Both "Look and Feel" Matter: Essential Factors for Robotic Companionship

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Abstract

Physical embodiment of robots provides users with a social environment. To design social robots further to be accepted as our companions, we need to understand the essential factors and implement them and so, users get to bring them to their personal environments. To this aim, we focused on two important factors in robotic companionship: robot appearance (look) and emotional expression (feel). Twenty-one participants played an online game with the help from two humanoid robots, Nao (more human-like looking) and Darwin (less human-like looking). Participants interacted with each robot either with emotional words or without emotional words. Results show that *only* when the robot both looks more human-like and speaks with emotional expression, participants perceive it as their companion. Implications are discussed with future works.

Author Keywords

Human-robot interaction; robotics companionship; emotion; robot appearance.

ACM Classification Keywords

I.2.9. [Robotics]: Commercial robots and applications;

Introduction

Robots have a huge potential to assist humans in many capacities, including acting as companions for modern isolated people. Much research on robotic companions has been done on building robots that are capable of fulfilling a range of assistive functions (e.g. [1]). With physical embodiment being as a core component, robotic companions are increasingly being designed so that people can interact with them in a more natural way. Design considerations include anthropomorphism [2], social responses [3] such as emotions [4, 5], personality [3], physical appearance [6], and adaptation to the individual needs and preferences [7].

Companionship refers to a positive feature in a friendship concept [8]. Hoffman, Bauman, and Vanunu defined robotic experience companionship as “the sense and outcomes of sharing an experience with a Robot” [9]. Therefore, to be accepted as a companion, the robot should show some of characteristics above that people want from their friends. Currently, social robots are designed to be more human-like because a humanoid appearance evokes human social interaction rules. Hinds et al. [10] investigated the effects of robots’ appearance and relative status on human–robot collaboration and responsibility sharing. They found that people share responsibilities more with humanoid robots than with machine-like robots for the perceived common ground and shared identity. In other words, the robot’s cognitive capabilities need to match its physical appearance [6]. Other than appearance, emotions also strongly influence users’ perception of robots. A study [11] suggested that a companion robot requires some level of emotional expression for a good interaction with children. Another study showed that people accept and believe the robots more if the robot has some emotional activities [12]. In a study by [13], the integration of dynamic emotional expression and movements made the humanoid robot more attractive, more favorable, more useful, and less mechanical-like. These results show that robot appearance and emotional expression are important variables on robot acceptance. However, the interaction and integration of these variables need to be more investigated (e.g., “Are human-like looking robots always acceptable?”, “Is emotional expression a sufficient condition for robotic companions?”).

In the current study, we investigated how both appearance (two different humanoid robots) and emotional expression of robots (robots with emotional expression and robots without emotional expression) might influence people’s acceptance on their robotic companionship. To create a companionship scenario, we designed the experiment where participants played an online game with the robot. In this interaction, the robot and the participant cooperated with each other to get as high a score as they can in the limited time. Two different humanoid robots, Nao and Darwin, were used to evoke social interaction rules [10]. Nao is more human-like with higher degrees of freedom [14, 15]. Darwin has more mechanical look, with visible mechanical joints, boxier limbs, and torso. Finally, in this study we tried to address these research questions: Does a robot’s appearance influence on participants’ attitudes towards the robot as a companion? Does emotional expression/affective communication influence attitudes towards the robot as a companion? What are the predictors for trust and experience of enjoyment in robotic companionship?

Participants

Twenty-one students (Male = 13, Female = 8) age 20 to 39 years old (*M* = 25.82, *SD* = 5.21) from Michigan Technological University were recruited through the

Figure 1: Nao

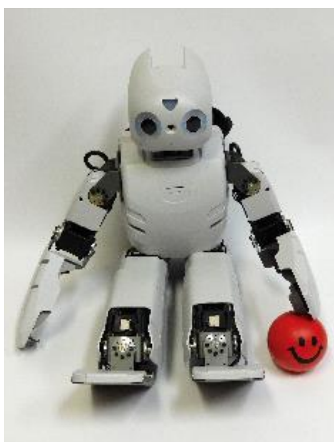

Figure 2: Darwin

online recruiting system (SONA). They participated in the experiment for partial course credits.

Apparatus

Nao: Nao (Figure 1) is a humanoid robot created by Aldebaran Robotics (now SoftBank Robotics). Nao features 25 degrees of freedom, voice recognition, facial recognition and tracking, text-to-speech, multiple cameras and microphones, and a variety of touch sensors.

Darwin: Robotis OP 2 (Figure 2), also known as Darwin with 20 degrees of freedom, it is capable of a wide range of movements and verbal responses to stimuli.

Development

Nao and Darwin were programmed to allow commands to be given over SSH (secure shell), so we could remotely control when the commands were given. Nao's program was written in Python, utilizing it's built in text-to-speech program to give suggestions and responses. The script was run based on whether the participant was to be exposed to human-like phrasing with emotional words, or robotic suggestions without emotions. Based on an entered number, Nao would iterate through the respective list of phrases, suggesting that piece to the participant. A response option was entered so that Nao would also iterate through a static list of responses to respond to the participant's choice.

The program for Darwin was written in C++ as an extension of the base script that allows Darwin to switch between "modes". Modes were switched by pressing a physical switch on the back of Darwin's chassis. The implementation of Darwin's script was identical to Nao's. However, Darwin does not possess a built in text-to-speech library, so the script instead played back recordings of Nao speaking for the human and robotic conditions.

Script

The robots spoke in two ways: providing suggestions and feedback. The words spoken by the robots were in two distinct styles: (1) a human-like phrasing - using common phrases, emotional, and inclusive language (e.g. let's play the second piece (for suggestion), Well, there was a better place that you could choose (for feedback)) and (2) a robot-like phrasing - using emotionless, short, and bland language (e.g. the third one (for suggestion), unsuccessful (for feedback)). The feedback was neutral, mildly positive, and mildly negative. All phrases and words were written and selected by the experimenters. The script was designed to represent equal content among human-like and robotic-like phrasing. In addition, the number of neutral, positive, and negative feedback was also balanced.

Game

Hex FRVR (http://hex.frvr.com/) (Figure 3), a web-browser based game, was used where players drag different shapes onto a hexagonal game grid with the goal of getting the highest score possible. Each shape earns the player points when it is placed onto the board, with extra points earned if the player creates a line connecting at least two sides of the game board. The game continues until it reaches a state where there are no more valid moves. We selected this game for different reasons. First, it is possible to make a cooperative scenario with this game where the robot and the participant play as a team. Second, it is a similar activity or game to many online games or apps that a lot of people spend time playing with. Finally, it is simple enough that participants can learn it in a short period of time.

Figure 3: Hex FRVR

Figure 4: Participant is playing the game with Darwin.

Questionnaires

Unified Theory of Acceptance and Use of Technology (UTAUT): This questionnaire was developed based on the Technology Acceptance Model (TAM) [16]. TAM states that Perceived Usefulness and Perceived Ease of Use determine the behavioral intention of using a system, which consequently predicts the actual use of that system (mostly explains utilitarian systems). In hedonic systems, other factors such as enjoyment (as an influential factor on ease of use and usefulness) are deterministic as well [17]. We used the modified version of UTAUT which was used just for robots [18].

Experimenter-Developed Questionnaire: After playing with each robot, participants were asked to answer to the questions that we developed related to the robot's companionship, game, and robots' gender.

Procedure

We randomly assigned our participants into two groups where we counterbalanced the order of the robots. Once the participant signed an informed consent, a researcher would bring the participant into a room with the Nao or Darwin robot and a computer running the online game Hex FRVR (Figure 4). The participant was given a short overview of the game, utilizing the game's built-in tutorial to familiarize themselves with how the game is played for 30 seconds. Participants were informed that the robot would give them verbal suggestions on which piece they should place on the game board next, and that they were also free to ignore the robot's suggestions and play any piece they wanted. Once the researcher left the room, the robot gave a verbal greeting to the participant and they played the game with the robot giving suggestions and feedback for three minutes.

This is a Wizard of Oz study where each robot was remotely controlled by an experimenter with a computer in the room that was separated by a one-way mirror (Figure 5). The experimenter used a computer to make the robots give suggestions for piece selections using a variety of phrases for the emotion and unemotional conditions. Once the participant placed a piece, the robot gave verbal feedback on the participant's selection. This feedback differed between emotional and unemotional conditions. For each phrase in the emotional/unemotional conditions for Nao and Darwin, we recorded if the participant accepted or rejected the robot's suggestion. After the three minutes, the participant was taken to another room where they completed the questionnaires on their thoughts about the robot (experimenter-developed questionnaire, and UTAUT). While this occurred, the robots were swapped. Next, the participant repeated the same task with the other robot using different emotional expressions. For example, if the participant started with the Nao robot using the emotional condition, their second session was with Darwin using the unemotional condition. Upon completion of the second three-minute game, the participant completed the same questionnaires about the newer robot as well as some demographic and robot comparison questions.

Results

We used mixed design and analyzed the results with planned comparisons. Once participants experienced two different robots with different emotion conditions (e.g., Nao with emotional expression vs. Darwin without emotional expression). Thus, this comparison was done by paired samples t-tests. The other comparisons (e.g., Nao with emotions vs. Nao without emotions and Nao with emotions vs. Darwin with emotions) was done by independent samples-tests.

Figure 5: The experimenters are controlling the robot and observing the participants behavior.

Behavioral observation: The behavioral observation was focused on the number of rejection and acceptance of the robot's suggestions. Results show that the percentage of rejecting Darwin's suggestion without emotional expression (M = 34.72, SD = 22.32) is significantly higher than Nao's suggestion with emotional expression (M = 17, SD = 10.8), $t(9) = -.16$, $p < .05$. Results show that the percentage of rejecting Darwin's suggestion with emotional expression (M = 33.8, SD = 13.5) is not significantly different from Nao's suggestion without emotional expression (M = 34.5, SD = 16.22), $t(10) = 2.28$, $p > .05$. Another comparison between Darwin and Nao with emotional expression shows that the participants rejected Darwin's suggestion (M = 33.8, SD = 13.5) more than Nao (M = 17, SD = 10.8), $t(19) = -3.16$, $p < .01$, but no difference was found between Darwin and Nao when they had no emotional expression.

Perceived enjoyment: Results show that perceived enjoyment in Nao with emotional expression (M = 16.18, SD = 3.09) is significantly higher than Darwin without emotional expression (M = 13.45, SD = 2.76), $t(10) = 3.01$, $p < .05$. We did not find the same result between Darwin with emotional expression (M = 14.3, SD = 3.19) and Nao without emotional expression (M = 14.2, SD = 3.01), $t(9) = .1$, $p > .05$.

Perceived sociability: Results show that the perceived ability of the system to perform sociable behavior in Nao with emotional expression (M = 11.72, SD = 3.37) is significantly higher than Darwin without emotional expression (M = 8.9, SD = 2.8), $t(10) = 3.31$, $p < .01$. The same pattern was not found between Darwin with emotional expression (M = 9.2, SD = 2.69) and Nao without emotional expression (M = 9, SD = 2.7), $t(9) = .28$, $p > .05$.

Social influence: This item measures how using the system impact other people's thought about the user (e.g. one of the items is "I think it would give a good impression if I should use the robot."). Results show that social influence in Nao with emotional expression (M = 18.63, SD = 3.69) is significantly higher than Darwin without emotional expression (M = 5.45, SD = 1.43), $t(10) = 12.05$, $p < .001$. However, social influence in Darwin with emotional expression (M = 5.6, SD = 1.57) is not significantly different from Nao without emotional expression (M = 5.5, SD = 2.01), $t(9) = .23$, $p > .05$.

Social presence: Results show that the experience of sensing a social entity when interacting with Nao with emotional expression (M = 13, SD= 3) is significantly higher than Darwin without emotional expression (M = 8.36, SD = 2.01), $t(10) = 5.35$, $p < .001$. The same pattern was found for the other group. Also, social presence in Darwin with emotional expression (M = 8.4, SD= 2.06) is significantly higher than Nao without emotional expression (M = 9.6, SD = 2.95), $t(9) = -3.08$, $p < .05$. People also scored Nao with emotional expression significantly higher in this item (M = 13, SD = 3) than Nao without emotional expression (M = 9, SD = 2.95), $t(19) = 2.61$, $p < .05$. In addition, Results show that people scored Nao with emotional expression significantly higher in this item (M = 13, SD = 3) than Darwin with emotional expression (M = 8.4, SD = 2.06), $t(19) = 4.05$, $p < .01$.

Trust: This subscale shows how much the system performs with personal integrity and reliability [18]. Results show that trust in Nao with emotional expression (M = 5.63, SD = 2.01) is significantly higher than Darwin without emotional expression (M = 4.64, SD = 1.85), $t(10) = 2.47$, $p < .05$. However, trust in

Darwin with emotional expression (M = 5.6, SD = 1.77) is not significantly different from Nao without emotional expression (M = 4.4, SD = 1.77), $t(9) = 2.16$, $p > .05$.

Questions related to the robot's companionship: Results show that participants reported that Nao with emotional expression is significantly more helpful (M = 3.18, SD = .87) than Darwin without emotional expression (M = 2.18, SD = 1.25), $t(10) = 2.47$, $p < .05$. Moreover, participants reported that Nao with emotional expression has significantly more emotional knowledge (M = 2, SD = 1.41) than Darwin without emotional expression (M = .81, SD = .98), $t(10) = 3.13$, $p < .05$.

Robot's gender: Most of the participants attributed female gender to the emotional robots regardless of their appearance. Nao was considered female regardless of its verbal expression. Regarding unemotional Darwin, most of the participants could not attribute any gender to it.

Robot preference as a companion: Around 47% of the participants chose Nao with emotional expression and 28% mentioned Darwin with emotional expression. In other words, more than 75% of the participants selected robots that express emotions and uses human-like phrasing more in their interactions.

Discussion

Although there have been many studies on designing social robots in the domain of assistive technology and work environment, little is known about when and why people will accept social robots as their companions. In this research, we focused on the effects of emotional expression of two humanoid robots with two levels of human-like appearance on users' preference, attitude, and behavior in a companionship scenario. Results showed that participants accepted Nao's suggestions more, especially when it shows human-like phrasing with emotional words. Participants' answers in the trust subscale of UTAUT show the same pattern. This is consistent with the literature [19] that people perceived agents as being more positive when they display emotions [9]. Feelings of joy or pleasure were most associated with the Nao robot with emotional expression. Interestingly, participants perceived higher sociable behavior in Nao with emotional expression but not in Darwin with emotional expression. If we refer to the items that define this subscale (e.g. "I feel the robot understands me", etc.), we can conclude that Darwin's appearance mediated participants scores on perceiving it as a sociable system. Participants believed that Nao gives a good impression if they use the robot. Moreover, the experience of perceiving a social entity when interacting with robots with emotional expression highlights the importance of verbal expression and phrasing in social interactions. In terms of companionship, most of the participants selected robots that could express emotions as their companions and mostly Nao which is more humanoid, cute, and less mechanical. In sum, either appearance or emotional expression may not be a sufficient condition to form robotic companionship. Both components seem to be necessary. In our future research, we plan to focus on some of the limitations of this study such as small sample size and limited interactions scenario. Moreover, we will consider other means of emotion expression such as gesture and voice. Since companionship is a specific type of social communication like friendship, we will consider the interaction of all these variables with personality characteristics.

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