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仮想現実を利用してロボットの視点取得による人間対ロボットの向社会性の促進

Perspective-taking for promoting prosocial behaviors through robot-robot VR task

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Perspective-taking, which enables individuals to consider the thoughts and objectives of another, is well established to be a successful strategy for encouraging pro-social behavior in human-computer interactions. Nowadays, perspective-taking is no longer limited to text; it is now more frequently used in virtual reality (VR). However, most previous research has focused on simulating human-human interactions in the real world in VR by providing participants with experiences connected to different moral tasks. In this study, we investigated whether participants' prosocial behaviors toward robots would change if they experienced an altruistic VR task involving robots from the perspective of different robots. Our findings show that participants who had the help-receiver-view exhibited more altruistic behaviors toward a robot than those who had the help-provider-view one in a dictator game.

1. INTRODUCTION

Technological artifacts that behave autonomously in social settings, such as autonomous automobiles, vacuum cleaners, cellphones, virtual agents, and robots, are quickly becoming a reality and are anticipated to interact with people more socially in the future [1]. How these objects can influence individuals to act in a prosocial way has captured the attention of many researchers.

Prosocial behavior is a multidimensional concept that is broadly defined as voluntary behavior to benefit the other[2], [3], [4], [10], such as altruism, solidarity, sharing, care- giving, and comforting [6]. There are also distinct types of prosocial behavior ranging from high-cost (e.g., extensive volunteering, helping in dangerous or emergency situations) to low-cost behaviors (e.g., helping to pick up a dropped item, sending an uplifting text message [3]). Based on the motivation behind prosocial behavior, including altruistic, cooperative, and individualistic behavior [7], [8], altruism based on inter-reciprocity is a strong motivational factor in prosocial behavior [9].

Previous work has paid more attention to the characteristics of robots or agents and to the influence on the prosocial behavior of humans (e.g., donation behavior), such as the social background of users[10], where a robot is installed [11], the gender of a robot [12], the appearance of a robot [13], the head behavior of humanoid robots [14], and the facial expressions of virtual agents [15].

Considering a possible hybrid society of humans and machines [16] in the near future, robots or agents may be members of human society. In the field of Human-Robot Interaction (HRI), there have been a number of studies on the interaction between a human and a robot [17], on the interaction between a group of people and a robot [18], and on the interaction between a human and a group of robots [19] where the appearance or behavior of a robot or the form of interaction with humans affects the human's helping behavior toward the robot (e.g., completing a task together, playing against each other, or playing a game together) [20]. In addition, Nagataki et al. [21] asked participants to do a series of moral tasks after performing a bodily coordinated motion task with either another participant or a robot, and they observed that participants also made fair proposals to their robot partner. Although there are a lot of studies on human-robot relations, these studies did not have the human imagine how the robot thinks.

Numerous studies have demonstrated that adopting the viewpoint of another person (i.e., envisioning what it would be like to actually be the other person), which is called perspective taking, can be an effective strategy for encouraging prosocial behaviors [22] in human-human interaction. Mediated perspective-taking tasks (e.g., online role playing games, videos, immersive virtual realities) that supply extra information to participants or users rather than depending solely on the user's imagination have also demonstrated a strong potential for encouraging prosocial behaviors [23][24][25].

Research on mediated perspective-taking prefers to simulate realistic human interactions in VR or to allow participants to have experiences that their existing physical bodies cannot, for example, allowing white people to experience the perspective of black people [25] or Einstein [26]. Robin et al. [26] allowed participants to experience the feeling of having extraordinary abilities in a VR environment, which encourages participants to socialize with others in the real world. Jeffrey et al. [27] compared the different ways of perspective taking toward a non-player, in this case, a robot avatar, in terms of closeness, empathy, and game immersion. Although they used a robot avatar, they did not compare the attitude toward a different role in the game. Xiang et al. [28] showed how playing multiple roles in a single role-playing process in immersive virtual environments can encourage more morally correct opinions about bullying others. Although they compared views on violence between different characters, this was based only on the relationship between human and human and did not take into account the relationship between human and robot.

It can be seen that there is still a lack of research that looks at using perspective-taking to facilitate human- robot relationships through VR technology. One recent study exemplifies people ’ s prosocial behavior toward machines. With the computers are social (CASA) framework [29], the study of the sociality, or even prosociality, of machines is no longer just a paper exercise. We think it is necessary to verify whether taking the perspective of different robots in a robot task can influence people ’ s prosocial behaviors toward a robot.

In this study, we focus on altruism, one of the many components that make up prosociality [30]. According to the definition of altruism, which is the act of someone helping someone else at their own expense [31], an altruistic task must include at least two objects: the help-provider and help-receiver. We conducted an experiment in order to find out if participants ’ social behaviors toward robots will be affected by adopting different robot perspectives during a robot-altruistic VR task.

We conducted a between-participants experiment by asking participants to take different perspectives (help-provider and help-receiver) in the same robot altruistic VR task. We tracked behavioral changes using the dictator game [32], [33], [34], a simple economic game commonly used to gauge altruistic attitudes, and the desire to assist scale. The findings demonstrate that after having different robot perspectives in the same task, participants changed their prosocial behavior towards robots.

2. METHOD

2.1 Participants and apparatus

Thirty-five university students participated in the study (29 males, 6 females, Age: $Mean = 27.6$, $SD = 3.9$). They received a shopping card (about US$12) as a reward for their participation. Participants were randomly assigned to one of two conditions. Eight participants (all from the help-provider view) were removed because they answered incorrectly to certain questions or did not follow a pop-up message in the game, for example, input xxx yen for a question asking for battery to be allocated or thought the pop-up message was the garbage message and missed information it provided. The final number of participants was 27 (22 males, 5 females, Age: $Mean = 27.3$, $SD = 4.2$) (1 Brazilian, 13 Chinese, 1 Estonian, 2 French, 5 Germans, 1 Indian, 2 Italians, 2 Japanese, 1 Moldovan, 2 Portuguese, 1 Spaniard, 1 Swiss and 3 Vietnamese in alphabetical order) .

The study ran on Intel Core i7-11800H, 32GB RAM computers running Windows 11 Pro. The experiment software was written in C# in Unity and recorded user actions in the game through Unity Recorder. The VR game was driven on the Oculus Quest 2 device.

For additional information, we also conducted an online experiment and asked 10 university students (5 males, 5 females, Age: $Mean = 26$, $SD = 2.68$)(10 Chinese) who did not have any VR experience to answer questions on

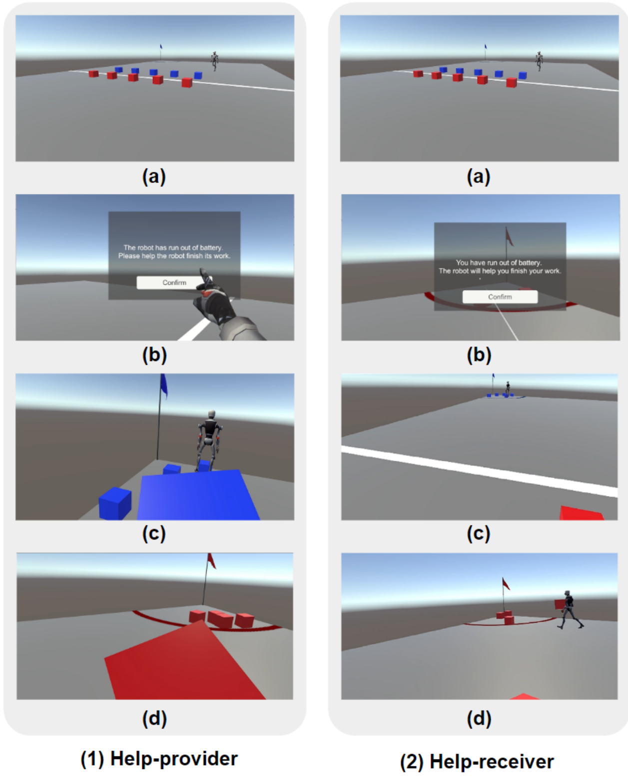

図 1: Scenarios of VR tasks

their willingness to help robots, the robot-partner version of the Dictator game, the battery version of the Dictator game, and acceptance of robots.

2.2 Stimulus design

Altruism is when someone helps others at their own expense [Batson14], and the robots’ battery was seen to be their own expense [Hang21, Hang22]. Therefore, we considered an altruistic event where two robots are doing a task, one of the robots runs out of battery, and the other robot comes to help on its task.

The task was to move cubes to a target position. To distinguish the work to be done by each robot, we set the cubes in their respective work areas to different colors. Also, to make the work load as consistent as possible, we placed the cubes in their respective areas in mirrored locations and kept the initial position of one robot and the robot that the participant played the role of the same (see Fig. 2.(1)-(a) and Fig. 2.(2)-(a)).

There were two types of scenario in the game: the help-provider view and the help-receiver view. For making it more nature while participants take the help-receiver and stop during the work because of running out of the battery, we choose robot-avatar for both help-provider-view and help-receiver-view.

For the help-provider view, once the other robot moved the third cube to the target area, it stopped working (see Fig. 2.(1)-(c)). At that time, the participants received a pop-up message on their screen informing them that, “The robot has run out of battery. Please help the robot finish its work” (see Fig. 2.(1)-(b)). Although the instruction

図 2: Mirror for participant to see him/herself as robot

we provided on the pop-up message for participants was to help the other robot, they still had the right to choose not to help the robot and end the game.

For the help-receiver view, as it is hard to control the speed at which participants move cubes, we also set the stopping point to be when the other robot moved the third cube to the target area. This time, the robot that participants were playing the role of got stuck at the current location, and a pop-up message showed up on their screen stating that, “You have run out of battery. The robot will help you finish your work.” (see Fig. 2.(2)-(b)). The participants could still move their head to get a different view from their location, but they could not move their location in the game. The participants were asked to stay in the game until the robot finished both its own work (see Fig. 2.(1)-(c)) and helped participants to finish their work (see Fig. 2.(1)-(d)).

We included a mirror part in our VR experience on the basis of Oh et al. [Oh16]. Before each stimulus, the participants were reminded to look at their own body as a robot through a mirror in VR (see Fig. 1.), and for experiencing what it is like to be a robot, they were asked to wave the controllers at the mirror (which were displayed as the robot’s hands).

On the basis of our stimulus design and results basing on Lee et al.[Lee21] which showing that different attitude towards robots which expressing different types of self-compassion, we made a hypothesis that the participants who experienced the help-provider view and who experienced the help-receiver view will have significant difference in terms of help behavior towards robot (1a), altruistic behavior towards robots (1b), and acceptance of robots (1c).

2.3 Procedure

First, we asked the participants to read the instructions and ethical materials for this experiment. Then, they were asked to do a pre-questionnaire, which inquired about demographic questions and about participants’ subjective knowledge of VR. On the basis of this, we also provided the participants with a brief overview of the VR game so that they could have a smooth VR experience. After the participants confirmed their understanding of the game, we first asked them to complete training for object grabbing by moving different colored cubes to the target area. After completing the training, they were given 30 seconds to see their avatar through the mirror in VR. Then, different games were offered for different groups, either to help one robot complete the task (help-provider) or to be helped by the robot to complete the task (help-receiver). Here, we want to highlight that we did not state the task as involving a cooperative or competitive relationship at the beginning of the game. After completing the game, the participants were asked to fill out a post-test questionnaire. The questionnaire regarded the willingness to help the robot, the dictator game with the robot as the partner and the dictator game with the battery as the allocated resource, the acceptance of the robot, body ownership and agency in VR games, and inclusion of the other in the self. A free description question was asked after completing the whole questionnaire. Finally, a short interview was conducted to confirm that the participants had understood the game correctly.

2.4 Measurements

For the pre-questionnaire, a demographic question including name, nationality, age, gender, and highest qualification was asked. In addition, to determine the participants’ initial understanding of VR, we asked them two subjective questions on VR.

- `Knowledge of VR`: How much do you think you know about VR? The answer was given on a five-point Likert scale .
- `Expertise using VR`: How often do you use VR devices? The answer was given on a five-point Likert scale .

For the post-questionnaire, the details were as follows.

- `Help behavior towards robot`: On the basis of Avelino et al. [Avelion18], we asked participants, “Would you help the robot if that robot was out of battery?” The answer was given on a five-point Likert scale (1: help to 5: not help).
- `Dictator game`: For measuring the participants’ altruistic behavior, previous studies usually use the Dictator game [Andreoni10, Capraro19, Engel11] in which one player (the proposer) makes a one-time offer to the other (the responder). The original version was as follows: “Now you are given x yen. The money needs to be shared with the other participant. How much money would you give to the other participant?”

The Dictator game is sometimes transformed into a new version to fit the different purposes of different studies [Engel11]. As our setting was participants' prosocial behavior towards robots, we transformed the original version into two new versions designed by the authors.

For one version, we changed the responder from human participant to robot, so the question was as follows: "Now you are given 1,000 yen (about US$8.70). The money needs to be shared with the other robot. How much money would you give to the robot?"

For the other version, we changed the allocated resource from money to battery. As there are no common values between a human and a robot and money makes no sense to a robot, we tried setting the allocated resource to battery [Hang21, Hang22] as it was the energy source of the robot. Therefore, the question was as follows: "Now you are given 100% battery. The battery needs to be shared with the other robot. How much battery would you give to the robot?"

- `Acceptance of robots`: We picked only questions on trust in regards to the acceptance of robots [Heerink09]. We asked participants to answer the following questions on a five-point Likert scale (1: strongly agree to 5: strongly disagree): 1. "I would trust the robot if it gave me advice." 2. "I would follow the advice the robot gives."

- `Body ownership and agency`: On the basis of the previous studies on body ownership, we followed the questionnaire by Banakou et al. [Banakou16]. The participants were asked to answer the following questions on a five-point Likert scale (1: strongly agree to 5: strongly disagree): 1. "I felt that the virtual body I saw when looking down at myself was my own body." 2. "I felt as if I had two bodies." 3. "I felt that the virtual body I saw when looking at myself in the mirror was my own body." 4. "I felt that the movements of the virtual body were caused by my own movements."

- `Inclusion of other in the self (IOS)`: In addition, to measure participants' perceived closeness with the robot [Ho20], an IOS question was asked.

3. RESULTS

For the pre-questionnaire, we analyzed the data with an independent sample t-test. The result shows that there were no significant differences between the helper group and be-helped group in terms of knowledge of VR ($t(23) = 1.72$, $p = 0.10$) and expertise in using VR ($t(21) = 1.59$, $p = 0.13$).

For the post-questionnaire, we analyzed the data with an independent sample t-test.

For the help behavior towards the robot, there were no significant differences ($t(23) = -0.42$, $p = 0.68$) between the helper group ($Mean = 1.46$, $SD = 0.77$) and be-helped group ($Mean = 1.64$, $SD = 1.79$), which rejects hypothesis 1a. For the robot-partner version of the Dictator game, there were significant differences ($t(25) = -2.87$, $p = 0.008$, Cohen's $d = 1.10$) between the helper group ($Mean = 269.23$, $SD = 189.67$) and the be-helped group ($Mean = 507.14$, $SD = 225.09$) (see Fig. 3.), which supports hypothesis 1b partially. For the battery version of the Dictator game, there were no significant differences ($t(14) = -0.69$, $p = 0.50$) between the helper group ($Mean = 56.15$, $SD = 19.43$) and the be-helped group ($Mean = 79.29$, $SD = 115.05$), which rejects hypothesis 1b partially.

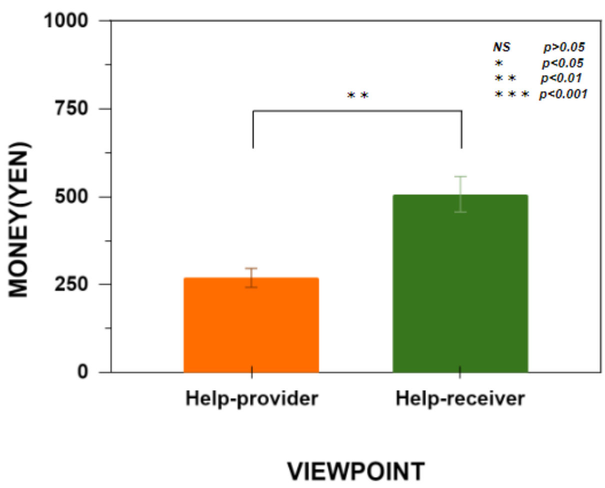

図 3: Result of dictator game

For the acceptance of robots, there were no significant differences ($t(24) = -0.18$, $p = 0.86$) between the helper group and the be-helped group, which rejects hypothesis 1c. For body ownership and agency, there were no significant differences between the helper group and the be-helped group in terms of how much the participants felt the virtual body to be their own body ($t(24) = -0.77$, $p = 0.45$), felt they have two bodies ($t(25) = -0.18$, $p = 0.86$), felt the avatar in the mirror was their own body ($t(24) = -0.76$, $p = 0.46$), and agency ($t(25) = -1.11$, $p = 0.28$). For the IOS, there were no significant differences ($t(25) = -0.40$, $p = 0.69$) between the helper group and be-helped group.

For additional information, we conducted another online survey and asked 10 participants to answer questions on their willingness to help robots ($Mean = 1.5$, $SD = 0.81$), the robot-partner version of the Dictator game ($Mean = 470$, $SD = 303.48$), the battery version of the Dictator game ($Mean = 55.1$, $SD = 40.18$), and acceptance of robots without any stimulus ($Mean = 3.05$, $SD = 0.69$).

4. DISCUSSION

We conducted this experiment to investigate whether experiencing two different points of view from robots in the same altruistic task could promote human prosocial behavior and trust towards robots. In addition, we also wanted to know if there are differences in terms of body ownership and agency in VR experiences after taking different points of view from robots.

The results showed that participants who had the help-receiver view in the VR task gave more money to the robot than those who had the help-provider view. Also, comparing the result with (the additional information in result) and without the VR task, those who had the help-receiver view split more money with the robot compared with those who did not experience any VR tasks, and those who had the help-provider view split less money with the robot compared with those who did not experience any VR tasks. This gives us some warning that the experience of doing a task with a robot can not only have a positive effect on a human's prosocial behavior towards robots but also a negative one, which shows that researchers should pay more attention to the task setting. In addition, from the interview with the participants, some said that how they split the money was based on how many tasks the robot had done in the VR task.

There were no significant differences between participants who had the help-receiver view and help-provider view regarding help behavior, the battery version of the Dictator game, and the acceptance of robots in terms of trust. For the help behavior, although there were no significant differences between the two groups, both groups themselves had mean values that were more favorable toward helping robots. For the battery version of the Dictator game, although there were no significant differences between the two groups, both groups themselves had mean values that were higher than the group without a stimulus. Thus, we can observe a trend in the result that, in the VR task, no matter the help-provider or help-receiver role, both had a positive effect on promoting participants' prosocial behavior towards robots. We also found that even when we changed the allocation resource from money to battery, this confused some of the participants about the questionnaire itself as "There is no reason for me to have a battery." For future work, it is also important for us to design a proper measurement for evaluating human prosociality towards robots.

For acceptance of robots in terms of trust, although there were no significant differences between the two groups, both groups themselves tended to trust the robot more than the group without a stimulus. However, for body ownership and agency and IOS, there were no significant differences between the two groups. We found some possible reasons from the free description answers given by the participants. As some of them were familiar with video games and VR games, they did not feel that they were in the body of a robot even though they checked their body movement through the mirror. In addition, in human-human interaction tasks, Pierce et al. [Pierce13] have shown that taking the perspective of a competitor might lead to more unethical behaviors.

From the interview after the experiment, we found that participants who were from European countries tended to treat the robot who ran out of battery as "being sick" unlike participants from other countries. There is also research on the influence of nationality in HRI [Evers08, Rhim20]. In our current work, although we conducted the experiment with participants from different countries who have different cultural backgrounds, we did not set nationality as a factor, which we can add in our future work. In addition, this time, we observed only short term effects, but long term effects should also be observed as well as whether one form of prosocial behavior (e.g., helping) leads to another form of prosocial behavior (e/g., sharing).

5. CONCLUSION

In tasks ranging from traditional perspective-taking tasks to mediated perspective-taking tasks, perspective-taking has been demonstrated to be an effective strategy for fostering prosocial behavior. In this study, we evaluated how participants' prosocial behavior changed as they adopted the perspectives of different robots in a robot-altruistic virtual reality task. Our research revealed that individuals who adopted the help-receiver view acted more favorably toward a robot than those who adopted the help-provider view. We will use the findings from our study in subsequent work to explain how various tasks and relationships in the tasks could change participants' prosocial behavior towards robots.

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