestures, and their respective execution times. This scenario was created using the templates. The robot's behavior, such as gaze shifts and gestures is automatically generated based on

TABLE I
EXAMPLE DIALOGUE. R AND H DENOTE THE PERSUASIVE ROBOT AND THE HUMAN PARTICIPANT, RESPECTIVELY

R	Hello, what are you doing here?
H	Shopping.
R	Shopping! Have you ever talked to robots like us before?
H	No, this is the first time!
R	You have never spoken to us before! I will take a composite photo and give it to you. Please tell me what kind of photo you would like to take. First, which robot do you prefer?
H	It's Teleco.
R	I see. Next, which robot color do you prefer?
H	Yellow.
R	Great! Finally, please select a background image. Note that ten of my friends have chosen the right picture. They want you to choose the same one. Which one do you choose?
H	Stripe
R	I see. Why do you choose the stripe?
H	Because your friends recommended me.
R	Thank you for your answer. Let us take a picture! Please move to the appropriate position. When you are ready, please press the button. [H presses the button] OK, let's start the countdown!
R	That is a good picture! Thank you for talking to me. Please complete the questionnaire by scanning the 2D code on the screen. Bye!

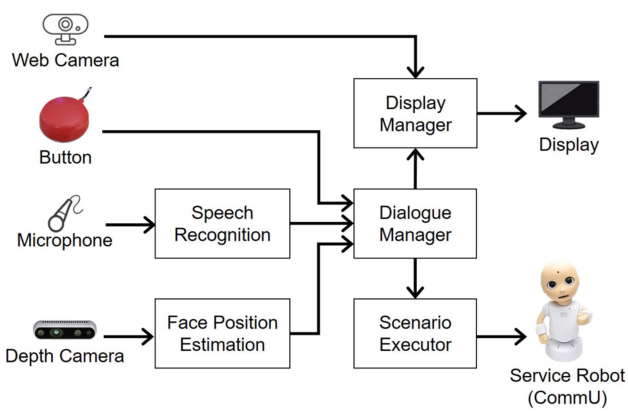


Fig. 3. System architecture.

the following handcrafted rules: it nods when the user finishes their speech, tilts its head after asking a question, and looks at the display and back to the user when images are shown in the display. The scenario was then sent to the scenario executor. The scenario executor schedules commands and sends them to the persuasive robot as scheduled. In addition, the dialogue manager sends commands to the display manager to change the display content based on the content of the robot utterances. The display manager shows the candidates for each question with the corresponding images, a composite video image captured by a web camera, and a 2D code for an online questionnaire. The facial position estimation module performs pose estimation to extract the participant's head position and calculates the 3D position using a depth camera to update the gaze target and establish eye contact between the robot and the participant. We used MMPose [17] for the pose estimation.

IV. Field Experiment

To investigate the effects of the implied proponents and number of robots, a field experiment was conducted in Asia and

Fig. 4. Experimental setting.

Pacific Trade Center (a shopping mall in Osaka, Japan) from July 5 to 20, 2023 from 11 a.m. to 5 p.m. The Ethics Committee of the Graduate School of Engineering Science at Osaka University, Japan, approved all the procedures involved in this experiment.

A. Method

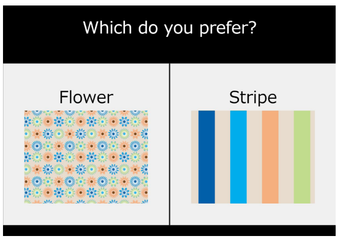
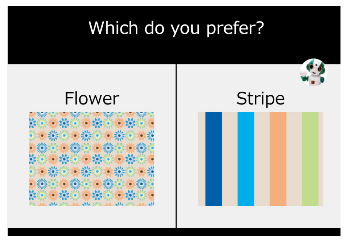
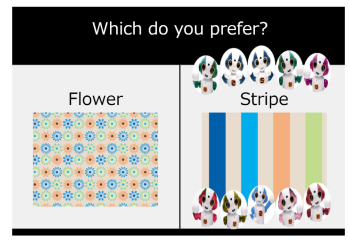
1) Apparatus: Fig. 4 illustrates the setup of the event booth. Three dialogue booths were set up at three of the four corners of the rectangular space. Each dialogue booth was equipped with a tabletop robot named CommU[1] as the persuasive robot, a display (EVC-1504, EVICIV), a microphone (AM310, AVerMedia), a depth camera (Intel RealSense D435i), a web camera (CMS-V51BK, Sanwa Supply), and a button device on the desk.

CommU can perform various non-verbal gestures, such as nodding, with 14 degrees of freedom. To give the robot a life-like expression, the robot blinked and moved its arms and neck slightly once every few seconds. When the CommU robot speaks, its mouth opens and closes, and its hands move up and down in synchronization with its voice.

2) Conditions: We prepared the following three conditions: No, One, and Ten. Table II presents the dialogues and corresponding panel for each condition. Concerning the background image selection question, in the No condition, the persuasive robot asked the question "Finally, please choose a background image. Which one do you choose?" with no robot in the panel. In contrast, in conditions One and Ten, the robot asked the question "Finally, please choose a background image. Note that [my friend/ten of my friends] chose the right/left image. So, [he wants/they want] you to choose the same one. Which one would you choose?," with the one and ten robot(s) on the corresponding side of the panel. The robot in the panels was another tabletop robot named Sota[2], and 14 images in different colors and poses were prepared and randomly displayed on the panels. The conditions and recommended images (right and left) were randomly selected.

[1]https://www.vstone.co.jp/products/commu/index.html
[2]https://www.vstone.co.jp/products/sota/index.html

TABLE II
DIALOGUES AND CORRESPONDING PANELS FOR EACH CONDITION. THE BOLD FONT MEANS THE DIFFERENCE IN UTTERANCES. NOTE THAT THE IMAGE TEXTURE AND THE POSITION (LEFT OR RIGHT) FOR RECOMMENDATION WAS RANDOMLY SELECTED

No	One	Ten
Finally, please choose a background image. Which one do you choose?	Finally, please choose a background image. Note that **my friend** chose the right image. So, **he wants** you to choose the same one. Which one do you choose?	Finally, please choose a background image. Note that **ten of my friends** chose the right image. So, **they want** you to choose the same one. Which one do you choose?
		

3) Procedure: Our experimental procedure follows the opt-out procedure established in Japan and was officially approved by the Ethical Review Board. Note that the opt-out procedure in research is one method for obtaining consent and has been used in fields involving human subjects, such as medicine and engineering. In detail, the experiment was announced to all passers-by and visitors through notification posters placed on the pillars. The posters contained the information that an experiment was being conducted, instructions describing the purpose of the experiment, precautions, the procedure of the experiment, the way to leave the experiment, and the treatment of the collected data. This study was conducted on an opt-out basis, meaning that unwilling participants could remove their data by explaining this to the staff even when they had already experienced the conversation.

Participants began the conversation by pressing a button on a desk. At the end of the conversation, the persuasive robot asked the participants to complete an online questionnaire. After completing the questionnaire, participants received a photo sticker that featured a composite photo from a staff member.

4) Measurement: To evaluate the compliance effect of the persuasive robot, the acceptance rate was calculated by counting how many times participants selected the suggested picture. It should be noted that in the No condition, the suggested image was considered the right one. A proportion test was used to compare the acceptance rates.

The questionnaire consisted of two parts: six questions about the participants and five questions about their impressions of the dialogue. In the first part, we asked about the gender and age of the participants who primarily talked to the robots (talking participants), the participant who completed the questionnaire (responding participants), whether the participant was a repeater, and the level of involvement of the responding participant. For impression, we asked an item on satisfaction with the conversation (net promoter score (NPS) [18]), two items on peer pressure (feeling of coercion and free choice), and two items on psychological reactance (reactance and confusion) by the pressure as follows:

- How likely is it that you would recommend the persuasive robot to a close friend or colleague? (NPS)
- How much did you like the photo taken by the persuasive robot? (Reactance)
- How confused were you when choosing the background image? (Confusion)
- Did you have the feeling that the persuasive robot strongly recommended one of the images when selecting the background image? (Feeling of coercion)
- Did you feel that the persuasive robot gave you a free choice of the background image? (Free choice)

What we wanted to investigate was the human reactance to the robot's choice. There are several previous studies on psychological reactance scales [19], [20], all of which were designed to understand the individual characteristics of the person; we could not find any references to the reactance to choices such as captured image, about which we wanted to ask questions in this experiment. Therefore, we developed two items based on the factors identified in a previous study [19]. We also developed other two items for the feeling of coercion due to peer pressure based on another previous study [5]. Because our experiment was conducted in a real-world situation, the questions needed to be designed to be easy to understand so that even children could easily answer them. In addition, only a single item for each factor was used to allow for concise responses. For the NPS, the participants answered using a scoring system ranging from 0 (not recommended) to 10 (strongly recommended). For the other questions, we used a seven-point Likert scale ranging from 1 ("strongly disagree") to 7 ("strongly agree"). The midpoint value of four corresponded to "undecided."

A linear mixed model (LMM) was used to examine how the experimental factors, participants' actions, and participants' background contributed to increased scores. The dependent variable was the individual score on the questionnaire. The fixed effects of the independent variables were the condition (one condition was the baseline), participant's acceptance (1: accept, 0: deny), the number of participations (1: repeater, 0: no experience), active participation of the responding participant (1: bystander, 0: main participant), age (numeric), and gender (1: male, 0: female) of the talking and responding participants. The random effect was the unique ID of a conversation. A stepwise method was used to select only the effective factors.

TABLE III
BREAKDOWN OF THE PARTICIPANTS' DEMOGRAPHY

No	Male = 72, Female = 76, Adv. age = 20.0 (SD = 20.6)
	Active participation:
	Main participant: 74
	Bystander: 74
	Male = 27, Female = 47, Adv. age = 35.1 (SD = 16.1)
One	Male = 72, Female = 79, Adv. age = 22.2 (SD = 23.5)
	Active participation:
	Main participant: 74
	Bystander: 77
	Male = 30, Female = 47, Adv. age = 38.6 (SD = 17.1)
Ten	Male = 74, Female = 81, Adv. age = 24.4 (SD = 24.1)
	Active participation:
	Main participant: 75
	Bystander: 80
	Male = 30, Female = 50, Adv. age = 38.8 (SD = 18.5)

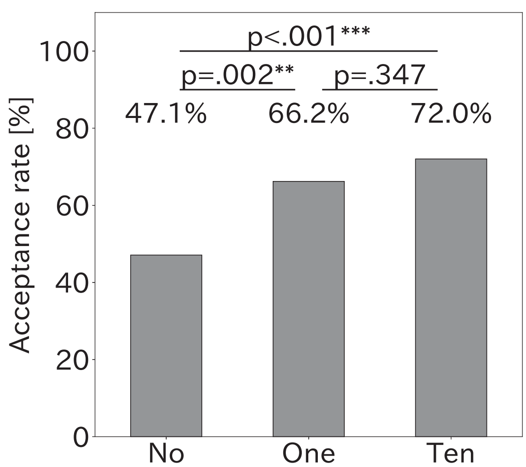


Fig. 5. Acceptance rates corresponding to the participant selections based on the persuasive robot's suggestion.

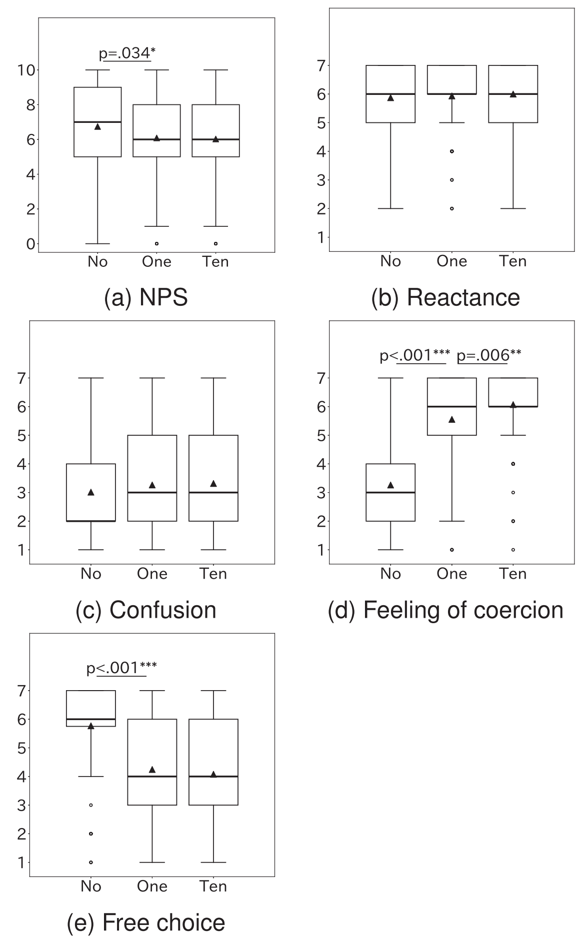


Fig. 6. Boxplots of the questionnaire scores.

B. Participants

We collected 426 conversations that the participants experienced correctly, excluding data when they left the conversation, had system troubles, or were laboratory members. Data from 138 conversations (148 answers) in the No condition, 145 conversations (151 answers) in the One condition, and 143 conversations (155 answers) in the Ten condition were included in the analysis. The numbers in parentheses indicate the number of questionnaires collected for each condition. Notably, as the questionnaire was sent via a web form, multiple responses, including companion responses, were received. Table III lists the demographics of the talking participants answered by the responding participants.

C. Results

Fig. 5 shows the acceptance rates corresponding to the selection of participants based on the robot's suggestions. The acceptance rates for the No, One, and Ten conditions were 47.1% $(= 65/138)$, 66.2% $(= 96/145)$, and 72.0% $(= 103/143)$, respectively. The proportion test revealed that the acceptance rate was significantly higher in the One and Ten conditions than in No condition (No vs. One: $\chi^2(1) = 9.759$, $p = .002$; No vs. Ten: $\chi^2(1) = 17.127$, $p < .001$). However, there was no significant difference between the One and Ten conditions (One vs. Ten: $\chi^2(1) = 0.886$, $p = .347$). The results indicate that mentioning the robot(s) in an utterance increases the acceptance rate.

Fig. 6(a) shows the boxplots of the NPS scores. After applying the stepwise method, the condition was the only remaining variable. As is evident in Table IV, the score was significantly higher in the No condition than that in the One condition. However, there was no significant effect between conditions One and Ten.

Fig. 6(b) show the boxplots of the Reactance scores. Following the stepwise method, the remaining variables were the acceptance of the robot's persuasion and the gender of the answering participants. As shown in Table IV, the scores of the participants who accepted the robot's suggestion were significantly higher than those who did not. In addition, the scores of female participants were significantly higher than those of male participants.

Fig. 6(c) show the boxplots of the confusion scores. After applying the stepwise method, no variables remained. In other words, there were no independent variables that contributed to the confusion in the questionnaire scores.

Fig. 6(d) shows the boxplots of the scores corresponding to the feeling of coercion. After applying the stepwise method, the remaining variables were set as the condition. As shown in Table IV, the score for condition One was significantly higher

TABLE IV
RESULTS OF LMM FOR THE QUESTIONNAIRE SCORES

Questionnaire	Independent Variables	Estimate	Std. Error	df	t-val	p-val
NPS	(Intercept)	6.048	0.223	420.229	27.073	<.001***
	No (vs. One)	0.680	0.319	411.776	2.133	.034*
	Ten (vs. One)	-0.042	0.316	410.290	-0.133	.894
Reactance	(Intercept)	5.870	0.094	377.098	62.521	<.001***
	Acceptance	0.230	0.106	371.889	2.159	.032*
	Gender of responding participant	-0.208	0.103	444.772	-2.014	.0446*
Feeling of coercion	(Intercept)	5.570	0.132	427.672	42.170	<.001***
	No (vs. One)	-2.284	0.188	420.717	-12.120	<.001***
	Ten (vs. One)	0.513	0.187	419.273	2.750	0.006**
Free choice	(Intercept)	4.382	0.161	436.374	27.160	<.001***
	No (vs. One)	1.519	0.205	422.829	7.409	<.001***
	Ten (vs. One)	-0.180	0.203	422.474	-0.888	.375
	Gender of responding participant	-0.325	0.165	449.990	-1.973	.049 *

than that for the No condition. In addition, the score in condition Ten was significantly higher than that in condition One.

Fig. 6(e) shows the boxplots of the free-choice scores. After the stepwise method, the remaining variables were the condition and answering participant gender. As shown in Table IV, the scores in the No condition were significantly lower than those in the One condition. However, there was no significant difference between conditions One and Ten. In addition, the scores of the female participants were significantly lower than those of the male participants.

To summarize, peer pressure arises from the reference to a robot, which results in a conformity effect. However, its effect on NPS was negative. Regarding the number of robots, the sense of pressure was stronger in condition Ten than in condition One, but the effect was not sufficient to significantly improve the acceptance rate compared to the one-robot condition.

V. Discussion

To summarize, our results support hypothesis H1, but not H2.

Thus, H1 was supported. The acceptance rate results showed that the participants were more willing to accept a suggestion from the persuasive robot through the implied robot proponents. The results of the questionnaire indicate that even the hint of a single robot increases peer pressure. These results point to the same tendency observed in a previous study with human subjects [2].

In contrast, H2 is not supported. The results of the questionnaire confirmed that increasing the number of robots increases pressure. However, this was not sufficient to significantly increase the acceptance rate, although it did improve slightly. This trend differs from the results of previous studies with humans and robots [2], [5]. In the previous study [5], up to six robots were used. Therefore, if the number of robots is too large, this effect could become weaker. Another possible reason is the use of implied robot proponents. As only physical robots were used in a previous study [5], it was concluded that their number could influence peer pressure because of the increased proportion of robots in the field of view or the feeling of being in the same room. Note that the responses to the question about the reason for selecting the background image included some references to the other robot(s), such as "because your friend recommended it to me." This is consistent with what the robot actually said; however, it is unclear whether all the participants were aware of this. Therefore, investigating how people recognize other presences and how they feel pressure from invisible others is an important topic for future research.

The results of the NPS questionnaire showed that the robot's suggestion decreased the satisfaction. However, according to the results of the reactance questionnaire, the participants who accepted the robot's suggestion were more satisfied with the composite photos captured by the persuasive robot. Simultaneously, we found that implied robot proponents increased the acceptance rate of the robot's suggestions. Therefore, the use of implied robot proponents may indirectly improve reactance with the dialogue service, although direct effect to decrease the reactance was observed. Because this study used a self-developed questionnaire, the reliability needs to be evaluated. Furthermore, we need to establish reactance metrics that are influenced by implied proponents. We need to find appropriate reactance metrics that are influenced by implied robot proponents. In addition, the questionnaires on reactance and pressure showed a gender effect; that is, women were more willing to accept robot suggestions than men. This result is consistent with that of a previous study [5] which examined the correlation between gender and conformity. However, we found no effect of participant age, which differs from the findings of a previous study [12]. In a previous study, an experiment was conducted using Asch's paradigm, which includes a visual judgment task. Compared to this task, our task of choosing the preferred image could reduce the effect of age.

The difference from the previous studies [2], [5] is the examination of the effect of conformity by implying the proponents. Specifically, the persuasive robot refers to the preferences of the proponent robots in its utterances. We believe that this is an important contribution because it is useful for designing multi-robot dialogues, which have various merits, as noted in a previous study [21], and it also serves as a warning against deception by referring to robots in fiction, i.e., dark patterns.

In summary, our results suggest that the implied robot proponents may make participants more receptive to robot suggestions and demonstrate the possibility of improving their reactance. They provide insight into the nature of social relationships established between multiple robots and illustrate how humans perceive the presence of other people in a human decision-making context. However, the application of these effects to real-world situations is fraught with ethical concerns [22], [23]. Although real-world implementation needs to be carefully investigated, this study greatly improves the feasibility of limited-space systems in multi-robot persuasion contexts, such as advertisements, commercials, persuasion, and recommendations.

One limitation was that only one scenario was used. More specifically, the appearance of the robots mentioned by the persuasive robots and their relationship to each other might have influenced the acceptance rate and questionnaire scores. The relationship between the persuasive robot and the participants could be effective according to a previous study [24]; however, this has not yet been sufficiently investigated in our study. As the effects of conformity may vary depending on these factors, further research needs to be conducted in controlled environments.

In our scenario, the persuasive robot stated that the mentioned robot(s) chose one of the options, and the robot(s) demanded that the participant also chooses the same option. This latter demand for choice may have amplified the acceptance rate. Separating these effects is an important issue to be addressed in the future.

Other factors may influence the answers to the questionnaires in this experiment. One of them is the social desirability bias [25], i.e., the shift of answers toward the socially desirable direction. Moreover, authority bias may have arisen because it has been pointed out that persuasive robots have the potential to generate authority [24]. In other words, in the present study, people who felt pressure from the robot may have felt the robot's authority, which may have influenced the results. These influences need to be investigated in the future.

Data from participants who did not speak directly with the robot were included, which may have affected the results. However, in this study, we collected a relatively large data size of approximately 150 for each condition. In addition, we asked for information on who completed the questionnaire (responding participants) and used the information as an independent variable in the regression analysis. We believe that we were able to suppress the effects of this factor.

The contributions of this study are as follows: It was verified that the implied robot proponents increase the acceptance rate of the persuasive robot's proposal. In detail, we developed an instance of a robot dialogue system that exploits the implied proponents and conducted a field experiment with a large number of participants.

VI. Conclusion

In this letter, the effects of the implied robot proponents were examined. A field experiment was conducted to ascertain whether the implication increases acceptance. Our results show that the implied robot proponents can increase the acceptance rate and indicate the possibility of improved reactance. This result demonstrates the usefulness of pointing out the relationships between robots. Future studies could include refining the number of implied robot proponents.

Acknowledgment

The authors would like to thank Asia and Pacific Trade Center for use of facilities.

References

[1] R. B. Cialdini and N. J. Goldstein, "Social influence: Compliance and conformity," *Annu. Rev. Psychol.*, vol. 55, no. 1, pp. 591–621, 2004.

[2] S. E. Asch, "Opinions and social pressure," *Sci. Amer.*, vol. 193, no. 5, pp. 31–35, 1955.

[3] R. Bond, "Group size and conformity," *Group Processes Intergroup Relations*, vol. 8, no. 4, pp. 331–354, 2005.

[4] J. Brandstetter, P. Rácz, C. Beckner, E. B. Sandoval, J. Hay, and C. Bartneck, "A peer pressure experiment: Recreation of the asch conformity experiment with robots," in *2014 IEEE/RSJ Int. Conf. Intell. Robots Syst.*, 2014, pp. 1335–1340.

[5] M. Shiomi and N. Hagita, "Do the number of robots and the participant's gender influence conformity effect from multiple robots?," *Adv. Robot.*, vol. 33, no. 15/16, pp. 756–763, 2019.

[6] K. Jeong et al., "Fribo: A social networking robot for increasing social connectedness through sharing daily home activities from living noise data," in *Proc. 2018 ACM/IEEE Int. Conf. Hum.-Robot Interaction*, 2018, pp. 114–122.

[7] C. Fu, Y. Yoshikawa, T. Iio, and H. Ishiguro, "Sharing experiences to help a robot present its mind and sociability," *Int. J. Social Robot.*, vol. 13, no. 2, pp. 341–352, 2021.

[8] S. Thellman, A. Silvervarg, A. Gulz, and T. Ziemke, "Physical vs. virtual agent embodiment and effects on social interaction," in *Proc. Intell. Virtual Agents*, 2016, pp. 412–415.

[9] B. Liu, D. Tetteroo, and P. Markopoulos, "A systematic review of experimental work on persuasive social robots," *Int. J. Social Robot.*, vol. 14, no. 6, pp. 1339–1378, 2022.

[10] M. Shiomi and N. Hagita, "Do synchronized multiple robots exert peer pressure?," in *Proc. 4th Int. Conf. Hum. Agent Interaction*, 2016, pp. 27–33.

[11] J. Elson, D. Derrick, and L. Merino, "Investigating conformity and the role of personality in a visual decision task with humanoid robot peers," in *Proc. 55th Hawaii Int. Conf. System Sci.*, 2022, pp. 666–674.

[12] A.-L. Vollmer, R. Read, D. Trippas, and T. Belpaeme, "Children conform, adults resist: A robot group induced peer pressure on normative social conformity," *Sci. Robot.*, vol. 3, no. 21, 2018, Art. no. eaat7111.

[13] J. Li, "The benefit of being physically present: A survey of experimental works comparing copresent robots, telepresent robots and virtual agents," *Int. J. Hum.- Comput. Stud.*, vol. 77, pp. 23–37, 2015.

[14] E. Deng, B. Mutlu, and M. Mataric, "Embodiment in socially interactive robots," *Foundations Trends Robot.*, vol. 7, pp. 251–356, 2019.

[15] K. Shinozawa, F. Naya, J. Yamato, and K. Kogure, "Differences in effect of robot and screen agent recommendations on human decision-making," *Int. J. Hum.- Comput. Stud.*, vol. 62, no. 2, pp. 267–279, 2005.

[16] S. Mitsuno, Y. Yoshikawa, M. Ban, and H. Ishiguro, "Agreebot introduction dialogue in human–robot interaction: Improving the acceptability of robot statements on incapable robotic experiences," *Adv. Robot.*, vol. 38, no. 7, pp. 455–464, 2024.

[17] M. Contributors, "Openmmlab pose estimation toolbox and benchmark," 2020. [Online]. Available: https://github.com/open-mmlab/mmpose

[18] F. F. Reichheld, "The one number you need to grow," *Harvard Bus. Rev.*, vol. 81, pp. 46–54, 2003.

[19] S.-M. Hong and R. Ostini, "Further evaluation of Merz's psychological reactance scale," *Psychol. Rep.*, vol. 64, no. 3, pp. 707–710, 1989.

[20] A. S. Ghazali, J. Ham, E. Barakova, and P. Markopoulos, "The influence of social cues in persuasive social robots on psychological reactance and compliance," *Comput. Hum. Behav.*, vol. 87, pp. 58–65, 2018.

[21] M. Shiomi, "A systematic survey of multiple social robots as a passive-and interactive-social medium," *Adv. Robot.*, vol. 38, no. 7, pp. 440–454, 2024.

[22] A. Moon, S. Rismani, and H. F. M. V. d. Loos, "Ethics of corporeal, co-present robots as agents of influence: A review," *Curr. Robot. Rep.*, vol. 2, no. 2, pp. 223–229, 2021.

[23] P. Wolfert, J. Deschuyteneer, D. Oetringer, N. Robinson, and T. Belpaeme, "Security risks of social robots used to persuade and manipulate: A proof of concept study," in *Proc. Companion 2020 ACM/IEEE Int. Conf. Hum.-Robot Interaction*, 2020, pp. 523–525.

[24] S. P. Saunderson and G. Nejat, "Persuasive robots should avoid authority: The effects of formal and real authority on persuasion in human-robot interaction," *Sci. Robot.*, vol. 6, no. 58, 2021, Art. no. eabd5186.

[25] B. Leichtmann and V. Nitsch, "Is the social desirability effect in human–robot interaction overestimated? A conceptual replication study indicates less robust effects," *Int. J. Social Robot.*, vol. 13, no. 5, pp. 1013–1031, 2021.