A Robot that Encourages Self-Disclosure by Hug

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Abstract: This paper presents the effects of being hugged by a robot to encourage self-disclosure. Physical interactions, which are known to be essential for communication with others, also show the effects of eliciting self-disclosure from the people with whom one is interacting and contribute to the construction of social relationships. Previous research demonstrated that people who touched a robot experienced positive impressions of it without clarifying whether being hugged by a robot elicits self-disclosure from people. We developed a huge, teddy-bear-like robot that can give reciprocal hugs to people and experimentally investigated its effects on self-disclosure. Our experiment results with 32 participants showed that those who were hugged by the robot significantly offered more self-disclosure than those who were not hugged by it. Moreover, people who were hugged by the robot interacted with it longer than those who were not hugged by it. On the other hand, the perceived feelings about the robot were not significantly different between the conditions.

Keywords: Hug, Human-Robot Interaction, Self-disclosure

1 Introduction

Forging relationships between agents and people is essential to serve a number of intimate support roles in human society such as education [1-5] and elderly care [6-8]. For this purpose, various interaction strategies have been proposed and evaluated in human-agent and human-robot interaction research fields: the characteristics of social robots [9-11], beliefs about agent autonomy [12], physical behavior design [13, 14], and the design of long-term behavior changes [15, 16].

The elicitation of self-disclosure is one common strategy to build a friendly relationship between an agent and an interaction partner [17-19]. Past research works mainly employed verbal tactics to elicit self-disclosure. For example, agents asked provocative questions to elicit self-disclosure from interaction partners [17]. Another approach is reciprocal self-disclosure from agents; several research works reported the effectiveness of people who reveal more of themselves after listening to disclosures from agents [18, 19]. However, physical tactics that elicit self-disclosure are less focused than verbal tactics; some works have encouraged self-disclosure from people by focusing on the effects of physical existence [20] and changes in physical distances [13]. Even though robotics researchers investigated the positive effects of physical interaction with robots [21-26], no influence on eliciting self-disclosure has been identified. Therefore, there is room to investigate the effectiveness of physical interaction effects on eliciting self-disclosure from people to build friendlier relationships.

In human science literature, such physical interaction as touch is essential to building relationships with others [27-30] and eliciting self-disclosure from the persons who were touched [19, 31]. If physical interaction with a robot provides similar positive effects as humans do, it would be useful for building relationships with people by eliciting more self-disclosure from them.

This paper investigates whether physical interaction with a robot encourages self-disclosure from an interaction partner. For this purpose, we developed a robot named "Moffuly" that resembles a large teddy bear and implemented a simple structure with which it hugs an interaction partner. We experimentally investigated the effects of being hugged by it by measuring the amount of self-disclosure during interaction.

Fig. 1 Hug behaviors of robot

2 System overview

2.1 Hardware

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 used speech synthesis software [32] to generate its voice. An operator took over its speech recognition and choose its behaviors based on pre-determined rules to control it.

2.2 Conversational behavior

For conversation with interaction partners, we prepared three main chat contents: self-introduction, requesting self-disclosure from people, and replies. In the self-introduction behaviors, the robot introduces itself with such a self-disclosure as "Hello, I'm Moffuly! Even though I look like a bear, my favorite food is electricity, not honey." We included self-disclosure contents because they are important for friendly human-computer and human-robot interactions [16]. In the behavior that requests self-disclosure from people, the robot asks to hear their stories: "I'd like to learn more about you, could you please tell me something about yourself?" To respond to its interaction partners, the robot uses reply contents: "I see," and "you did your best,".

In this experiment, we employed the Wizard-of-Oz approach [33] and systematically tele-operated it. Appropriate reply behaviors are chosen by the operator based on the conversation contexts. Also, we designed the robot as a listener in this study to encourage self-disclosure. Therefore, it politely refuses to answer most questions: "Sorry, I don't know much about that. But I'd love to hear more about you!" to prevent complex conversations about itself when the interaction partners ask questions.

2.3 Hug behavior

To realize reciprocated hugs from the robot, we designed it to first ask for a hug, which it then returns, as follows. First, the participant's position is fixed at a distance of 75 cm from the front of the robot, which is based on the definition of the personal distance where friendly people interact [34] (Fig. 1-left). Then the robot opens its arms and says, "Before we start talking, would you please give me a hug?" (Fig. 1-middle). After the person hugs the robot, it moves both of its arms until it touches the person's body and pats the person on the back (Fig. 1-right). 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 conversations or on 30-second periods.

3 Experiment

3.1 Hypothesis and predictions

People disclose more personal information through physical interaction with others [19, 31]. Positive effects from physical interaction are not limited to humans; people also received positive feelings toward robots through physical interaction with them [21-25]. Therefore, we believe that reciprocated hugs from a robot will also encourage more self-disclosure from a person who hugged the robot than non-reciprocated hugs or no-hugs.

We also focused on people's willingness to interact with the robot. Tactile stimulations through touch facilitate social bonding [27]. If people prefer reciprocated hugs from a robot and start to build a social relationship with it, they might want to interact with it again. Longer interaction would also encourage self-disclosure. Based on these reasons, we make the following hypotheses:

Prediction 1: People who were hugged by a robot are more likely to interact with it longer than people who were not hugged by it.

Prediction 2: People who were hugged by a robot are more likely to disclose more about themselves than people who were not hugged by it.

3.2 Participants

Thirty-two Japanese people (16 women and 16 men, whose average ages were 36.22, S.D 9.64, the age range was from 20 to 52) were paid for participation.

3.3 Environment

We attached the robot to a wall and installed two cameras and microphones on the ceiling and one camera/microphone near it. We used the information from the sensors to analyze the experiment and to control the robot by an operator from another room.

3.4 Condition

The study had a between-participant design with the following two conditions. For each condition, sixteen subjects (eight females and eight males) participated. In all the 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.

No-hug: The robot only chats with the participants; it did not request a hug. We also asked the participants to avoid physical interact with the robot and to stay in their initial position. Thus, they did not physically interact.

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.

3.5 Procedure

Before the experiment, the participants were given a brief description of our experiment's purpose and procedure. We explained their interaction with the robot and literally demonstrated how to hug it (as shown in Fig. 1-right), except for participants who joined the *no-hug* condition. We also explained that the robot's face part with which the participants' faces make contact during hugging was replaceable to alleviate any sanitation concerns. Moreover, we explained that since the robot's conversation capabilities are limited, complex conversations are difficult and should be avoided. 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 experiment.

At the beginning of the experiment, the robot introduced itself to the participants, and made its hug-request except in the *no-hug* condition. After that, the robot talked with them using the self-disclosure contents and asked for stories/information 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. The minimum length of the interaction time was 10 minutes; if the participants would like to interact more, we extended the interaction time to 20 minutes in maximum. Thus, the participants could freely finish the interaction any time after 10 minutes passed.

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

3.6 Measurement

In this study, we measured two items: the interaction time they spent with it, and the ratio of the self-disclosure and non-self-disclosure conversations, i.e., the number of the conversation related to self-disclosure divided by the number of the conversation without self-disclosure. The reason of why we focused on the ratio is because our experiment also investigates the willingness to interaction with the robot by measuring interaction time. The different length of interaction time would have influences to the total number of self/non-self-disclosure conversations, therefore we normalized them by calculating the ratio between them.

For this measurement, first a coder transcribed all of the conversations of the participants from the recorded data. As a result, the coder segmented the conversation data to 210 scripts, based on the conversation theme. Then the coder coded the transcribed 210 conversation scripts into either the self-disclosure (e.g., including such private topics as hobbies, personal experiences, private matters, and so on) or non-self-disclosure (e.g., mundane topics like the weather) categories. After that, to investigate the coding's validity, another coder coded 10% of these data [35], and we calculated the kappa coefficient [36], which was 0.74, indicating substantial agreement between coders.

We additionally measured the subjective impressions of the participants by a questionnaire that addressed perceived friendliness toward the robot on a 1-to-7 point scale where 7 is the most positive and 1 is the most negative.

4 Results

4.1 Verification of predictions

Figure. 2 show the average interaction time they spent with the robot and its standard error. We conducted an ANOVA for the interaction times, which showed significant differences among the two conditions ($F(1, 30)=26.965$, $p<.01$, *partial* $\eta 2 =0.473$). Thus, prediction 1 was supported.

Figure 3 shows the average ratio of the self-disclosure and non-self-disclosure conversations and its standard error. We conducted an ANOVA for this measurement and it showed significant differences among the two conditions ($F(1, 30)=11.930$, $p<.01$, *partial* $\eta 2 =0.285$). Therefore, prediction 2 was supported.

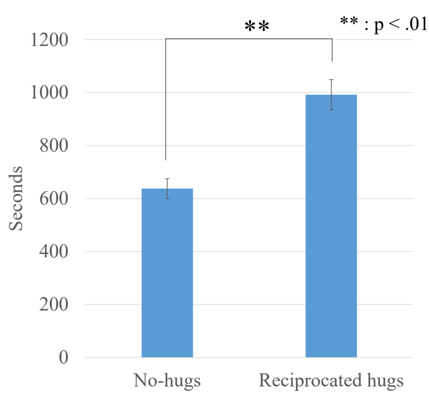

Fig. 2 The interaction time

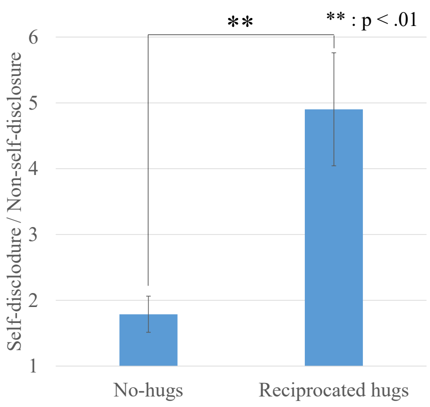

Fig. 3 the ratio of conversation contents

4.2 Questionnaire results

Figure 4 shows the questionnaire results of the total impressions of the participants (average and standard error). We conducted an ANOVA for statistical analysis that it did not show any significant differences among the three conditions ($F(1,30)=0.884$, p=n.s.). Even though the interaction time with the robot and the ratio of the self-disclosure and non-self-disclosure conversations were significantly different among conditions, the total impressions were not different in this study.

4.3 Additional analysis: amount of self-disclosure

The experimental results showed that the interaction time and the ratio of the self-disclosure and non-self-disclosure conversations were significantly increased at the *reciprocated hug* condition than the *no-hug* condition. As an additional analysis, we also measured the total amount of the self-disclosure and non-self-disclosure conversations and investigated whether the amount of them are different between the conditions.

Figure 5 shows the average numbers of the self-disclosure and non-self-disclosure conversations and its standard error. We conducted a two-way repeated-measure ANOVA with mixed factors: condition and category. Significant main effects were revealed in the category factor ($F(1, 30)=15.127$, $p<.01$, *partial* $\eta 2=.335$), and in the interaction within them ($F(1, 305)=5.530$, $p<.05$, *partial* $\eta 2=.156$). There is no significant difference in the condition factor ($F(1, 30)=1.055$, p=n.s.).

Multiple comparisons with the Bonferroni method for the simple main effects of condition in the *self-disclosure* category were significant in *reciprocated hug* > *no-hug* ($p<.05$). There was no significance in the *non-self-disclosure* category (p=n.s.).

Multiple comparisons with the Bonferroni method in the simple main effect category in the *reciprocated hug* condition were significant in *self-disclosure* > *non-self-disclosure* ($p<.01$). There was no significance in *no-hug* condition (p=n.s.). These results would become another evidence for supporting the prediction 2.

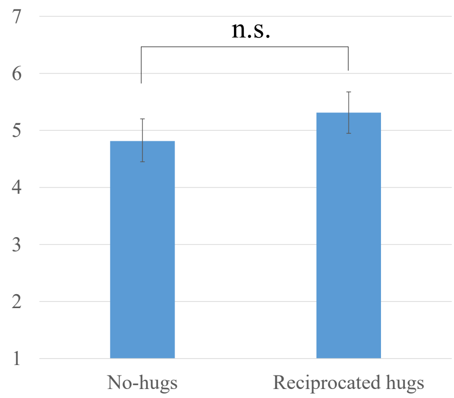

Fig. 4 The total impression

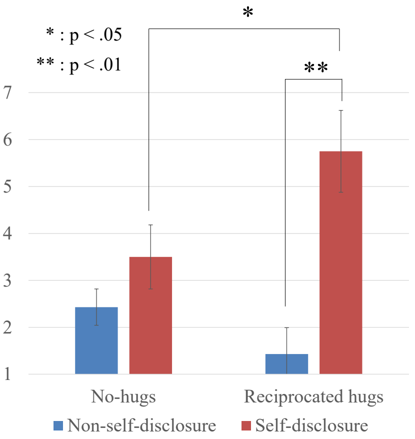

Fig. 5 The number of conversations

4.4 Observations of interactions and self-disclosure

In both conditions, the typical interaction pattern was that participants talked about themselves. In the *reciprocated hug*, most seemed surprised by the robot's hug-request behavior, even though we did explain it to them. About self-disclosure, most participants related such positive contents as their recent travels, experiences of summer festivals, and so on. For example, one participant talked about his hobby (running) and described recently completing a full marathon. On the other hand, some participants talked about relatively serious contents, such as failing an entrance examination for graduate school, difficulties of bringing up children, and so on. For example, one participant expressed melancholy about the remainder of his life, especially after his children leave home. He said to the robot, "Life is full of ups and downs."

5 Discussion

5.1 Design implications

Our experiment results revealed that reciprocated hugs from a robot influence people's self-disclosure and encourage more interaction with it. Since not only physical interaction but also self-disclosure are essential to construct social relationships in human-human interaction [19, 27-31], the capabilities of reciprocated hugs would be useful for constructing social relationships between people and robots.

A clinical context is one possible application for huggable robots, because past research works showed the advantages of autonomous agents in such contexts. For example, Lucas et al. reported that patients preferred to disclose personal information to autonomous agents than to tele-operated ones [12]. Even though our robot is tele-operated, the capabilities of reciprocated hugs for autonomous robots might contribute to clinical uses by eliciting disclosure from patients, both constructing social relationships and understanding their physical/mental situations.

Even though the results revealed that reciprocated hugs from a robot encouraged more interaction with the robot, it is still unknown why such effects occurred. In our settings, it is still unknown which factor contributed to longer interaction: a reciprocated hug or a hug feeling of the robot. One interesting future work is to compare a hug-only condition where participants hug the robot but it did not reciprocate hug.

From another perspective, to investigate further relationships using other measurements would be useful to discuss the effects of reciprocated hug. One interesting trial is to investigate such physiological measurements as cortisol, which indicates the stress levels of people. A past research has already investigated huggable medium effects, which decrease stress levels by conversations [21], but it did not address reciprocated hugs from a robot. Other physiological measures, such as brainwaves also help to understand the reciprocated hug effects. A past research work analyzed robot's touch effects through EEG analysis shows that they affect Medial Frontal Negativity, whose amplitude is correlated with feeling of unfairness [25].

5.2 Limitations

This research work has several limitations. Since our experiment was conducted with a robot with a teddy-bear like huggable appearance, its generality is limited. We cannot ensure that our findings can be applied to all interactive robots because size and touch feelings are essential for hug interactions. Moreover, we only investigated a simple reciprocated hug i.e., patting a person's back, even though obviously many hug styles exist in human-human interaction. Investigating different hug-style situations is critical, e.g., standing face-to-face instead of sitting on the floor. However, we believe that our setting is still adequate to offer essential knowledge for researchers who are interested in hug interaction with interactive robots.

6 Conclusion

We focused on the effects of reciprocated hugs from a robot for eliciting self-disclosure. Even though previous research investigated the positive effects of hug interactions with robots, such works less focused 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 with two conditions: hug and no-hug.

Our experiment results showed that reciprocated hugs from the robot significantly increased the amount of self-disclosure from people. Also, more participants who were hugged by the robot interacted with it again than participants who were not hugged by it. Thus, this study showed that a reciprocated hug from a robot influences self-disclosure and willingness to interact.

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