

Machine or friend: understanding users' preferences for and expectations of a humanoid robot companion

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Abstract

As humanoid robots become increasingly lifelike, the boundaries are blurring between their roles as functional products and socially aware companions. Humanoid robots, or androids, have been developed and marketed along three general lines: entertainment robots (such as toys), service robots (task-oriented, such as security guards or receptionists) and companion robots (used in prolonged social interactions, such as teachers or home attendants). Little is known, however, about users' expectations and preferences for highly interactive humanoid companions. What design characteristics would encourage or reduce human attachment to a humanoid robot? How do users differentiate service humanoid robots from other androids designed for companionship? Do humanoid products present unique issues for person-product attachment? This paper presents the results of a pilot research project investigating how potential robot users differentiate between "companion" and "service" robot preferences and expectations.

Keywords

Android, appearance, companion robot, design, emotion, function, human-robot interaction, robot, service robot, usability.

Introduction

Androids are humanoid robots with varying degrees of anthropomorphic appearance and autonomy. Roboticists develop androids with many end-goals in mind, ranging from performing rote physical tasks to complex human-robot social engagement. Currently, there are a number of developers around the globe are working on sophisticated androids with capabilities ranging from performing simple household tasks to providing companionship and nurturing through physical touch and conversation.

People tend to react to humanoid robots with a mixture of emotions which can include pleasure, curiosity and aversion (Mori, 1970; McDorman, 2005). These reactions depend on a number of factors, including the type of interaction, the robot's appearance, the situated context of the interaction, and the user's previous experience with, or expectations of, robots. Given the variability of emotional reactions to humanoid robots, how then do developers create an android product that appeals to a broad-based market? The goal of this pilot study was to discover user's primary subjective responses to robots designed for home use. The guiding research questions were:

- What are the user's preferences, expectations and the perceived purpose of androids?
- How do users differentiate service humanoid robots from other androids designed for companionship?
- What design characteristics would encourage or reduce human attachment to a humanoid robot?

This paper reports the results of a qualitative study of user expectations and preferences in regard to humanoid service and companion robots. Participants viewed a series of short videos of currently existing humanoid robots and described whether the designs were appropriate for either an in-home service robot or as an in-home robot companion. Using a semi-structured interview protocol coupled with surveys, participants were asked to comment on a number of design characteristics, including interaction style, human versus machine-likeness and the level of pleasure, value and practicality of home use. Field notes from these interviews were analyzed for emergent themes, which will be framed as design principles for both robot design and for the larger sphere of humanoid product design.

The following section highlights some of the theoretical underpinnings of human-robot interaction, especially pertaining to the human side of these interactions. Then the study procedures are described in greater detail. Finally, the findings are described and their implications discussed.

Background

The market for robots used in the home has increased substantially over the last several years, and this number is predicted to continue to rise. A recent United Nations (UN) robotics survey (2004) claims that the numbers of robots, humanoid or otherwise, purchased for household use was over 600,000 by the end of 2003, a number that is anticipated to grow by more than 4 million units by 2007. The same survey states that service robots “will be everyday tools for mankind... They will not only clean our floors, mow our lawns and guard our homes but they will also assist old and handicapped people with sophisticated interactive equipment, carry out surgery, inspect pipes and sites that are hazardous to people, fight fire and bombs and be used in many other applications.”

Service vs. companion robots

Service robots are rooted in task performance, but have more sophisticated interactive capabilities and are designed for use in domestic, business, and public settings. Severinson-Eklundh, Green and Hüttenrauch (2003) describe a service robot as one which will “move around in an environment, inhabited by a group of people, and perform physical tasks, such as to fetch and deliver objects. It may also keep track of various kinds of information for the users. The robot is partly autonomous, and it carries out its missions in the immediate, shared environment, interleaved with rather frequent user interactions.” A robot like the popular vacuum-cleaner Roomba® is an example of a non-humanoid service robot, performing a specific household task.

A companion robot has been defined by Dautenhahn et al. (2005) as a sub-specialty of service robots, one that is imbued with natural social interaction capabilities and is “expected to communicate with non-experts in a natural and intuitive way.” Fong (2003) further describes socially assistive robots as having a number of characteristics that we normally

ascribe to human beings, including embodiment, emotion, dialog, personality, human-oriented perception, user modeling, socially situated learning, and intentionality.

The distinction between service and companion robots is important for two reasons. First, the differing terms denote a fundamental design emphasis. The service robot is designed primarily around physical task completion, with enough interaction ability to successfully perform tasks in tandem with human conversational direction. The companion or socially assistive robot has far more advanced interaction capabilities, with some tasks being purely conversational rather than physical in nature. Secondly, this foregrounding of different capabilities may also affect user expectations and the ways that users assess satisfaction. For example, users may apply differing expectations when an android attempts complex conversational interaction as opposed to verbally affirming that it will carry out a command. A fundamental goal of this study was to explore the possibility that users would have such differing sets of expectations.

Human-android attachment

Any examination of human-android interaction must include a discussion of human attachment tendencies. Weiss (1982) suggests that human-human attachment in childhood consists of children attaching to adults for protection, survival, and companionship. Weiss contrasts this with attachment in adult life where attachment can be seen as a mechanism for "fostering the attached individual's own capacity for mastering challenge." Crowell and Treboux (1995) define adult attachment relationships as "those which provide feelings of security and place and which ameliorate loneliness and restlessness, as opposed to relationships which solely provide guidance or companionship, opportunities to feel needed or to share common interests or experiences, feelings of competence, alliance and assistance."

Human-product attachment, like human-human attachment, involves an emotional bond. Battarbee and Mattelmaki (2002) describe three categories of human-product attachment which closely parallel the themes pertaining to human-human attachment. The first category is "Meaningful Tool," in which human-product attachment occurs because the object serves as a symbol for a highly valued capability. The second category is "Meaningful Association," in which human-product attachment rests within an object's association with a prized cultural

meaning or value. These two categories can serve to provide those feelings of security and place so important to adult human attachment.

The third category in Battarbee and Mattelmaki's model reveals the complexities involved in human-android attachment. This category suggests that people can treat products as "Living Objects," in which the product "is a companion that has been with a person for so long that it is perceived as having personality, soul, character, is loved and cared for." While Battarbee and Mattelmaki emphasize that the ascription of human personality characteristics to products is related to long-term use, the anthropomorphic nature of androids may itself trigger this type of meaningful human-product attachment. For humanoid robots, the potential for these "living" associations is purposefully designed using facial characteristics, patterns of movement, and voice intonation. Reeves and Nass' (1996) "computers as social actors" (CASA) theory further posits that humans unconsciously ascribe agency, personality, and intentionality to computer-mediated technologies. This combination of human appearance and user-projected human intentionality creates a complex mixture of attachment-related responses for users of android products in which the drive to respond to the android as if it was human is at odds with the realization that the android is a machine.

A cornerstone of human-robot interaction literature which emphasizes these opposing drives is Mori's (1970) Uncanny Valley theory, a principle of robotics concerning the emotional response of humans to robots and other nonhuman entities. Mori's premise states that as a robot is designed more humanlike in its appearance, the emotional response from a human being to the robot will become increasingly positive and empathic. However, Mori theorizes that a point is reached on the continuum of design (machinelike to humanlike) at which the response suddenly becomes strongly repulsive to humans; this sudden and severe dip in empathy is what Mori describes as the Uncanny Valley. Yet, as the appearance and motion are made to be indistinguishable from a human being's, the emotional response becomes positive once more and approaches human-human empathy levels.

This Uncanny Valley response adds another layer to the study of human-android attachment. Currently there are no androids in development that are entirely indistinguishable from humans. A number of projects are approaching this point, but enough differences remain to

trigger a negative response from some users that may be a “show-stopper,” limiting or obstructing attachment.

Method

This study was designed to explore human-android interaction through an investigation of user’s pre-existing preferences and expectations. In this study, participants watched three videos of androids interacting with adult humans. The robots in each of these videos varied in their degree of human likeness and their interactive abilities. The reaction of the participants to these videos was recorded through observation, interviews, notes and surveys. Given that this was a pilot study prior to a larger study, only the observational and interview field notes will be discussed.

Participants

Five participants took part in this pilot study; two of them were male, and three were female. The mean age of the participants was 32.6 years, ranging from 22 to 50. The participants were undergraduate, Master’s and Ph.D. students in Technical Communication at the University of Washington. Participants received a gift certificate for their participation.

Materials

For this study, three video clips were used as stimuli for discussion. Each of the three videos fit the following criteria:

- Featured robot was humanoid
- Demonstrated a human-robot language interaction (in English)
- Time was approximately three minutes long
- Showed the robot’s entire body at least once in the video
- Presented only one robot per video

While these videos illustrated some of the interactive capabilities of these robots, they were not designed to demonstrate the full range of their capabilities nor were they designed to highlight either service or companion roles.

The robots used in the videos were, as shown in Figures 1-3 below, HERMES (Intelligent Robots Laboratory, Bundeswehr University Munich), Robovie (ATR), and Replee Q2 (Osaka University). The android Replee Q2 was specifically developed by Osaka University and KOKORO Co. Ltd. with the intent of studying human-robot interaction, as was Bundeswehr University's HERMES.



Figure 1: HERMES



Figure 2: Robovie



Figure 3: Replee Q2

Each of the robots differed in their degree of human likeness and in their interactive capabilities. Here, we briefly describe the interactions shown in the videos:

- HERMES was the most “industrial” in appearance, with a machine representation that was humanlike only because the placement of the mechanical parts mimicked the human placement of a head, torso, arms and hands. HERMES is blue, rolls on a wheeled base and has vice-like hands. This robot’s voice was the most mechanized of the three robots. Its interaction style was related solely to task completion. In this video, an adult woman asks HERMES to carry a water glass across the room and set it on a table. HERMES’ dialogue consisted of repeating back the task, describing the various subtasks involved, and asking for confirmatory information.
- Robovie, while obviously a robot, had more fidelity with human likeness: a head with two large camera eyes and arms that moved with an almost human fluidity. Its hands were shaped like balls and were not capable of gripping objects. Unlike HERMES, much of its movement-related machinery was hidden from the user under silver-colored metal. Robovie’s voice, while still synthetic, had prosodic fluctuation that

mimicked human speech, and had what seemed to be an American accent. Robovie's interaction style was somewhat child-like in nature, verbally asking to be hugged, saying "I love you" and "I'm hungry." In this video, the robot interacts with an adult male, asking repeatedly to be touched and playing simple games with him.

- Replee Q2 was highly human in appearance, especially in its face and display of unconscious movement, such as blinking. Replee Q2 has arms which end in unarticulated but human-appearing hands, and was dressed in casual but contemporary women's clothing. Replee Q2's voice was also highly human-like, softly spoken with a mild Japanese accent. Replee Q2's movement capabilities were less life-like than her appearance. While the previous robots moved across the floor during the interactions, Replee Q2 was stationary in the videos, with movement limited to the face, head, and arms. In the video, Replee Q2's interaction style was also the most human-like, asking polite questions, listening for replies, and often responding with human confirmatory sounds like "Hmmm." Replee Q2 interacts with three humans individually in this video. In the first interaction, Replee Q2 stands behind an office desk and acts like a receptionist, greeting an adult male and directing him with comments and gestures to an off-screen office. In the other two interactions, she introduces herself as a reporter and conducts short interviews with human "guests."

In the study sessions, each video was displayed full screen on a Dell Inspiron computer, while interview notes were recorded on two Panasonic Toughbook W2's.

Procedure

Participants were assigned to one of two conditions. The investigator first read a short explanation of the procedure, framing the videos they were about to view as either a *service* robot or a *companion* robot; the condition was then consistent for all three videos. A service robot was defined as one "designed to help you around the house completing simple household tasks"; a "companion" robot was defined as one "designed to be a friend or a member of the family, offering assistance through social interaction." Participants were randomly assigned to one of these two conditions with three participants assigned to the companion condition and two assigned to the service condition.

Participants viewed the videos one at a time, presented in random order. In an interview after each video, participants were asked to describe the advantages and disadvantages of the robot in the video as either an in-home service android or as a companion android. In a final discussion after all videos had been shown, the interviewer described the other possible condition (service or companion) and asked participants which robot they would prefer for that condition and why.

Field notes from the sessions were analyzed using qualitative thematic analysis techniques (Boyatzis, 1998). Each field note transcript was coded by multiple coders for comments related to appearance, function, emotional response, and expected future use. These codings were compared and aggregated into thematic categories. The following section presents the primary themes that emerged during data analysis.

Findings

The following themes emerged from the data analysis process. They are presented as difficulties commonly encountered by our participants.

Are robots people or are they machines?

Participants in this study frequently spoke about the three robots using terms normally used to describe humans. Participants used personal pronouns when referring to the robots, referring to HERMES and Robovie as male and Replee Q2 as female. Participants also framed the robots' functionalities in terms of human social roles. One participant said that Robovie "would make a good dancer." All of the participants framed the robots' expected functional use in terms such as maid, secretary and butler (whether the robots had been framed as service or companion robots).

One of the participants actively voiced that this confusion between human and machine was problematic enough to cause her to reject in-home robots that mimicked human shape and behavior, stating that she would prefer an 'iPod-vacuum cleaner' having a "sleek" and obviously machine-like design. This same participant, who was clearly bothered by the more anthropomorphized robots, offered a reason for her preference of obvious machines over humanoid robots in the home, stating that "it's hard not to think of it as a companion even

when framed as a service robot because they are demanding interaction.” She also stated that she wouldn’t want “a human that she could turn on and off.”

How should I relate to an android in my home?

Participants also had difficulty determining how they should relate to these humanoid machines if they were actually in their homes. Participants frequently resolved this difficulty by invoking pre-existing social categories, often based on the task or function the robots would be expected to fulfill. In a surprising finding, three out of five participants suggested that they would relate to the robots as if the machines were pets, indicating an attitude of care and nurturing on the part of the participants with expectations about pleasing and engaging interactions. One participant was particularly verbal about treating robots as pets, comparing them to cats and suggesting that a companion robot could “bring a phone or fetch your slippers.” While robot pets like the AIBO are currently on the market, participants put even highly anthropomorphized robots into this category. Servant was another common social role used by these participants with participants using the aforementioned descriptors of butler and maid.

Shouldn’t the robot do something practical?

Participants in both conditions questioned the practicality of the robots based on the capabilities demonstrated in the videos. All participants commented negatively on HERMES large size and its slow pace completing tasks, wanting it to perform its task “as fast as a human could.” Participants also compared the demonstrated capabilities of the more socially adept robots to humans, suggesting that Robovie’s lack of functional hands would limit its usefulness in the home as would Replee Q2’s apparent immobility. While one participant suggested that Replee Q2 might “sit on the couch” and keep him company, the implication is that social interaction was not in itself enough for these participants and that for home use the performance of practical tasks was vital.

I think robots that emulate humans are creepy.

Mori’s Uncanny Valley theory was certainly demonstrated in this study. The participants described Replee Q2’s highly human appearance as “creepy” or “too human,” suggesting that they would be unnerved by its presence in the home. Participants also reacted negatively to Robovie’s repeated statements of “Please touch me” and “I’m hungry.” This latter comment

provoked one participant to state that the robot was either asking for fuel in an indirect manner or that it was “lying.” These negative reactions suggest these participants had some pre-existing limits to how humanlike a robot should actually be, in appearance and in manner. When asked to choose one robot for the home, participants in this study predominantly opted for the moderately humanoid design, with several participants wanting to customize its voice and interaction style to their liking.

Discussion

Before discussing the implications of these findings, it is important to note several aspects of this study. First, this study was conducted with American students who had little or no previous experience with working humanoid robots. Participants from cultures such as Japan and Korea, where humanoid robots are more commonly encountered in the media and in person, may have radically different approaches to android technologies (Bartneck, Nomura, Kanda, Suzuki, and Kenssuke, 2005). Second, this study was based on participants’ impressions after watching videos rather than from more prolonged interactions, which might result in participants reframing their initial responses. Third, although the videos used in this study fit the criteria listed under *Materials*, they were not necessarily crafted to demonstrate the robot in either a companion or service role.

Given these caveats, the results of this study offer important information for those designers developing humanoid products for the home:

- Humanoid products powerfully engage users’ natural tendencies toward product attachment, with users often relating to such products as social entities ranging from pets to human assistants.
- Users may be more comfortable, at least initially, with products that moderately capture human likeness in appearance, voice, and behavior, while high levels of human likeness can possibly evoke negative reactions.
- The degree of human likeness of humanoid products should be directly proportional to the product’s functionality, as high levels of human likeness can lead to unrealistic expectations of sophisticated functionality.

- Companionship as a user experience outcome can occur spontaneously, whether the user expects it or not, but it can be seen as frivolous when not accompanied by other, more physically oriented capabilities.

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