A Hug from a Robot Encourages Prosocial Behavior

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Abstract—**This paper presents the effects of being hugged by a robot to encourage prosocial behaviors. In human-human interaction, touches including hugs are essential for communication with others. Touches also show interesting effects, including the "Midas touch," which encourages prosocial behaviors from the people who have been touched. Previous research demonstrated that people who touched a robot experienced positive impressions of it without clarifying whether being hugged by a robot causes the Midas touch effect, i.e., positively influences engagement in prosocial behaviors. We developed a huge, teddy-bear-like robot that can give reciprocal hugs to people and experimentally investigated its effects on their behaviors. In the experiment, a robot first asked participants to give a hug and then asked them to make charitable donations in two conditions: with or without a reciprocated hug. Our experiment results with 38 participants showed that those who were hugged by a robot donated more money than those who only hugged the robot, i.e., without a reciprocated hug.**

I. INTRODUCTION

Robots can physically interact with people, which is an essential difference from computer-graphic-based agents. In fact, past research has reported that the physical presence of robots influences interactions with people differently or more strongly than computer-graphic-based agents [1-4]. For example, Bainbridge et al. investigated different responses to a request to throw a book by comparing humans, agents, and robots [2]. Shinozawa et al. concluded that people are more likely to follow a robot's opinion than the opinion of a computer-graphic agent [4].

Physical existence enables robots to communicate with people through haptic interaction. In human science literature, the positive effects of haptic interaction have already been broadly investigated, and both the mental and physical benefits have been unveiled [5-10]. An interesting phenomenon known as the "Midas touch" effect, which encourages prosocial behaviors, has also been reported [11]. Following these results, robotics researchers also investigated the positive effects of a robot's haptic interaction [1, 12, 13]. For example, touching a robot positively affected the mental health of seniors [14]. Hugs, another kind of touch, are also an interesting research topic in the human-robot interaction research field, and researchers have started to investigate their effects. For example, Sumioka et al. reported that a voice call to another person through a huggable robotic device decreased stress levels more than with a common smartphone [15].

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Figure 1. Participant being hugged by a robot

However, in research that focused on hug interaction with robots, the robots did not reciprocate the hugs because of the difficulties of hug behaviors or their size and shape. Moreover, the literature in human-human interaction showed several contradictory (positive and negative) effects of reciprocal haptic interaction. For example, reciprocal touch lends support and generally binds the affective relationship more tightly together [16]. But other works reported that nonreciprocal touch evokes dominance, status, and power [17-20]. Another work concluded that a non-reciprocal touch expresses warmth or love and rarely dominance or control [21]. Therefore, there is room to uncover the effects of reciprocated hugs by a robot. A question arises: how does being hugged by a robot (Fig. 1) influence people to change their behaviors?

This paper addresses this question by investigating the effects of being hugged by a robot. We developed a robot named "Moffuly" (Fig. 1) that resembles a large teddy bear and implemented a simple structure with which it hugs an interacting person. We compared the effect of being hugged by it by investigating responses to prosocial behaviors (donations) requested by the robot. We also discussed both positive and negative perspectives on the effects of being hugged by a robot based on our experiment results.

II. RELATED WORKS

A. Human's touch effects

Touching, including hugging, increases happiness and health through both mental and physical benefits. For example, past research confirmed that the act of hugging reduces blood pressure and protects against heart rate increases under stressor events [5]. Hugs also provide stress-buffering social support and protection against the infectious virus that causes the common cold [6]. Such tactile stimulation as back-rubbing and hugs induces the release of oxytocin, a hormone that facilitates social bonding and trusting behaviors [22]. Even if touch is imagined, buffers stress and pain better than verbal support [7]. Burgoon et al. investigated how touching interactions affect impressions in human-human interaction [23], such as intimacy and immediacy.

Touching also influences prosocial behaviors, not only health status. Researchers investigated touch effects for positive impressions [24], and higher compliance to requests [25, 26]. This phenomenon was dubbed the "Midas touch," which is one famous effect of touching in human science literature.

B. Human-robot haptic interaction

In human-robot interaction research fields, touching including hugs with robots provides positive effects [12-15, 27-29], as in the case with human interaction. For example, touching a seal robot (Paro) provided mental health benefits for elderly people [14]. Being touched by a robot increased people's motivation during monotonous tasks and improved their impressions of it [13]. Chen et al. investigated the influence of a combination of a robot's touches and verbal communication cues on robot impressions [30]. Conversations through huggable devices decreased stress levels more than with a smartphone in an investigation of cortisol levels [15]. Hug interactions are preferred by interacting people who are observing their reactions in real environments [31, 32].

Midas touch effects in human-robot interaction are broadly investigated because they are a commonly used measurement of the behavioral effects of touches in the human interaction research field. For example, Fukuda et al. measured them from a robot's touch by analyzing Medial Frontal Negativity by EEG [33]. Haans et al. investigated whether tactile stimulation with vibration motors influenced the helping behaviors of people [34]. Another viewpoint investigated Midas touch effects through telepresence robot negotiation [35].

These research works thoroughly investigated the effects of touch with a robot and the Midas touch in human-robot interaction. However, the hug interactions with robots in them were a one-way hug interaction; due to the limited capabilities of the robots, only the people hugged them, not the other way around. Some research implemented a reciprocal hug behavior for robots [31, 32]. But since these behaviors were part of an interaction, the scrutiny of reciprocated hugs remains inadequate.

We believe that reciprocated hugs from a robot will probably have a stronger influence than one-way hug interactions from people. In this study, we unveil the effects of reciprocated hugs from a robot by measuring both prosocial behaviors and the interactions of people, both of which are commonly used to investigate behavioral effects in human-robot interaction.

III. System Configuration

Our system is designed for Wizard-of-Oz studies [36] in which we systematically tele-operated it. This enables us to concentrate on user interactions in ideal situations where the robot always responds correctly.

A. Robot

For this study, we developed "Moffuly," a robot that resembles a large teddy bear (Fig. 1). It is 200-cm tall with two elbows (1*2 DOF) and a speaker. Its arms are 80 cm long, which is adequate to reciprocate a hug. To ensure safety when the robot gives a hug, we covered its frame with polypropylene cotton and used weak motors that can be easily resisted if needed. We addressed sanitation concerns by attaching a washable cover to its face part that makes contact with the faces of participants during the hugs (Fig. 1). Its utterances were generated using speech synthesis software [37]. The robot was placed in a room with three cameras and three microphones. Speech recognition was performed by an operator who chose from among pre-determined rules to control it.

We prepared several chat contents and reply behaviors for conversations, including such self-introductions as "Hello, I'm Moffuly! Even though I look like a bear, my favorite food is electricity, not honey." We also prepared self-disclosure contents because they are important for friendly human-computer and human-robot interactions [38, 39]. During conversations, the robot asks to chat with people and simply replies to them: "I see," "you did your best," and so on. Appropriate reply behaviors are chosen by the operator based on the conversation contexts. Since we designed the robot as a listener in this study, to prevent complex conversations about itself, the robot politely refused to answer most questions: "Sorry, I don't know much about that. But I'd like to hear more about your story!"

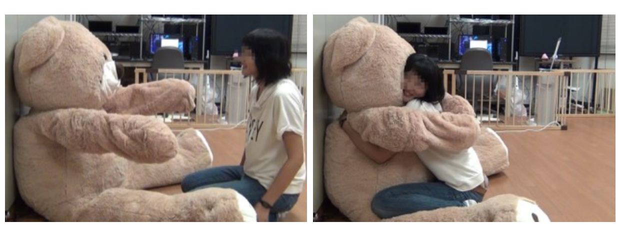
B. Hug behaviors

We prepared two hug behaviors for the experiment: a hug-request in which the robot asks for a hug, and a reciprocated hug behavior in which the robot hugs the participants who hugged it.

For safe reciprocated hugs from the robot, we followed a similar experiment procedure from a past research work [13]; we designed it to ask the person for a hug first, which it then returns. The following are the details of these behaviors:

Hug-request behavior: The robot opens its arms and says, "Before we start talking, would you please give me a hug?" (Fig. 2-a). The robot says, "Hug me longer, please" when the person seems to stop the hug or to leave the robot.

Reciprocated hug behavior: After the person grants its hug-request behavior and hugs the robot, it moves both of its own arms (which are controlled by the operator) until it touches the person's body. Then the robot pats the person on the back (Fig. 2-b); the timings of the pats are based on two rules. First, while the robot is talking, the timing is based on the end of its contents. Second, when the person is talking to the robot, the timing is either based on the end of their contents or on 30-second periods.



(a) Hug-request behavior (b) Reciprocated hug behavior

Figure 2. Hug behaviors of robot

IV. EXPERIMENT

A. Hypothesis and prediction

Hugs are basically reciprocal. A reciprocated hug conveys acceptance and positive impressions. We believe that reciprocated hugs from a robot can also more strongly convey positive impressions to the person who hugged the robot than non-reciprocated hugs and would probably influence his/her behavior.

To investigate the effects of reciprocated hugs from a robot, we focused on behavior changes: the Midas touch effect. In human-human interaction, touch encourages such prosocial behaviors as donations and helping the person who was touched [11, 24-26]. Such effects are also observed in human-robot interaction [33, 34]. Therefore, a hug from a robot, which is one typical touch behavior, might influence prosocial behaviors in the interacting persons. Based on these reasons, we make the following hypothesis:

Prediction: People who were hugged by a robot will donate more money to charity than people who only hugged it (i.e., without a reciprocated hug).

B. Participants

Thirty-six Japanese people (18 women and 18 men, whose average ages were 35.49, S.D 10.13) were paid for their participation.

C. Environment

In the experiment environment, we fixed the robot to a wall and installed two cameras and microphones on the ceiling and one camera/microphone near it. We used this information to analyze the experiment and to control the robot by an operator who manipulated it from another room.

D. Condition

The study had a between-participant design with the following two conditions. For each condition, nineteen subjects (nine women and ten men) participated. In both conditions, the conversational and the replay behaviors were identical, and the operator controlled the robot based on the same pre-defined rules in both conditions.

Hug-request only: The robot requests a hug from the participants and then chats. It did not hug the participants.

Reciprocated hug: The robot requests a hug from the participants, hugs them back, and then starts to chat. During the chats, it pats them on the back based on pre-defined rules.

E. Procedure

Before the experiment, the participants were given a brief description of our experiment's purpose and procedure. In this explanation, we only asked the participants to interact and talk with the robot by hugging without mentioning the donations. We explained the nature of their interaction with the robot and literally demonstrated how to hug it (Fig. 2-b). We also explained that the robot's face part with which the participants' faces make contact during hugging was replaceable for sanitation concerns. We also explained that since the robot's conversation capabilities are limited, complex conversations are difficult. We stressed that the robot likes listening to stories and encouraged them to talk with it. After the above explanations, the experimenter left the participants in the experiment room and started the first session. During this session, only the participants and the robot were in the room.

After starting the experiment, the robot introduced itself to the participants and made its hug-request behavior. After being hugged, the robot talked with them using the self-disclosure contents and asked for stories or just offered to listen to them. In the reciprocated hug condition, the robot hugged the participants and started patting them on the back based on the pre-defined rules. All the participants interacted with the robot for ten minutes per session. At the end, the robot said, "By the way, I'm collecting donations for earthquake victims. Would you like to give? There's a donation box in the room where you'll answer a questionnaire after the experiment." Then the experimenter entered the room and led the participants to another room that held a desk, a chair, and a donation box. The experimenter paid the participants and asked them to complete questionnaires. The experimenter again left the participants in the room for ten minutes. At this time, they could freely donate some money. After ten minutes, the experimenter returned and interviewed them.

In debriefing sessions after the interviews, we explained the purpose of this experiment and calculated the amount of their donations. We offered to return their donation to them (if they wanted) and promised to donate the same amount of money ourselves even if they wanted their donation back. But all of the participants declined our offer, i.e., they wanted to donate money. Therefore, we donated the participants' money to the earthquake charity.

This research was approved by our institution's ethics committee for studies involving human participants. Written, informed consent was obtained from all of them.

F. Measurement

To investigate whether the reciprocated hug behavior encouraged prosocial behavior, i.e., donations for earthquake victims, we measured both the number of people who donated and the amount of their donations.

Although our main interests are in the behavioral changes, we additionally measured one subjective impression of the participants by a questionnaire that their total impressions of it. They answered a questionnaire on a 1-to-7 point scale where 7 is the most positive and 1 is the most negative.

V. RESULTS

A. Verification of prediction

Table 1 and Fig. 3-left show the numbers of people who donated and the average donation by all 36 participants. For the number of people, we conducted a Chi-square test, which did not show any significant differences between the conditions ($x^2(1) = 0.446$, p=n.s, φ=0.111).

We also conducted a t-test for the donation amount. The results showed significant differences between the conditions ($t(34)$=2.391. p=0.022, r=0.38). Even if we conducted a t-test for the average donation by only those participants who donated (hug-requests only: 8 participants, reciprocated hugs: 11 participants), we still identified a significantly different level (p <.05). Thus, the prediction was partially supported.

TABLE I. NUMBER OF PEOPLE WHO DONATED

	Did not donate	Donated
Hug-requests only	10	8
Reciprocated hugs	7	11

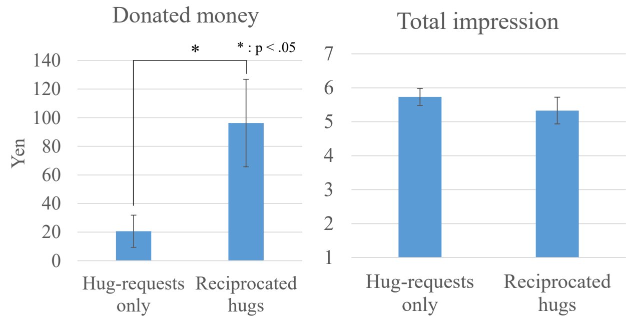


Figure 3. Average and S.E. of donated money and total impression

Figure 4. Participant who smiled after being hugged

B. Questionnaire results

Figure 3-right shows the questionnaire results of the total impressions of the participants. We also conducted a t-test that did not show any significant differences between the conditions ($t(34)=0.278$, $p=0.782$, $r=.13$). The donation amounts were different between the conditions, but the total impressions were not different between them in this study.

C. Observations

In both conditions, typical interaction pattern was that the participants talked about themselves while hugging the robot. Most seemed surprised by the robot's hug-request behavior, even though we did explain it to them. In the reciprocated hug condition, sometimes participants even smiled the first time that they were hugged by the robot (Fig. 4).

Participants listened to the robot and often responded by nodding. After finishing its self-introduction and self-disclosures, the robot asked the participants to talk about themselves. They mainly chose to talk about their families, holidays, or school/work. For example, several participants described their most recent trips: "Every year, I go on a cycling tour with my friends. This was our fourth year. Every year we've had trouble, such as heatstroke, leg cramps, and so on. This year, we again had a problem; my friend took a spill and broke his bicycle during the tour." Another participant described her job at which she works hard outside on hot summer days, and the robot said, "I see, you're working very hard." She thanked the robot and smiled.

Some participants asked the robot about itself, even though we had already explained that its conversation capabilities were very limited. For example, a participant asked whether its name (Moffuly) was derived from "mofumofu" (fluffy in Japanese). Other participants asked about its favorite foods, birthplace, and first love. The robot answered simple questions using yes or no, but refused complex questions that needed explanations or reasons.

D. Interview results of hug impressions

In the interviews, first we asked the participants about their favorite robot interaction. 5/18 participants (the hug-request only condition) and 14/18 participants (the reciprocated hug condition) positively evaluated their hug experiences with the robot. The remaining participants positively evaluated their chats with the robot, but they did not mention their hug interactions.

We also asked the participants in the reciprocated hug condition whether their impressions of the reciprocated hugs from the robot were positive or negative. 17/18 participants positively evaluated the reciprocated hugs, and only 1/18 participant criticized it because the hugging wasn't smooth. Most positively evaluated their hug interactions with the robot in the reciprocated hug condition.

E. Interview results about why people donated

In the interviews, we asked the participants whether the robot's requests and/or interactions were related to their donation behaviors. In the hug-request only condition, 3/8 participants who donated said that the robot's request did not influence their decision; 6/8 participants who donated said that the robot's request did influence their decision. As in the reciprocated hug condition, 3/11 participants who donated said that the robot's request did not influence their decisions; 8/11 participants who donated said that the robot's request influenced their decision. The results suggest that the robot's reciprocated hug did not influence their donation decisions.

Also, we asked participants whether they usually donate during such charity drives/opportunities. 12/18 participants in the hug-request only condition and 12/18 participants in the reciprocated hug condition reported that they often donated. From these results, the number of people who often donate did not seem biased between the conditions.

We additionally investigated the average ages of those who donated because age is probably related to their disposable income (we did not ask about their income in this study), which might influence donation behaviors/habits. The average ages of those who donated were 33.29 (S.D: 10.36) in the hug-request only condition and 38.78 (S.D: 8.39) in the reciprocated hug condition; there were no statistical differences between the conditions.

VI. DISCUSSION

A. Positive and negative perspectives

Our experiment results revealed that reciprocated hugs from a robot influenced people's prosocial behaviors, although the reciprocated hug mechanism was relatively simple without rich chat contents. Interestingly, some people wanted hugs without verbal communication. This phenomenon happens in human-human interaction too, e.g., when we silently hug an intimate friend or family member.

Touching including hugs is essential to construct social relationships in human-human interaction [8], where the capabilities of reciprocated hugs are useful to construct social relationships with robots, especially for long-term interaction. Past research implemented physical interactions to develop a rapport between a robot and people [31, 32]. Moreover, huggable robots are already being used to investigate haptic interaction effects and for such daily supports in real settings as elderly care [14, 40]. Reciprocating hugs from a robot might facilitate social relationships in such contexts.

On the other hand, the effects of reciprocated hugs on prosocial behaviors, i.e., donations, are related to ethical issues. In this study, we conducted an experiment under an academic context and donations from participants for earthquake victims in Japan, but we need to carefully design reciprocated hug behaviors in real-world contexts. We are concerned about how to touch people [41], e.g., since a robot must avoid touches that brazenly solicit contributions. Moreover, if the robot's reciprocated hug could contribute to the construction of social relationships, as described above, we also need to design robot behaviors that avoid beseeching requests from robots by exploiting such relationships. A worldwide social movement has emerged called the "free hugs campaign" whose events are sometimes related to donations or charity events [42]. Such a context is another possible application with our robot because it can reciprocate a hug.

B. *Future work*

Even though our results revealed that reciprocated hugs from a robot encouraged prosocial behaviors, it remains unknown why such effects occurred because our questionnaire results did not show significant differences between the conditions. We must investigate further relationships via other measurements to discuss the effects of reciprocated hugs.

One potentially interesting trial is to investigate such physiological measurements as cortisol, which indicates the stress levels of people, because in human science literature, such physiological measurements are commonly investigated. A past research already investigated huggable medium effects, which decrease stress levels through conversations [15], but it did not address reciprocated hugs from a robot. If being hugged by a robot further decreases stress levels, it might serve as evidence for the effects of reciprocated hugs, and applications might be useful for therapy. Other physiological measures, such as brainwaves, might also help understand the reciprocated hug effects. A past research work analyzed robot's touch effects through EEG analysis, which shows that they affect Medial Frontal Negativity, whose amplitude is correlated with feeling of unfairness [33].

From the psychological perspective, one possible measurement is the Big Five personality traits that investigate the relationships between personal characteristics and behavior changes. Earlier works demonstrated several measurements toward robots such as negative attitudes toward robots scales (NARS) and the robot anxiety scale (RAS) [43, 44]. Measuring them might deepen our understanding of the effects of reciprocated hugs.

Another possible future work is to compare the effects of non-hug. In fact, past research investigated touch effects by comparing them with non-touch conditions [13, 45]. For example, Tai et al. showed how touching a doll or a teddy bear impacts the effect of social exclusion on prosocial behavior by comparing touch and non-touch [45]. We assume that non-hug condition would show similar results with the hug-request only condition because Shiomi et al. have also compared between non-touch, passive touch (human touch only) and active touch (reciprocated touch) and reported that there is no difference between non-touch and passive touch [13]. Comparing non-touch conditions might provide richer knowledge about hug interaction with a robot.

C. *Limitations*

Since our experiment was conducted with our developed robot, which has a huggable appearance and size, robot generality is limited. We cannot ensure that our findings can be applied to all interactive robots because size and feelings about being touched are essential for hug interactions. To generalize reciprocated hug effects, we must investigate them with different kinds of robots, especially non-huggable robots.

Since the robot's hug interaction was relatively simple, we must also investigate more effective hugs. Investigating different hug-style situations is another potentially enlightening approach, e.g., a hug while standing face-to-face, instead of sitting on the floor. However, we believe that our setting offers essential knowledge for researchers who are interested in hug interactions with interactive robots.

The meaning of touching differs by culture. For example, in Japan, hug interactions are less common than in such countries as Italy [8]. Japanese people might have strong positive impressions toward hugs because they are relatively rare in their daily lives. Even though past worldwide research on hugging has identified positive effects, we cannot generalize our results yet. Cross-cultural experiments are critical to scrutinize the effects of reciprocated hugs.

VII. Conclusion

We focused on the effects of reciprocated hugs from a robot on people's prosocial behaviors. Even though previous research investigated the positive effects of hug interactions with robots, such works focused less on being hugged by a robot during the interactions. To investigate the effects of reciprocated hugs from a robot, we developed a large, teddy-bear type robot that can reciprocate hugs from people and conducted a between-subjects experiment in which it asked participants for donations (i.e., prosocial behaviors) with a reciprocated hug.

Our experiment results showed significant differences about the amount of donations among participants who were hugged or not hugged by the robot. On the other hand, the numbers of people who donated was not significantly different between the conditions. This study showed that a reciprocated hug from a robot influences people's behavior, even though impressions toward it did not different between conditions.

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