Robot Sociality in Human-Robot Team Interactions

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Abstract. Robots are entering everyday life (e.g., TUG medical robots, Roomba vacuum cleaners) to help improve quality of life. Research shows that humans collaborate more effectively with social robots than with nonsocial robots, but does this mean that humans trust social robots more than nonsocial robots? In this study, we examined how robots' social appearance and behavior (mechanomorphic vs. anthropomorphic) affected how trustworthy participants felt the robots were. Participants played a game in teams of two humans and two robots against similarly-composed opposing teams. After the game, participants rated how much they trusted their robotic teammates. Overall, people trusted anthropomorphic robots slightly more. In general, people had intermediate levels of trust for robots and felt low levels of uneasy around them. Therefore, future designs of robots should be more anthropomorphic and social to increase trust ratings.

Keywords: Trust · Mechanomorphic · NAO · iRobot · Anthropomorphic · Security · Respect · Unease

1 Introduction

Humans and robots are becoming more interconnected and are interacting with each other more. Designing robots for humans to be comfortable with is vital for increasing willingness to interact with them. Previous studies have shown that people responded positively to a robot that displayed human-like behavioral characteristics, in contrast to a purely functional design [4].

In this study, we compared human trust of anthropomorphic (NAO) versus mechanomorphic (iRobot) designed robots during a collaborative game. This study examines differences in trust of the two types of robots. We expect that humans will be more trusting towards anthropomorphic robots.

2 Background

2.1 Anthropomorphic Robot (NAO)

From year to year, robots are becoming more anthropomorphic and human reactions with them become more similar to human interactions [1]. For example, when they are

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with another human, humans showed "desirable traits" with an anthropomorphic robots even though they knew the subject was a robot [1]. That is, humans show respect towards anthropomorphic robots, treating them as if they were another human.

Similarly, the more anthropomorphic robots are, the more humans trust them. Some robots are designed to mimic many human-like traits to the extent that they are nearly indistinguishable (visibly) from humans. These robots fall into the "uncanny valley" [7]. First described by Mori, "uncanny valley" elaborates the effect that high levels of robot's anthropomorphism that humans highly distrust them [7]. Humans typically find robots increasingly likeable and trustworthy as robot's humanness increases until they reach a breaking point, at which point, the robots uncannily similar/dissimilar to humans, and humans lose trust is lost. A balance must be found between mechanomorphic- and anthropomorphic-appearing robots to build trust. We decided to pick an anthropomorphic robot (NAO) that would obviously be identified as robot and would not cause the uncanny valley effect but is more anthropomorphic than a mechanomorphic iRobot (Fig. 1).

Fig. 1. NAO Robot (anthropomorphic) on the left and iRobot (mechanomorphic) on the right

3 Security/Respect/Unease

Security, Respect, and Unease are the three measures we use to measure trust. Research shows that humans feel higher trust ratings in technologies (e.g. websites and Social networking) when humans feel more secure [4]. In human-human relationships, respect strongly relates to trust [9]. Unease or anxiety indicates a lack of lack of trust [6]. Since these three feelings are heavily related to trust, we chose these three emotions as our measures.

We seek to examine trust during actual human-robot interaction. In our experiment, humans and robots collaborate to win a game in which the human participants must rely on and trust the robots. We study if people trust anthropomorphic or mechanomorphic robots more during actual interaction. We identified (above) several markers for trust, and analyze them below separately. We expect people to trust anthropomorphic robots more than mechanomorphic robots. Therefore, we expect higher ratings in respect and security and lower rating in unease for anthropomorphic compared to mechanomorphic robots.

4 Methods

We examined how humans' trust compares when working with mechanomorphic versus anthropomorphic robotic teammates. Our procedure was taken from previous research on human-robot teaming [5].

4.1 Procedure

1. Two groups of four agents were formed. In each group, two teammates were robots and two were human participants. Participants were randomly assigned to teams. Team members wore armbands that matched their team colors (red or blue).
2. Participants who objected to hearing noise blasts as loud as 105 dB were excused from the session. However, no participants objected to noise blasts.
3. One group of human participants at a time was taken to meet their robotic teammates (iRobot or NAO Robot). The iRobot's designated movements were made to be simple (e.g. beeping and turning) match its mechanomorphic shape. The NAO robot's movement was more complex with human speech (e.g. "Hello, how are you doing today?").
4. The researcher explained the rules of the game teams played against each other (see Game Description section).
5. All participants were directed to individual rooms to play the online game.
6. After participants completed the game, they took a survey on their emotions and other measures (see Measures section).

4.2 Game Description

Participants played a price-guessing game that was programmed using Eclipse. A computer screen displayed an item (e.g. couch, watch), and participants guessed the price of the item. They were told that teammates' answers were averaged for a final answer. This created teams in which the members were interdependent, and the player was required to trust his/her teammates. The team that came the closest to the correct price on a given round won that round, and one member of the winning team would be "randomly selected" to assign noise blasts to all eight players (including themselves) before the next round. The noise blasts choices were ranged from 80db to 120db in intervals of 5 db (e.g. 80, 85, 90, etc.). Each value of noise blast assigned was designated uniquely to that player: if a player gave one person a noise blast of 80, then the player couldn't assign another player a blast of 80 that turn. The experiment included twenty rounds of the guessing game. For each round, participants would be shown the average guess for each team, the actual price, which team won, and if they were the player who would select the volume of noise blasts for this round.

In reality, the game was rigged such that participants actually played on their own, with other players' responses simulated. Participants won approximately 50% of the time and were "randomly assigned" to give noise blasts four times during the main rounds and once in the final round.

4.3 Measures

Participants were asked to report their emotions (e.g., security, trust, respect) in a post-game survey. They rated emotions on a scale from 1 (strongly disagree) to 7 (strongly agree). The study included measures of other emotions [2], perceived sociality of the robots [3], and more, but these measures exceed the scope of this paper and will not be described further.

5 Results

Survey results were analyzed in JASP. *P*-values of less than .05 were considered significant differences.

5.1 Security

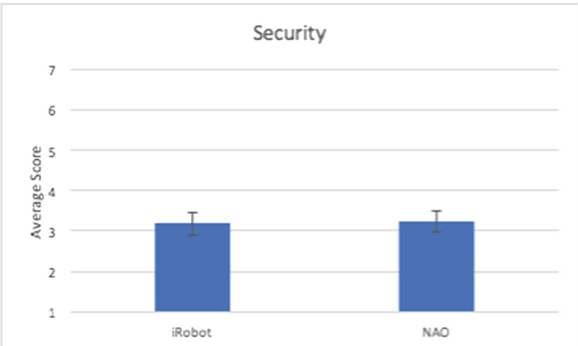

Fig. 2. Average ratings of security felt regarding both robots. Error bars denote standard error

Overall people did not feel very secure to be around the two robots with average response of around 3. There was no significant difference between the two robots (t$(106) = -0.179$, $p = 0.890$; Fig. 2).

5.2 Respect

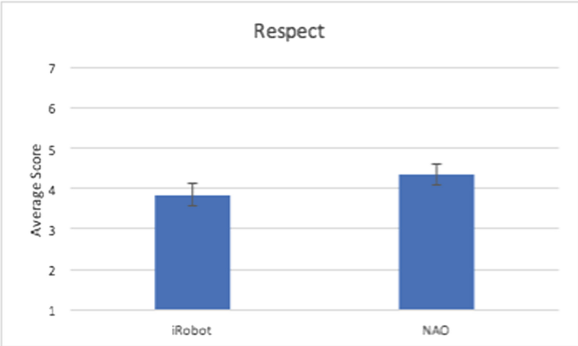

Fig. 3. Average ratings of respect felt regarding both robots. Error bars denote standard error

Most people felt moderate levels of respect towards the two robots. Again, There was no significant difference between the two robots (*t(106) = −1.253, p = 0.213*; Fig. 3).

5.3 Unease

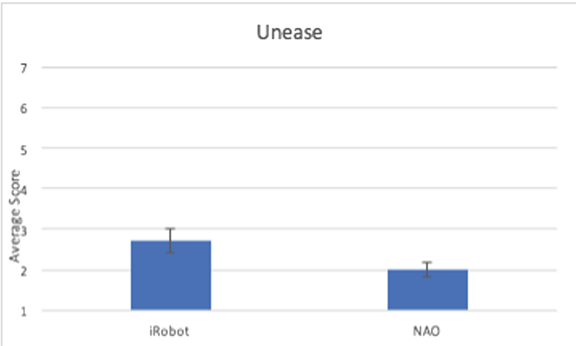

Fig. 4. Average ratings of Unease felt regarding both robots. Error bars denote standard error

There was a very low unease score for the robots. There was a statistically significant difference between conditions; participants indicated more unease around iRobots than NAO robots. *(t(106) = 2.112, p = .037;* Fig. 4*).*

6 Discussion

The main purpose of this study was to analyze how much humans trust robots when working together. In this study, we found partial support for our hypothesis that people would trust anthropomorphic robots more than mechanomorphic robots. We discuss this in more depth below.

- **Security and Respect**: The difference in security and respect ratings of the anthropomorphic and mechanomorphic robots was not significant. Ratings security were below neutral, indicating that participants did not feel very secure with the robots. The result could be caused by the limited time participants and robots had to interact with each other.
- **Unease**: Participants were significantly more uneasy of iRobots than Nao robots, supporting our hypothesis. It may be that mechanomorphic characteristics more strongly affect negative than positive emotions.

Overall, the results only partially support the hypothesis that people trust anthropomorphic more than mechanomorphic robots.

7 Limitations and Future Directions

All participants were students at NMSU, typically aged between 18–23 years old. The age range is significant because these age groups tend to be more familiar with technology than older age groups and may have less trouble adjusting to working with robots than older age groups [8].

Even though our results indicate that there is little to no difference between mechanomorphic and anthropomorphic robots, further research could be conducted on the subject. Different anthropomorphic and mechanomorphic robots might be used to see if the same results appear in comparing different robots. For example, if the two robots were human-size, how would that affect trust? Would humans be more trusting to human-size robots because they are more anthropomorphic because of their size? The opposite effect may occur, were humans are less trusting because the robots have reached “uncanny valley” territory.

Because mechanomorphic and anthropomorphic received relatively similar trust ratings, future studies could revise our experiment to more specific settings. For example, would anthropomorphic or mechanomorphic robots be more trustworthy when working with medical staff in hospitals? Also, multiple other human emotions can be measured to find the degree of trust humans feel (e.g. fear, dismay, happiness, etc.). Since the only significant difference found was in unease (a negative emotion), a further experiment, studying only negative emotions, could lead to more significant differences between anthropomorphic and mechanomorphic robots.

8 Conclusion

In this study, we examined participants in a competitive group setting in which humans had to rely upon robots for success. We then analyzed how much participants trusted the mechanomorphic robot (iRobot) and the anthropomorphic robot (NAO). The two positive measures (respect and security) yielded no statistical difference between anthropomorphic and mechanomorphic robots, but were rated relatively low for the robots overall. The unease factor showed, however, that humans felt more uneasy around mechanomorphic than anthropomorphic robots. This provides partial support to the idea that, humans trusted anthropomorphic robots slightly more than mechanomorphic robots. Overall, humans responded somewhat positively towards robots that exhibited anthropomorphic behavior.

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