

PILOT STUDY FOR EXAMINING HUMAN-ROBOT TRUST IN HEALTHCARE INTERVENTIONS INVOLVING SENSITIVE PERSONAL INFORMATION

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ABSTRACT

Socially interactive humanoid robots have been widely used in physical therapy and rehabilitation for children with motor disabilities. Previous studies have shown that embedding human-like behavior on a robotic playmate improves the efficacy of the physical therapy through corrective feedback. Understanding of trust in such scenarios is especially important since the behavior of the robot impacts the outcomes of the interaction through changes of trust, thus affecting rehabilitation performance. The objective of this pilot study was to examine aspects of trust between humans and socially interactive humanoid robots when robots provide incorrect personal information about them. A between-subject experiment was conducted with eight participants. Each participant was randomly assigned to one of the following conditions: 1) Reliable robot or 2) Faulty robot. Survey responses about trust were collected after interacting with the robot. Results indicate a trend showing that humans will trust a socially interactive robot with their personal information, even if the robot makes a mistake. These results can provide insights into the development of a robotic therapy coach but also motivates future studies to examine elements of human-robot trust in different healthcare scenarios.

INTRODUCTION

Cerebral palsy (CP) is the most common cause of motor disability in children (Accardo, 2008). Approximately 1.5 to 4 per 1000 new infants are born with CP worldwide (Arneson et al., 2009; Bhasin et al., 2006), and about 1 in 323 children in the United States are diagnosed with CP (Christensen et al., 2014). Children with CP have limitations in motor functions, causing difficulties in walking, reaching, and object

manipulation. Interventions used to improve motor functions in children with CP focus on repetitive therapeutic exercises, where a physical therapist provides corrective feedback on the child's performance through verbal or non-verbal commands.

Using socially interactive humanoid robots to motivate children with CP during intervention has been proven to be beneficial in many ways. Previous studies have shown that embedding human-like behavior on a robotic playmate improves the efficacy of the physical therapy through corrective feedback (García-Vergara et al., 2016). Humanoid robots can also be utilized as a social partner to improve patient engagement and experience (Huber et al., 2015), and as a personal coach to encourage motivation (Brown & Howard, 2014; Looije et al., 2008).

During therapy interventions involving humans and robots, trust is an important factor to consider as changes of trust may significantly affect the outcomes of the interaction, consequently affecting rehabilitation outcomes. We define trust as "a belief, held by the trustor, that the trustee will act in a manner that mitigates the trustor's risk in a situation in which the trustor has put its outcomes at risk" (Robinette, Howard, & Wagner, 2017). Researchers have studied factors related to trust in human-robot interactions in different scenarios (Carlson et al., 2014; Robinette et al., 2016; Salem et al., 2015) but few have investigated its relevance in the healthcare domain. Most typical healthcare scenarios involve collecting sensitive personal information from patients. Humans usually become more sensitive when disclosing personal information, which therefore results in a change of trust. In such scenarios, the trustor, in this case, has a belief that the individual to whom they are disclosing information will not divulge that information to others and thus cause harm. We

therefore hypothesize that scenarios where robots, who are privy to personal information, disclose an incorrect assessment about that information to the person, will impact trust (Hancock et al., 2011). As such, in this paper we examine this hypothesis through a study that provides a first step in examining this aspect of trust between humans and robots in a scenario involving the disclosure of personal information.

METHODOLOGY

We seek to examine the impact on human trust in robotic scenarios involving the disclosure of personal information, a routine practice found in healthcare-related scenarios. For this study, we compare the change in trust of participants assigned to one of two conditions: 1) a reliable robot or 2) a faulty robot. In this study, a reliable robot provided a valid disclosure about an individual's personal information whereas a faulty robot did not. Eight students (6 male, 2 female; between the ages of 20-25; mean age = 22.75) were recruited for this study. All participants signed approved IRB consent forms.

Personal Information

Given the wide range of personal information typically collected in healthcare-related scenarios, for this study, we selected age as the variable to use for our personal information data point. We utilized a deep learning algorithm developed based on the Microsoft Face API ("Microsoft Cognitive Services - Face API", 2017) to calculate age based on an individual's facial image. Two versions of the algorithm were utilized. One version computed age randomly whereas the other version used the API to compute age within a small standard deviation of the person's correct age.

Socially Interactive Robot Platform

Participants were asked to interact with the humanoid NAO robot (Figure 1). Socially interactive behaviors encoded on the robot included conversations and dance movements. The robot guessed the age of the participant after the interactions using one of the two versions of the deep learning age recognition algorithm. A reliable robot used the version in which the age was computed correctly, whereas the faulty robot used the one that computed age

randomly. Figure 1 shows the Nao robot and the experimental setup.

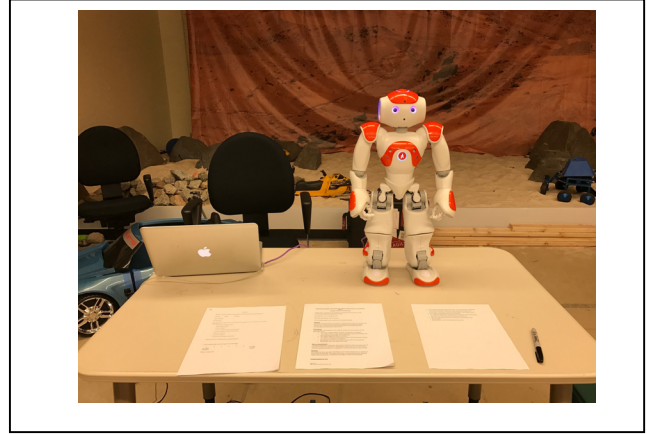


Figure 1: Nao robot and experimental setup

Procedure

After obtaining informed consent, we requested participants to fill out a pre-survey. The pre-survey questions include demographics information, attitude towards robots, and current feelings on a 7-point Likert scale. The experiment started with Nao introducing himself to the participants. Then, Nao asked participants to dance with him in order to build rapport. After two to three dance movements, Nao praised the participant's performance and provided an estimate of the participant's age. Next, Nao asked for the participant's feedback on the age disclosure. If the participant disagreed, Nao further asked the participant for their actual age. Table 1 lists the sequence of behaviors used in this study.

Table 1: Robot behaviors and corresponding verbal commands

Robot behaviors	Verbal commands
Nao introduces himself	Hello, my name is Nao. What's your name?
Nao asks participant to dance	Nice to meet you. I like to dance. Will you dance with me, please!
Nao guesses age of the participant	Wow, you did a great job. You move like you are xx(age)!
Nao asks for feedback on his guessing	Was I close in getting your age correct?
Nao asks for actual age of the participant	Can you tell me your age?

Upon finishing the experiment, the participants were asked to fill out a post-survey. The post-survey questions include attitude towards robots and general feelings about the interaction. In addition, as shown in Table 2, three specific questions with respect to trust were asked at the end of the survey.

Table 2: Survey questions with respect to trust

Question	Answer type
Q1. Did the robot do a good job guessing your age?	Yes or No
Q2. I trusted the robot when the robot provided correct/incorrect personal information about myself.	Agree or Disagree Why or Why not
Q3. Next time I interact with the robot, I am willing to give my personal information if the robot asks.	Agree or Disagree Why or Why not

RESULTS

Four participants were assigned to the reliable robot condition whereas four were assigned to the faulty robot condition. In each group there were three males and one female. Figure 2 shows the pre and post-survey results associated with participant attitudes towards robots.

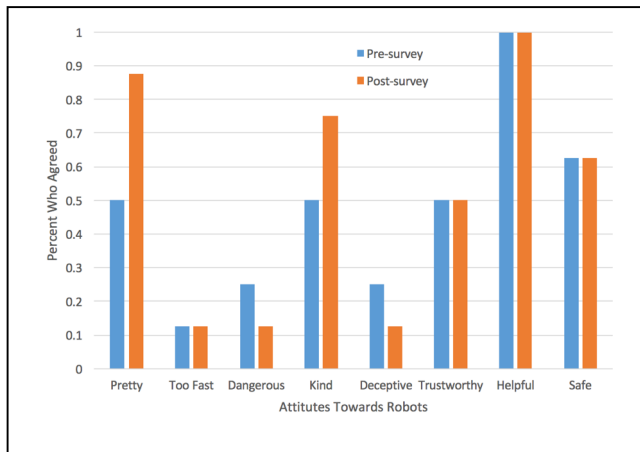


Figure 2. Change in participant responses to questions about their current attitudes before (blue) and after the interaction (red)

As shown in Table 3, subjects in both groups thought the robot provided incorrect personal

information, even for estimates that were within one standard deviation of error. As shown in Table 4, all participants in the reliable robot condition state that trust was not involved in their decision to give out personal information whereas there were mixed responses in the faulty robot condition. As for whether participants were willing to give their personal information if the agent asked next time, the majority of participants agreed.

Table 3: Results - Perception on Correctness (Average, Standard Deviation)

Condition	Guessed Age	Correct Age	% Agreed Correct
Reliable Robot	28.8, 3.5	22.3, 2.1	0
Faulty Robot	42.5, 4.8	23.3, 2.1	0

Table 4: Results - Perception on Trust

Condition	% Trusted Robot	% Willing to Disclose
Reliable Robot	N/A, Not involved	100%
Faulty Robot	50%	50%

DISCUSSION AND NEXT STEPS

This study shows a trend in the willing of individuals to provide their personal information, even to a faulty robot. This might perhaps be due to the fact that individuals felt that the disclosure of personal information to a socially interactive agent did not require trust. Additionally, the ones who interacted with the robot seem not to have much negative emotions towards the robot even if it guessed a wrong age (Figure 2). This suggests that human have a higher tolerance for mistakes made by a socially interactive agent. We also found that the participants had extremely low tolerance on the error of age guessing as all of them indicated the robot guessed their ages wrong, even in the cases where the error was within 3 or 4 years.

Even though this study shows a trend towards human trust of robots, this study has a number of limitations. First, the conclusion may not be generalizable as the sample size is relatively small. Second, the experiment could

be biased as the majority of the participants had previous experiences with robots. Further experiments with larger and more diverse participants are needed in order to conclude any significant results or statistical conclusions. Additional next steps will be to conduct a study that engages our specific target population of children with motor disabilities and their caregivers.

The market for healthcare robots is growing rapidly. Trust is a crucial factor to consider in developing rehabilitation and healthcare robots. A trustworthy robot not only encourages engagement but also helps build patient's confidence in their physical therapy and rehabilitation. Developing a robotic therapy coach who can gain trust from its patients could significantly improve the overall rehabilitation outcomes.

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