The Influence of a Robot's Embodiment on Trust: A Longitudinal Study

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ABSTRACT

Trust, taken from the human perspective, is an essential factor that determines the use of robots as companions or care robots, especially given the long-term character of the interaction. This study investigated the influence of a robot's embodiment on people's trust over a prolonged period of time. The participants engaged in a collaborative task either with a physical robot or a virtual agent in 10 sessions spread over a period of 6 weeks. While our results showed that the level of trust was not influenced by the type of embodiment, time here was an important factor showing a significant increase in user's trust. Our results raise new questions on the role of the embodiment in trust and contribute to the growing research in the area of trust in human-robot interaction.

Keywords

Human-Robot Interaction (HRI); trust; physical robot; virtual agent; embodiment; longitudinal study

1. INTRODUCTION

The level of intelligence exhibited by social robots and their actual level of intelligence may not always match. The discrepancy may provoke inappropriate user expectations of robot's intelligence and abilities. This has given rise to the growing research in social robotics from the user's perspective. Particularly important for the effective human-robot interaction is the user's trust in robots. Trust in robots directly affects the outcome of an interaction between a human and a robot and depends on several different factors, such as robot's appearance and proximity[2]. A disproportional

level of trust may have negative consequences, like misuse or disuse of the robot [3].

One possible factor to influence trust is the robot's embodiment, i.e., whether the robot has a physical body or is simulated (a virtual agent shown on a screen). Rae et al. [6] found that using a tele-presence robot to perform some task resulted in a significant increase in trust as compared with using a held-hand tablet. Similarly, participants tended to empathize with physical robots, but to a lesser degree (or sometimes even absent) with a virtual agent [7].

Another important factor that may influence trust is the amount of experience that users have interacting with the robots. It has been shown that time influences robots perception, the user's preferences of robots changed over time [4]. An example of a changing preference is the allowed approaching distance: the robot was allowed to approach closer after habituation.

This study investigates whether the robot's embodiment influences user's trust, and whether interactions with the robot or virtual agent over an extended period of time would change (increase or decrease) the initial level of trust. Following the study from Rae et al.[6], we hypothesise that users in our study would trust a physical robot more than a virtual agent, but believe that this difference would diminish over time with the increased exposure to the physical robot.

2. METHOD

In total 17 adults (including 9 females) participated in our study ($min = 21$, $max = 30$, $M = 25.5$). Each participant interacted ten times either with a physical robot ($N = 8$) or with a virtual agent ($N = 9$) over a period of six weeks. Figure 1 shows our experimental setup for the physical robot condition. The experimental setup for the virtual agent condition was the same, except that the virtual agent was shown on the black screen. The task involved completing a blank map. The robot asked the participant the names of the countries or their capital cities located on a topographical map. The robot was fully automated, to keep the interaction consistent for all participants during all interactions. When the participant would give an incorrect answer, the robot would not respond. Often the participant realized making a mis-

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take and would correct herself. If not, the robot would give the correct answer after some time. The error that could occur in the robot was an incorrect speech recognition followed by an incorrect response. The interaction was implemented such that even when an error occurred, no interruption from the experimenter was required. The interaction lasted for 5-10 minutes. A Trust Game [1] was played after the first and last session.

Figure 1: Setup of experiment with physical robot

3. RESULTS

A repeated measures ANOVA determined that trust differed statistically significantly over time ($F(1, 15) = 16.583$, $p < .005$, $\eta_p^2 = .525$). Figure 2 shows this difference as an increase in trust. No significant difference was found for embodiment ($F(1, 15) = .69$, $p = .796$, $\eta_p^2 = .005$), nor was there a significant interaction between embodiment and time ($F(1, 15) = .69$, $p = .796$, $\eta_p^2 = .005$).

Figure 2: Amount of money given to the robot. Participants 1-8 interacted with a physical robot, 9-17 with a virtual agent.

4. CONCLUSION

This study examined the effect of a robot's embodiment on user's trust, in combination with time. Contrary to other studies [6, 7] we have not found a significant influence of embodiment on trust. An explanation for the different outcome may be a different definition of embodiment [6] (telepresence robot/hand-held tablet versus physical robot/virtual agent). Our study used a humanoid robot NAO and a virtual agent NAO. Hence, the robot's appearance as well as the interaction patterns were similar in both conditions, only the

embodiment differed. Another important factor that may have contributed to differences in our results is that we used the trust game to measure user's trust instead of a questionnaire. We believe that the trust game represents a more objective measure of trust [5]. Another explanation for the different findings may be the focus on empathy [7] rather than trust. One may not feel empathy for a virtual agent knowing that it does not have feelings but trust that the virtual agent is capable of giving correct answers.

The results from the trust game additionally show that time is an important factor influencing trust. Our participants showed a significant increase of trust irrespective of the type of embodiment over the period of six weeks. This increase may occur due to habituation. Koay et al. [4] found that participants allowed robots to approach closer after habituation. These findings indicate that feelings of invasion or intimidation may decrease over time, resulting in an increase of trust. The amount of exposure to robots (time) should be taken into account when developing robots that will be used for a prolonged time. In the near future we intend to use a different robot and a different task that is not solely interactive to investigate trust.

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