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What makes robots social?: A user's perspective on characteristics for social human-robot interaction

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Abstract. A common description of a social robot is for it to be capable of communicating in a humanlike manner. However, a description of what communicating in a 'humanlike manner' means often remains unspecified. This paper provides a set of social behaviors and certain specific features social robots should possess based on user's experience in a longitudinal home study, discusses whether robots can actually be social, and presents some recommendations to build better social robots.

Keywords: Design Guidelines, Sociability, Social Intelligence, Social Robots.

1 Introduction

The field of robotics is rapidly advancing. There are a growing number of different types of robots, and their roles within society are expanding. As the capabilities of robots develop, the possibility arises that they will be able to perform more and more difficult tasks and become our full-fledged team members, assistants, guides, and companions in the not-so-distant future. The aim of social robotics research is to build robots that can engage in social interaction scenarios with humans in a natural, familiar, efficient, and above all intuitive manner.

Robots designed to share domestic environments with human users must interact in a socially acceptable way. According to Breazeal [1], an ideal social robot is capable of communicating and interacting in a sociable way so that its users can understand the robot in the same social terms, to be able to relate to it and to empathize with it. The common underlying assumption is that people prefer to interact with machines in a similar manner they do with other human beings [4]. Robotic researchers strive for the development of such sociable machines by making use of models and techniques generally used in interpersonal communication derived from (social) psychology and communication science. Yet, the social capabilities of today's robots are still limited (see [7] for a more in-depth discussion). Simple human social behavior can be quite challenging to program into the robot's software. Various research on the social be-

haviors of robots has been performed, and an abundance of literature suggests the following social characteristics for robots designed to interact socially with its users: social learning and imitation, dialog, learning and developing social competencies, exhibit distinctive personality, establishing and maintaining social relationships [4] [15]. This list of social characteristics is a list with robotic behaviors and features which social robots should ideally possess. Though, social robot prototypes existing today still lack important social characteristics and display only limited socially acceptable behaviors [7], which prevents these robots from engaging in truly natural interactions with their users [2]. Only when all of the essential social characteristics can be met, we can legitimately speak of social robots. Nevertheless, we would like to postulate that robots themselves are not social. Robots can only simulate social behavior or behave in such a manner perceived by human users as social.

This paper provides a set of social behaviors and certain specific features social robots should possess, discusses whether robots can actually be social, and presents some recommendations to build better social robots.

2 Method

The overall aim of the longitudinal study was to see whether and how a longer, uninterrupted period of use of a social robot in a home environment affects the long-term use of social robots. Based on real interaction experiences with the Karotz robot and triggered by some specific questions about social behaviors of robots for domestic purposes, we have identified a set of social behaviors and certain specific features social robots should possess.

2.1 The Karotz Robot

The robot used in this study is Karotz (see figure 1; http://store.karotz.com/en_WW/), which is a 30-cm high internet-enabled activated smart rabbit-shaped ambient electronic device. Communication occurs via verbal communication, the LED-light in its belly, the moveable ears, and by detecting the presence of other objects nearby. As the Karotz is permanently connected to the internet, it is able to react on, transmit, and broadcast all types of content available on his network, for example news, messages, music, texts, alerts, and radio. The build-in webcam enables users to communicate with family members at home or for surveillance purposes when away.

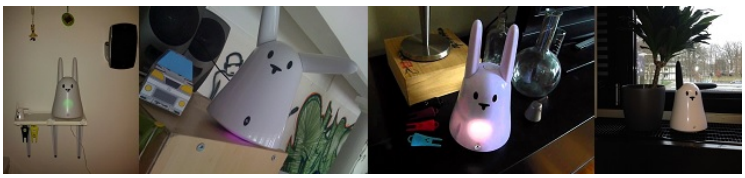

Fig. 1. The Karotz robot deployed in the participant's homes

Each robot was installed with a basic set of applications, such as daily news broadcasts, daily local weather reports, favorite radio stations, personalized reminders, and randomly spoken phrases to make the robot being perceived as more autonomous and animate. This basic set of applications ensured us that the user experience was somewhat similar among the participants, or at least initially as some participants chose to adjust these applications to their own needs. Besides the required applications, participants were free to install additional applications as they thought would be useful or fun for their households.

2.2 Data Collection and Procedure

The longitudinal study ran from October 2012 to May 2013 and consisted of seven moments of data collection. For the interviews, a representative of that household reported on their own individual user experiences with some additional questions about the opinions of other household members. Table 1 presents the number of interviews collected during the study and their associated time point with regard to the moment the participants were introduced to the robot.

Table 1. Distribution of sample sizes for each time point

Time points with regard to the introduction of the robot	Sample size
2 weeks before	21
1st day	21
2 weeks	18
1 month	17
2 months	13
6 months	7

The participants were interviewed at each of the time points. In total, 21 participants started the study who consented on being part of the interview sessions. We conducted semi-structured interviews at the participants' own homes to obtain detailed user experiences with the robot. The interview scheme contained, among other questions about the acceptance and use of the robot, some questions focused on the social characteristic of robots (e.g., Can you describe how you perceive the robot? How are the interactions with the robot similar to / different from interactions with other persons? Does the robot seems to have its own will / personality? How should the robot be improved to become more sociable? Does the robot offer some kind of companionship?). Only the codes applied to the answers of these questions were analyzed with the aim to identify a set of social behaviors and certain specific features social robots for domestic purposes should possess to be accepted by users.

2.3 Data Analysis

A total of 97 interviews were conducted over a time period of six months. The interviews were recorded and transcribed verbatim with the participants' approval. The transcriptions were done as soon as possible after conducting the interviews to guarantee information clearance and solve problems with interpretation quickly [19].

Based on the transcriptions of the interviews, key concepts were identified and translated into a coding scheme by the primary coder. Table 3 shows the social characteristics that have emerged as key concepts from the interviews, which together formed the coding scheme. Next, for each interview section, at least one code from the coding scheme was applied to that section. In total, 32 of the 97 interviews were also coded by a second scientist, which resulted in almost 33% of double-coded data. Intercoder reliability, which involves testing the extent to which the independent coders agree on the application of the codes to the different interview sections, has found to be substantial with a Cohen's Kappa of .73 [11]. In the results, from every interview transcript, 'striking' or 'typical' quotes [8] were selected which illustrated, confirmed or enhanced our understanding of the key concepts, i.e., the social characteristics for domestic social robots, from the coding scheme.

2.4 Participants

Participants were recruited with various methods, such as word of mouth, advertising in public locations (e.g., libraries, leisure centers and supermarkets), and snowball sampling by asking assigned participants for referrals to other people who might participate. During recruitment, we tried to balance out the households' demographic profiles to seek diversity (see table 2 for the distribution within the sample). However, from each household, only one person was interviewed. Furthermore, to facilitate the interactions with the robot, participants were required to have at least a limited working proficiency in either English or German as the Karotz robot does not provide interactions in Dutch. We compensated our participants by allowing them keep their robot after study completion. Moreover, to increase both homogeneity and convenience, most participants lived within 10 square kilometer around our university, the University of Twente in The Netherlands.

Table 2. Distribution of household types within the sample

	Number of participants	
Household type	*n (of which interviewed)*	%
Older single male (55+)	1	4
Younger single male (35-)	3	14
Older single female (55+)	2	10
Younger single female (35-)	2	10
Older couple (both 55+)	2	10
Younger couple (both 35-)	3	14
Young family	3	14
Mature family	2	10
Student dorm	3	14
Total	21	100.0

3 Results

From the interviews and based on the coding scheme, we observed several behaviors of social interaction and certain specific features domestic social robots should pos-

sess before the participants would accept such robots as social entities in their homes (see table 3). The following sections will clarify the meaning of these social characteristics with some quotes.

Table 3. Frequency distribution of social characteristics for social robot

Social characteristics	Count	%
Autonomy	20	7
Coziness	15	5
Mutual respect	7	2
Similarity	9	3
Social awareness	40	14
Social support	22	8
Thoughts and feelings	57	20
Two-way interaction	119	41
Total	289	100.0

3.1 Two-way interaction

The far most noted topic was two-way interaction, which constitutes speaking to the robot and for it to respond in an social manner. Some participants had expected to be able to do this with the current robot and were somewhat disappointed when they found out that the Karotz robot could only understand preprogrammed commands.

> "*He doesn't communicate with you. You have to push a button and then you could give [the robot] commands. Sometimes he answers, sometimes he doesn't.*" – female, 57, living alone

> "*[For the robot to be perceived as a social companion] he needs to interpret the things I say. He basically needs to continuously receive things and send out without needing to push the button.*" – male, 32, living alone

3.2 Thoughts and feelings

Another frequently noted topic was thoughts and feelings. Robots should be embedded with thoughts and feelings. Robots should be able to think for itself and act upon it. In addition, a robot be able to display humanlike emotions.

> "*[The robot] can't laugh or cry or look sad… If he wants to be a full-fleshed interaction partner, he needs to be able to shows his emotions.*" – male, 32, living alone

> "*When such a device becomes intuitive, gets more emotions, becomes more intelligent or something. Than it will be different… Then you will treat it differently too.*" – male, 31, living alone

3.3 Social awareness

The participants also indicated that robots should be aware of their social environment. Robots must be able to sense our presence and our moods to be able to be perceived as a social entity.

"*[The robot] doesn't respond to noise, except when you push that button. So he needs to permanently distinguish sounds and interpret and react upon them. That is when you could be speaking of contact*." – male, 32, living alone

"*[The robot] should react better to what he does… That his ears turn when you come in... That would make you perceive it more as something alive*." – female, 27, living with spouse

3.4 Social support

With social support, the participants referred to their friends being there for them to support them when needed and sharing life experiences with each other. For the possibility perceive robots as social entities, there should be a trust relationship between a human and a robot and knowing that you can always count on it to be there for you.

"*That you share stuff. That you have the feeling you can count on each other*." – female, 57, living alone

"*To share stuff. I have different friends for different purposes. With one friend I talk about superficial stuff and with another friend I can share more serious stuff when something is bothering me… And sports friends. And in that way I have for my different needs several people around me*." – female, 27, living with spouse

3.5 Autonomy

With autonomy, the participants particularly referred to the fact that the robot used for this study was standing still. For a robot to be perceived as a companion, the participants need that robot to be able to move around independently and behave unpredictably and spontaneously and not only have pre-programmed behaviors. Increase the robot's presence would let it be perceived as more animate or alive. With autonomy, the participants indicated that they would want the robot to act on its own.

"*It needs to be a completely movable robot. More in the direction of humans instead of something static. Then it would be more suitable for companionship*." – male, 24, living alone

"*If [the robot] could move more, it would be more alive… For example driving around… or some more degrees of freedom, so not just moving its ears*." – male, 32, living alone

3.6 Coziness

The topic of coziness was noted a few times by the participants as an essential characteristic for social robots. The participants discussed to their experiences hanging around with their friend just for the sake of being together. That feeling of companionableness is something the participants would miss in the company of a robot. Coziness or companionableness seems to be a predecessor of intensive social interactions.

"*For me companionableness is important. I like it to be surrounded by a group of people to talk to*." – female, 22, living alone

"*Coziness off course. Just to talk to each other and have some drinks*." – female, 19, living with spouse

3.7 Similarity

Similarity as an essential characteristic for social robots was also much less noted. Related to the topic of similarity, a few participants said that their friends are their friends because they share similar personalities or similar interests with them which makes is easier and more pleasant to interact with.

"*What I like about people is that they talk and have feeling that are similar to mine*." – female, 22, living alone

"*Having resemblances with people. And to talk about that with each other, and to brainstorm with someone who has the same interests. That is nice to that to. I think that is important*" – male, 38, living with young family

3.8 Mutual respect

Another topic noted only a few times was mutual respect. A few participants explained that the way they spook to the robot was different from how they interact with other people. They were quite rude and blunt to the robot, because they knew that the robot would not respond to that behavior. So in order to perceive robots as a social entity, users should be able to perceive the robot as a higher form of intelligence which would make them feel obligated to treat the robot with respect.

"*You are rude [to the robot], because you think that the robot doesn't have any feelings*." – male, 32, living alone

"*[The robot] is defenseless, so he can't say anything back. I also think you make shorter sentences, or even talk to him in stop words. Because he doesn't understand it anyway*." – female, 19, living with spouse

Together, these social characteristics for robots provide some insights into the essential characteristics social robots should possess before the participants would accept such robots as social entities in their homes.

4 General Discussion

This paper presents the results of a robot's sociability based on user's experiences from a longitudinal home study. Before discussing the general implications of these results, we need to address some limitations. First, the rather limited interaction capabilities of the robot used in this study. The choice of the Karotz robot is a fundamental result of the overall aim of this study, to see whether and how a longer, uninterrupted period of use of a social robot in a home environment affects the long-term use of social robots. Second, the employment of a zoomorphic robot imposes some limita-

tions on the generalizability of the results to other types of robots. Third, this study focuses on domestic social robots. It could very well be that other context demand different types of characteristics for social interaction with humans. Therefore, replication studies are needed to further support the results from the current study.

4.1 Essential social abilities for social robots

Interestingly, this study indicates that users remark similar essential social characteristics for future robots which social roboticists already pursue in their creations [4] [15]. The indication of two-way interaction as the most essential social characteristics is related to social characteristic of dialog, which describes that robots should be capable to verbally communicate with humans. Above all, people should be able to freely interact with robots in a natural humanlike manner. This is not surprising, because human cognition requires language to communicate with other people for mutual understanding [3]. Although we can conclude that robots are yet still far away from behaving socially in an ideal manner (i.e. possessing all the essential characteristics for social behaviors as for example reported by [4] and [15]), this is not entirely necessary because the creative human mind will restore these shortcomings with the subconscious process of the media equation [16]. In this way, the social behaviors of robots is shaped in the minds of the human user.

4.2 Can robots actually be social?

An important point for discussion is the potential sociability of robots. Social roboticists are striving to program robots with social behaviors that are similar to those of human beings. Yet, some people may argue that robots cannot behave socially and cannot have emotions or an appealing personality. Robots can only act as if they are social and pretend to empathize with our emotions. However, following the research on the media equation [16], human users interacting with robots themselves interpret the robot's behavior as social, and they respond to robots in ways that are similar to how they would respond to other people (e.g., [10] [12]). Although most people would reasonably agree that robots are programmed machines that only simulate social behavior, the same people seem to 'forget' this while interacting with these machines. Thus, the question whether robots are social beings seems to depend on how human users perceive (the interactions with) these types of robots.

The doubts of people who think otherwise can be neutralized by altering the well-known Turing test [20]. The Turing test is a proposed method for determining whether a machine should be regarded as intelligent. During the test, a person engages in natural conversations with both a human and a machine designed to generate a performance that is indistinguishable from that of a human being. The conversations are limited to text-based interactions via a keyboard and a screen. If a person cannot reliably discern which of the two conversations was with the machine, then the machine is said to have passed the test. Thus, if a machine appears to be intelligent according to the human user, then we should assume that that machine is indeed intelligent. Levy [14] proposes that we can apply a similar argument to other aspects of being

human, such as emotions, personality, and behavior. Furthermore, acting is also a part of human social behavior [5]. In this line of thought, robotics researchers and developers should acknowledge that robots are social entities when human users perceive robots as such.

4.3 How to make better social robots

This section will present some guidelines to improve the (interaction) design of social robots designed to share domestic environments with human users. People interact with and respond socially to robots (e.g., [10] [12]). Therefore, some researchers argue that it seems unnecessary to depart from the social rules of human-human interaction when evaluating human-robot interactions [9]. Thus, a first recommendation is that social roboticists should investigate theories of interpersonal communication to create better social robots.

For social robots to flourish as companions for human users, the results of a short-term study with the Pleo robot [6] indicate that people are more willing to treat a robot as a companion when they have high expectations of the robot's lifelikeness. The influence of lifelikeness has also been related to people's empathic responses to a robot [17]. Thus, a second recommendation is that social robots should have a lifelike appearance, which does not necessarily mean a humanlike appearance.

The main finding of the current study is that two-way interaction, possessing thoughts, feelings and emotions and being capable to sense the social environment are the most essential parts of social behavior to pursue for social robots at this stage of development. Thus, a third recommendation is that developers of social robots should focus on increasing a robot's social behavior by first addressing the possibility of two-way interaction with a robot followed by creating some 'theory of mind' for robots.

The possibility of sharing personal information with a robot and having that robot respond to this personal information in an empathic manner was observed in the current longitudinal study as the most important variable for explaining companionship with a robot. The importance of empathic behavior for social robots and the user's empathic responses to the robot have also been noted by other researchers [13]. Thus, as a fourth recommendation, social robots need to be perceived as empathic.

5 Conclusion

This paper presented a set of essential characteristics for social robots from a user's perspective, discussed the ability for robots to actually be social, and provided some design guidelines for social robots. The results of this paper further paves the way for better social human-robot interaction for future robots designed to share domestic environments with human users.

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