Enhancing Empathy toward an Agent by Immersive Learning

Hirotaka Osawa[1] and Michita Imai[2]

[1]Information and Systems, University of Tsukuba
[2]Faculty of Science and Technology, Keio University

Abstract: We propose enhancing the empathy of the user agent to improve the human-agent interaction (HAI). Previous agent interaction mainly used a sympathy strategy, which included using human-like appearance, expressions, and communication strategies. This approach restricted the agent's behaviors within the anthropomorphic range. We would be able to use more varied designs in HAI if humans could more easily understand a non-human-like agent's state. We used an of immersive learning method in which the user experiences the role of the agent throughdirect manipulation to improve the user's empathy towards the agent. We compared our hypothesis by conducting a teaching task, which entailed how to build blocks, using two kinds of robot modalities and two types of participants, which included those who have experience manipulating robot agents and those who have not. The results showed that the participants who had already experienced robot manipulation more naturally understood the robot's attitudewhen the robot's modality was far from the manipulator. The results suggest that the user's empathy toward the agent solidified when the user experienced the agent's modalities.

1 Introduction: Empathy improves HAI

Human-agent interaction (HAI) has become an important subfield in the field of human-computer interaction (HCI) [1], [2]. Virtual agents and social robots behave around users as if they have their own thoughts and emotions just as humans do, and trigger the users' social responses based on their behaviors and by solving tasks without the cognitive barrier of users. HAI is in widespread use such as in the entertainment field [3], [4] and for medical purposes like for people suffering from dementia and autism [5], [6].

The success of these HAI methods has mainly been supported by the sense of intimacy that a user has with an agent that they accept as a social actor [7]. One of the important factors for achieving this acceptance as a social actor is sympathy [8]. A biological study suggested that these sympathies are supported by mirror neurons [9]. Several studies have tried to accelerate the sympathy of users towards an agent by using the anthropomorphic appearance, emotional presence, and expressionism in sharing situations [10]–[12].
However, these anthropomorphic appearances also limit the number of possible designs for an agent. The hardware resource restrictions are particularly severe for robotic systems. In addition, non-human-like agents may offer several unique communication opportunities that are not achieved by human-like agents. We have been proposing usages for several non-human-like agents [13][14]. If the user's sense of intimacy toward an agent is applied to a non-human-like agent that uses different gestures, a different appearance, and different communication strategies, we would be able to use more variable agents. Figure 1 shows our vision. There are various agents that could be possibly used in several HAI systems. If we can better understand different types of agents, we could extend their applications in HAI.

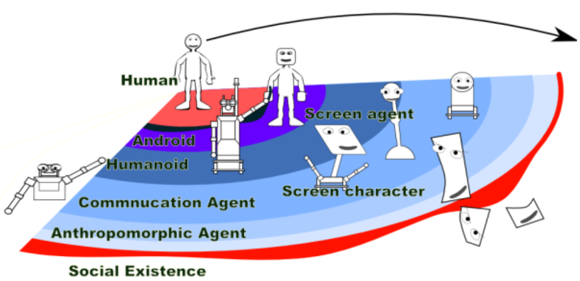

Fig. 1. Variation of agents in HAI

In this study, we propose enhancing a users empathy towards a non-human-like agent. We define the empathy towards an agent as an understanding of the process used by an agent and their behaviors as similar or equal to one's own behaviors. We use immersive learning to accelerate the user’s ability to empathize [15]. The immersive learning method is commonly used as a learning method, and we have extended it towards robots [16]. In this method, the user tele-operates the agent and behaves as if he/she was the agent. Then, they experience and betterunderstand the agent’s capabilities and thus feel more empathy towards it. Our vision is shown in Fig. 2. Before the experience, they only feel empathy towards humans and androids. If the manipulator experiences an agent's viewpoint, they will feel more empathy towards various communication agents. D’Ambrosio et al. succeeded in enhancing the user's ability to empathize towards older people using Age Gain Now Empathy System (AGNES) that changes humans into older people [17]. We extended this approach to the field of non-human-like agents.

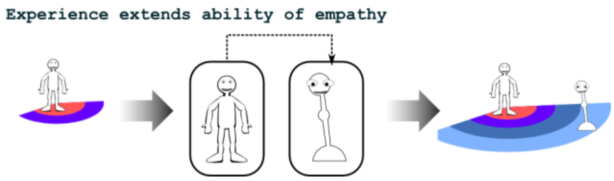

Fig. 2. Extending empathy toward non-human-like agent

We evaluated our proposal while conducting demonstrative tasks that instruct a user on how to assemble a building from wooden blocks using an agent by changing the agent's head modality.

The following sections are organized as follows. Section 2 explains how immersive learning extends the ability to empathize in detail. Section 3 explains the experimental system we implemented to evaluate the immersive learning. Section 4 explains the experiment for evaluating our hypothesis. The results are shown in Section 5 and they are discussed in Section 6. Section 6 also concludes our paper.

2 Immersive Learning in Agent

We compared the four groups shown in Fig. 3 to evaluate the empathy enhancement in our study. There are two kinds of agents that are manipulator-like and non-manipulator like, which are on the left and right sides of the figure. Under the manipulator-like condition, an agent's head and arms move according to the manipulator's movement. On the other hand, the agent's head is not movable under the non-manipulator-like condition.

The participants experience using the manipulator in the top half of the figure, and the participants have no experience in manipulation in the bottom part of the figure.

We estimated that immersive learning is effective if this method is used for non-human-like agents. Thus, the participants in groups C and D will evaluate the acceptance of the interaction differently if immersive learning enhances their ability to empathize. On the other hand, acceptance of the interaction by the participants in groups A and B will not be different because they expect each agent as human way and they can feel sympathetic towards the agent. We created an experimental system based on this prediction.

We need to create an appropriate teleoperation system that can simulate a given situation so that a user can become the agent to create an impressive method for real-world agent situations. This system requires quick responses and natural conversion of the user's movements by the agent.

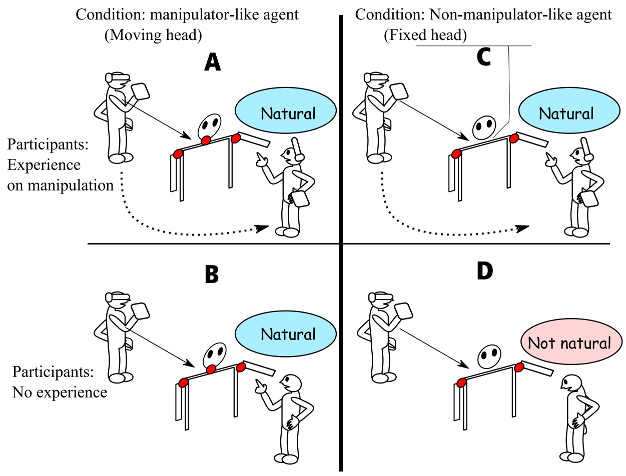

Fig. 3. Four conditions for evaluating how immersive method improves user's ability to empathize

3 Experimental System

, We implemented a reconfigurable agent, a monitoring device to capture movement, and a recording system to meet the system requirements explained in the previous section.

3.1 Reconfigurable agent that allows us to use variable shapes and modalities

We can evaluate not only the human-like robot shape and modalities but also any kind of shapes and modalities. We created a robot kit that has separate body parts and allows for various shapes and modalities [16]. The kit includes three axis heads and two four-axis arms. Each head has three motors. Each arm has two motors on the root of the device to create movements in the pitch and yaw directions of the arm. It also has two motors on the tip to create movements in the pitch and roll directions of the hand.

These devices are attachable and detachable using Velcro. Each head and arm are wired and connected to a microcomputer, and can be separately turned on and off. The total axes of the kit are sufficient for reproducing normal human-like robots. If you want to turn off the modality of the head of the robot, just turn off the switch and the robot stops controlling its head. If you want a different shaped human-like robot shape, you can detach each part and attach it in a different position. In the experiment, we assigned each part like that shown in Fig. 4 and compared the communication strategies of the human-like robot by turning on and off the head of the robot.

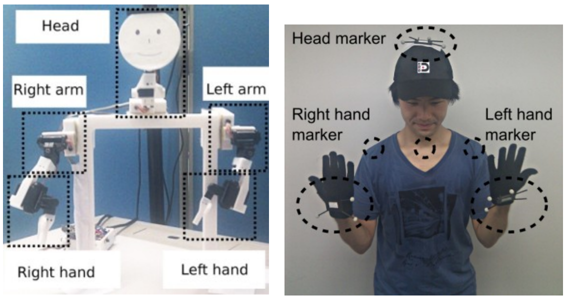

Fig. 4. Implemented reconfigurable agent and motion capture markers on participant.

3.2 Monitoring device using motion capture system

We need to monitor the behaviors of the manipulator and the feedback sent to the robot when a human is controlling it. We used a motion-capturing system to record the feedback from the human manipulator because it is then easier to understand how to move a robot. We used seven motion-capturing cameras in this system for tracing the human head and hands. Each human body part is captured and converted into the robot body movements described below:

- Head: The system extracts three angles (yaw, pitch, and roll) of the head and assigns them to the robot's head movement.
- Arm: The system calculates the robot's arm angles (yaw and pitch) by using a vector from the head position to the hand position.
- Hand: The system calculates the robot's hand angles (pitch and roll) based on the directions of the user's head.

Each marker is attached to the human body as shown in the photo shown on the right in Fig. 3. The head markers are attached to the top of the manipulator's head, and the hand markers are attached to the backs of the manipulator's hands.

3.3 System Connections

All the modules are connected like that shown in Fig. 5. The input data to the human manipulator is a video image and the output data from the human manipulator are the motion-capturing data and angles of each motor. The latency from the robot to the user is below 200 ms and this delay does not cause any critical communication problems. All the input (video) and output (motor angles) data are stored in the data server for later analysis.

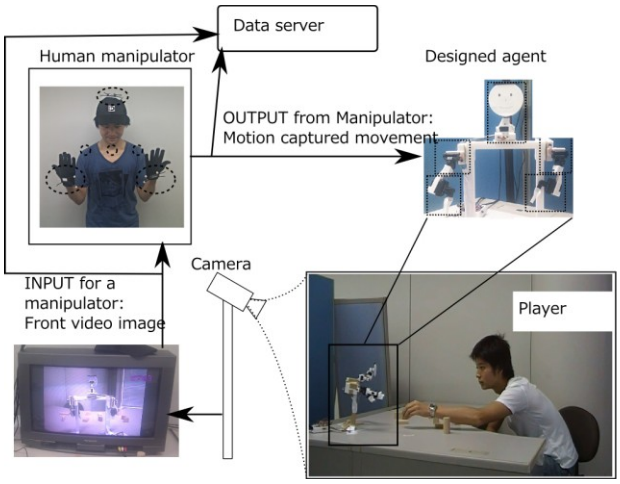

Fig. 5. System implementation

4 Experiment

We compared the manipulator-like and non-manipulator-like conditions. Under the non-manipulator-like condition, we fixed the head of the robot to decrease the modalities for confirmation. We also prohibited verbal communication during the interaction to emphasize the role of the head. As a demonstrative task, we also prepared a wooden blocks assembly process to evaluate our method.

4.1 Environment for the Experiment

The experimental setup is shown in the top half of Fig. 6. The manipulator and the player are in separate rooms. The robot is fixed to a desk and placed in front of the player. There are eight blocks on the desk between the player and the robot. The viewpoints of the camera and the robot are in the same direction. The manipulator can confirm the face and movement of the player (visual feedback condition). All the input and output data are recorded and stored in the data server for later analysis.

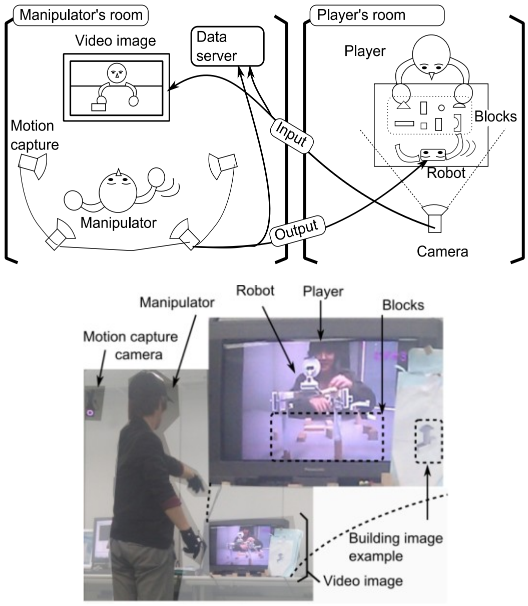

Fig. 6. Experimental setup (top) and experimental scene (bottom)

We show the manipulation scene in the bottom half of Fig. 6. The manipulator is standing on the left side of Fig. 6 at the bottom. Motion-capturing cameras surround him. The video screen is in front of the manipulator and the screen shows the robot, the blocks, and the player as shown in the top right part of the bottom part of Fig. 6. An image of the building is pasted on the right side of the screen, and the manipulator instructs the player how to assemble the blocks via the robot.

4.2 Participant and Experimental Flow

Thirty-six participants participated in the experiment. There were 34 males and 2 females and the participants were separated into six groups. Each group had six members. We assigned three groups (including one female) to the manipulator-like condition and the remaining three groups to the non-manipulator-like condition. The six participants in each group were separated into pairs. There was one manipulator and one participant in each pair. Each manipulator was equipped with motion capture tags and manipulated the agent.

The experiment was divided into a testing phase and a recording phase. Before the experiment, we instructed the participants as follows: "In this experiment, you need to create general communication strategies for the robot using the assembling task. Do not use any kind of code that is incomprehensible to other people." This instruction served the purpose of generalizing the designed communication strategies.

At first, each manipulator calibrated the robot parameters to the scale of his/her body. Then, the pairs started the testing phase. During this phase, each manipulator gave instructions for any kind of building she/he could imagine. The members in each pair made trial-and-error efforts and improved their communication strategies.

When all the pairs determined that they could no longer improve their manipulation time, the experiment moved to the recording phase. The manipulator instructed the player to build one of the three kinds of buildings shown in Fig. 7. All the examples in Fig. 7 consisted of five kinds of blocks. Each pair was required to assemble the building within 300 s. A total of fifteen interactions were made. The manipulator attempted two interactions and the participants with no manipulation experience attempted three interactions. All the interactions were randomly ordered and counterbalanced.

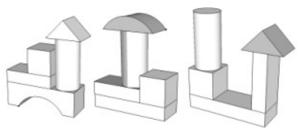

Fig. 7. Example buildings

When the recording finished, each participant answered a questionnaire that included the 7 scales of the Likert-scale for the accuracy and naturalness. We evaluated the results based on both the manipulation time and the evaluation of the participants.

4.3 Hypothesis

As previously predicted in Section 2, we hypothesized the results as follows. Under the manipulator-like condition, there is no difference in the accuracy and naturalness between both participants because the users in both groups already understand the behavior of an agent and can feel empathy towards it based on human behavior. On the other hand, the participants who experience the non-manipulator-like condition will feel more empathy towards an agent than those who did not experience the role of an agent. As a result, experienced participants feel that the interaction is more natural.

5 Results

36 participants joined our experiment. Two participants were female and 34 male. There is no significant difference in manipulation time between both groups and conditions. Under the manipulator-like condition, the average manipulation time of the participants who experienced the manipulator was 91.2 (SD = 28.8) and the average time of those who did not use the manipulator was 78.2 (SD = 27.1). Under the non-manipulator-like condition, the average manipulation time for the participants who used the manipulator was 113.2 (SD = 28.5) and that for those who did not was 110.6 (SD = 48.4).

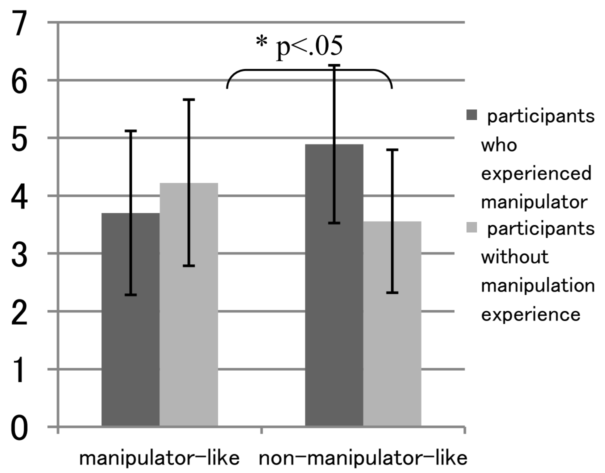

Fig. 8. Evaluation of accuracy of manipulation

Figure 8 shows the results of the evaluation of the accuracy in which the vertical axis represents the accuracy score based on the Likert scale). Under the manipulator-like condition, the average accuracy of the participants who used the manipulator was 3.7 (SD = 1.4) and that for those who did not was 4.2 (SD = 1.4). We found by conducting a t-test that there was no significant difference between these two groups. Under the non-manipulator-like condition, the average accuracy of the participants who used the manipulator was 4.8 (SD = 1.4) and those who did not was 3.5 (SD = 1.2). We found from the t-test results that there is a significant difference ($p = .04 < .05$).

Figure 9 shows the results of the evaluation of the accuracy, where the vertical axis represents the naturalness score based on the Likert scale). Under the manipulator-like condition, the average naturalness for the participants who used the manipulator was 2.7 (SD = 1.5) and that for those who did not was 2.7 (SD = 1.5). We found from the t-test results that there was no significant difference between these two groups. Under the non-manipulator-like condition, the average naturalness for the participants who used the manipulator was 3.2 (SD = 0.8) and that for those who did not was 2.1 (SD = 0.8). We found from the t-test results that there was a significant difference ($p = .01 < .05$).

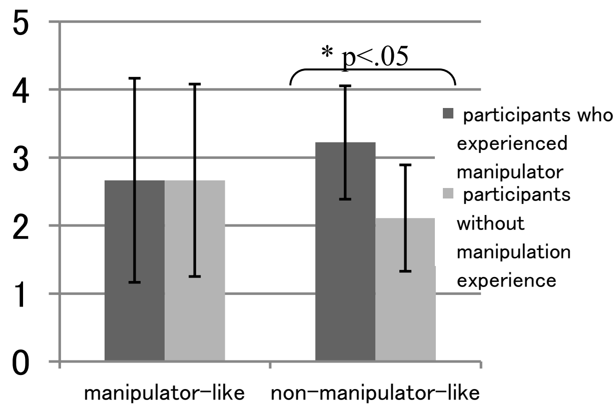

Fig. 9. Evaluation of naturalness of manipulation

6 Discussion

The experimental results concerning the naturalness supports our hypothesis that participants feel more empathy towards an agent after they experience using a manipulator. This suggests that immersive learning enhanced the ability of the participants to empathize. Under the non-manipulator-like condition, there was a significant difference in feeling concerning the accuracy, but there is no significant difference in the manipulation time. This suggests that the difference is not caused by actual manipulation failure, but by a difference in cognitive acceptance towards an agent.

Fujiwara et al. proposed disclose the internal state in HAI for improving the ability to empathize [18]. In our approach, the learner will share the abilities and learn the viewpoint of an agent. This approach shares more context and improves the user's ability more compared to the disclosure approach.

7 Conclusion

We proposed improving a user's empathy towards an agent for improving the human-agent interaction. We use an immersive learning method in which the user experiences the role of an agent by manipulating it in order to improve the user's ability to empathize. We compared our hypothesis by using a teaching task with two kinds of robot modalities and two types of participants, which were those who had experience manipulating agents and those who did not. The results showed that those who experienced manipulating a robot felt the robot's attitude more naturally, especially if the robot's modality was far from the manipulator. The results suggest that the user's empathy towards an agent improved when the user experienced an agent's modalities.

Acknowledgement

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