The Influence of a Robot's Social Abilities on Acceptance by Elderly Users

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Abstract - **This study examines the influence of perceived social abilities of a robot on user's attitude towards and acceptance of the robot. An interface robot with simulated conversational capabilities was used in a Wizard of Oz experiment with two conditions: a more socially communicative (the robot made use of a larger set of social abilities in interaction) and a less socially communicative interface. Participants (n=40) were observed in 5 minute interaction sessions and were asked to answer questions on perceived social abilities and technology acceptance. Results show that participants who were confronted with the more socially communicative version of the robot felt more comfortable and were more expressive in communicating with it. This suggests that the more socially communicative condition would be more likely to be accepted as a conversational partner. However, the findings did not show a significant correlation between perceived social abilities and technology acceptance.**

I. Introduction

THE expected growth in the elderly population and the labor shortages in the healthcare sector have inspired a number of researchers to explore the applicability of intelligent systems in general and robots in particular to be used by elderly users [1], [2]. For robots, this concerns functionalities related to support independent living [3] which may mean supporting basic activities and mobility as well as providing household maintenance and monitoring tasks [4]. Some studies also focus on the companionship a robot might provide [2, 5].

If robotic products are to be used in the (near) future by elderly users, they have to be accepted by them. There is some evidence that a robot that is perceived to be more social in its behavior will be more easily accepted [6]. This is supported by further studies on human-robot interaction stressing the importance of social intelligence [7]-[9]. Most research related to social intelligence in human-robot interaction concerning elderly people is based on qualitative findings from a small set of users (see [2], [3], [10] and [11]).

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In this paper, we present a field experiment that investigates the influence of perceived social abilities on the acceptance of a robotic interface. The experiment was carried out in an eldercare institution with an iCat robot, used in a more and less socially communicative condition.

In the following section we will report related work. Subsequently we will discuss the main concept of social intelligence, explain how social abilities were simulated for the robot's interface and present how acceptance was measured. This is followed by the results, discussion of the findings and conclusions.

II. Related Research

Research involving explicit tests of robots or agents with elderly users has been carried out by Wada et al. [5] and Shibata et al. [12]. These studies concerned a seal shaped robot named *Paro*, placed in a group of elders where they could interact with it, mainly by caressing and talking to it. The aim of this study was to observe the use of a robot in a setting described as 'robot assisted activity' and to see whether elders felt more positive after a few sessions. This was done by measuring the moods of the participants, both with a face scale form (on which participants can express their mood by selecting a facial expression in a scale from very happy to very sad) and the Profile of Mood States (POMS) questionnaire.

Another experiment that took place in an eldercare institution concerned a robot named *Pearl* as described by Pineau et al. [13]. The robot was used in open-ended interactions, delivering candies and used to guide elders through the building to the location of a physiotherapy department.

The experiments with Paro and Pearl both registered a high level of positive excitement on the side of elders, suggesting that a robotic aid would be accepted by elders. However, these studies were not directed towards collecting quantitative data on acceptance of robotic technology by elders and it is not clear what aspects of the robot interface caused the users' positive attitude and whether such a robotic aid would ensure actual use on a longer term basis.

Related research in which both acceptance and social abilities did play a significant role is described by De Ruyter et al. [6]. It concerned the Philips iCat tested in a Wizard of Oz setting in a home-like laboratory with adult, but not elderly participants. The iCat was programmed in two ways: a socially intelligent condition and a socially neutral condition. The researchers found that a robot in the socially intelligent condition would be more likely to be accepted.

In the context of using robots for elders, it is relevant to look at user interaction with on-screen agents, as it is reported [14], [15] that responses to physical and virtual embodied agent systems is similar. Research concerning experiments with screen agents for elders is reported by Bickmore et al. [16]. The study focuses on the acceptance of a relational agent appearing on a computer screen and functioning as a health advisor for older adults. Findings show that the agent was accepted by the participants as a conversational partner on health and health behavior and rated high on issues like trust and friendliness. It was also found to be successful as a health advisor.

It seems that research on robot and agent acceptance can be subdivided into two areas: acceptance of the robot in terms of usefulness and ease of use (functional acceptance) and acceptance of the robot as a conversational partner with which a human or pet like relationship is possible (social acceptance). The experiments with Paro were more focused on social acceptance while the experiments with Pearl and iCat focused more on the acceptance of the robot regarding its functionalities.

III. Theoretical concepts

A. Social abilities for robots

In research concerning social aspects of autonomous interactive systems there are several definitions of the concept of social intelligence [17]. For the purpose of this study, social intelligence will be the social abilities, perceived by the users when interacting with robots.

A similar description is given for *socially communicative* robots within the classification by Breazeal [8] (extended by Fong et al. [19]): robots providing a 'natural' interface by employing human-like social cues and communication modalities, that do not have to be based on deep models of social cognition.

Since we are interested in the influence of social abilities in a robotic interface on its acceptance, it is important to look at ways to measure both acceptance and social abilities. A widely used tool to evaluate social abilities for humans is Gresham & Elliott's Social Abilities Rating System (SSRS) [18]. This tool usually is applied in social research, mostly on scholars and students, often in relationship to disabilities. Nevertheless, the five basic features (Cooperation, Empathy, Assertion, Self-Control and Responsibility) match the aspects found in Human-Robot Interaction literature on social (or sociable) robots and agents [8], [19] well. These five constructs also appear to be relevant abilities in the study by De Ruyter et al. [6].

Other relevant concepts to study are Trust and Competence as they appear relevant in the experiments by De Ruyter et al. and research by Shinozawa et al. [15].

This leads to the following list of social abilities:

1. cooperate,
2. express empathy,
3. show assertivity,
4. exhibit self control,
5. show responsibility,
6. gain trust,
7. show competence

To translate these into programmable features, we tried to meet with the list of social behaviors, set up in the experiments by De Ruyter et al. and found the following behavioral features to be programmed into our robots character (the numbers refer to the above listed abilities) [6], [15], [16]:

- listening attentively, for example by looking at the participant and nodding (1, 2),
- being nice and pleasant to interact with, for example by smiling (1, 2, 7),
- remembering little personal details about people, for example by using their names (6, 7),
- being expressive, for example by using facial expressions (2, 3),
- admitting mistakes (5, 6).

This means that only the feature 'exhibit self control' (4) is not represented.

B. User acceptance of robots in eldercare

Research on how and why individuals adopt new information technologies has lead to several streams with different focuses. To construct a model that incorporates the most widely used models, Venkatesh et al. [20] included the theoretical models that employ intention and/or usage as the key dependent variable. The result of this process is the UTAUT model which has also been used in previous research in acceptance of robots [6].

The UTAUT model incorporates several influences on acceptance of technology, usually in the workplace. It covers the following constructs: performance expectancy, effort expectancy, attitude toward using technology, self-efficacy, anxiety and behavioral intention to use.

As mentioned above, when dealing with acceptance of robots, it is important to not only address acceptance in terms of the usefulness and ease of use of a system but also relational or social acceptance. This means that a user accepts the robot as a conversational partner, finds the robot's social skills credible, sees the robot as an autonomous social being and is more likely to exhibit natural verbal and non-verbal conversational behavior as well as feeling comfortable in interacting with the robot. This means that a user will demonstrate more conversational engagement by being more expressive [21] and thus we can use behavioral clues as an indication of conversational acceptance [22].

IV. The experiment

A. Problem statement

The aim of this study is to evaluate the effect of social abilities in a communicative robot interface on its acceptance by elders. In this specific experiment, the effect was to be measured regarding both functional acceptance by using a technology acceptance model and conversational acceptance by using relevant questions and observations. The social abilities were programmed using the behavioral features as listed previously (IIIA).

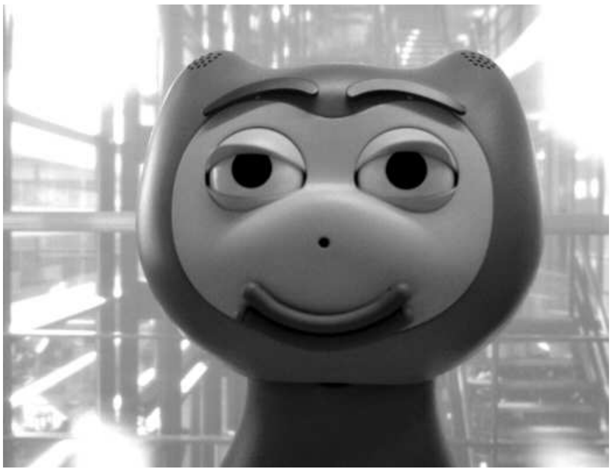
The hypotheses for this experiment were: (1) t*here is a measurable influence of social abilities on the acceptance of a robotic interface by elders in an eldercare environment* and (2) *a more socially communicative robotic interface will be perceived to be more social by its users*.

B. Setting

The experiment was carried out at an eldercare institution in Lelystad, the Netherlands in December 2005. Participants were 40 elderly inhabitants (13 male, 27 female) of the institution, living more or less independently, or needing daily care and who volunteered for the study. In the final analyses, data from 4 participants were not included because of disturbances during the observation session and severe hearing problems. Nursing staff pre-selected participants whose mental condition was such that a questionnaire could be coped with. Otherwise there was no selection on mental or physical health features.

C. The robotic interface

The particular robot we used in our experiment is the iCat ("interactive cat"), developed by Philips, also used in the experiments by De Ruyter et al. [6].



The iCat is a research platform for studying social robotic user-interfaces. It is a 38 cm tall immobile robot with movable lips, eyes, eyelids and eyebrows to display different facial expressions to simulate emotional behavior. There is a camera installed in the iCat's nose which can be used for different computer vision capabilities, such as recognizing objects and faces. The iCat's base contains two microphones to record the sounds it hears and a loudspeaker is built in for sound and speech output.

Conversational scripts were developed for the iCat in two conditions: more socially communicative and less socially communicative. The more socially communicative condition exhibited the social abilities as listed earlier: it listened more attentively (by looking at the participant and nodding while the participant was speaking), it smiled during the interaction, it remembered and used the name of the participant during the interaction, it was showing more facial expressions and it would apologize for making a mistake.

The scripted dialogues for the two conditions were identical except for the participant's name being used by the more social version. All dialogues were set up with the same text to speech (tts) application.

D. Procedure

A specific interaction context was created where the iCat could be used in a Wizard of Oz fashion, which guaranteed a similar pattern for all sessions. The participants were first exposed to the iCat in groups (8 participants per group). After a short introduction by one of the researchers the robot told them what its possibilities were: an interface to domestic applications, monitoring, companionship, information providing, agenda-keeping and memorizing medication times and dates. They were told that for today's experiment, the robot was only programmed to perform three tasks: setting an alarm, give directions to the nearest supermarket and giving the weather forecast for tomorrow. The experimenter subsequently demonstrated how to have a conversation with the robot in which it performed these tasks.

After this group session, the participants were invited one by one to have a conversation with the robot, while the other group members were waiting in a different section of the room. The conversation was standardized as much as possible and we asked the participants to have the robot perform the three simple tasks. While being engaged in conversation, the participants' behavior was observed by a researcher and recorded by camera. The group session and the individual session were both about 5 minutes, so the maximum time spent with the robot was 10 minutes for each participant.

E. Instruments

After the individual observation sessions, the participants were interviewed. The questions concerning acceptance were adapted from the UTAUT questionnaire. The adaptations were necessary for three reasons. First, some elders that piloted the questionnaire had difficulty indicating the level to which they agreed with statements and responded far better to questions than to statements. Also, because some of the participants had trouble reading, it turned out to be much easier for most of them if they were asked the questions by an interviewer, who could clarify the question if necessary. Furthermore, since UTAUT is developed for using technology at work, the questions needed to be adapted to a domestic user environment. This meant that questions that could not be adapted were omitted. We also added five questions concerning trust and perceived social abilities.

The answers to the UTAUT questions were given on a five point scale (1 is ‘absolutely not’, 2 is ‘not’, etcetera).

The final questionnaire contained 28 questions of which 19 were related to UTAUT constructs, each construct represented by two, three or four questions. Apart from the UTAUT constructs we added five questions concerning trust and social abilities (also to be answered on a five point scale), two questions on experience with computers (to be answered with yes or no) and one question concerning the extent to which people felt (un)comfortable when talking to a robot (to be answered with ‘yes’, ‘no’ or ‘a bit’).

During user observation, notes were taken by the observer of interesting and unexpected behavior as well as the start and end times of the sessions and interesting comments made by the users.

The sessions were recorded by video and were analyzed afterwards. During analysis verbal and non-verbal forms of conversational expressiveness were counted for each participant such as greeting (with or without words) nodding or shaking the head, smiling, looking surprised or irritated (frowning), and moving towards or away from the robot. This list of items considering conversational expressiveness was generated by listing classical feedback gestures (see [21]-[25]) without categorizing them to specific communicative functions. We added the behavior of verbal greeting to it, because we considered this also a sign of relational feedback.

V. RESULTS

A. The two conditions

When the scores for the more and less socially communicative conditions were analyzed, we first calculated Cronbach’s Alpha for the UTAUT constructs to see if they were consistent. In psychology, an alpha of 0.7 and higher is considered acceptable [26].

As table 1 shows, the scores on the constructs for Social Influence and Anxiety were too low, implying that we should not take these constructs into account.

TABLE 1: CRONBACH’S ALPHA AND T-SCORES ON UTAUT CONSTRUCTS REGARDING THE MORE AND LESS SOCIALLY COMMUNICATIVE CONDITIONS

Construct	Cronbach’s Alpha	t	Sig. (2-tailed)
performance expectancy	,7649	-0,1327	0,8953
effort expectancy	,8610	0,3622	0,7195
social influence	,2997*	0,3453	0,7322
attitude toward using technology	,8889	0,4961	0,6230
self-efficacy	,8942	0,4567	0,6509
Anxiety	,4303*	-0,0046	0,9964
intention to use	,8954	0,4036	0,6891
all constructs	,9346		
all questions	,9084		

Table 1 also shows the results of the paired T-test, showing the significance of the differences. In fact, none of the UTAUT-constructs showed a significant difference for the two conditions.

Also the scores on the five questions related to social abilities did not show any significant differences for the two conditions.

As is shown by table 2, there was a significant difference found between the two conditions on the question ‘Did you feel uncomfortable talking to a robot’ which could be answered with ‘yes’, ‘a little’ or ‘no’ (so this concerned in fact a question with answers on a 3-point scale). All (17) participants who experienced the more socially communicative condition reported to feel comfortable (or ‘not uncomfortable’) about it, while 47% of the (19) participants that encountered the less socially communicative condition reported to feel a little or very uncomfortable.

TABLE 2: T SCORE ON FEELING UNCOMFORTABLE TALKING TO A ROBOT REGARDING THE MORE AND LESS SOCIALLY COMMUNICATIVE CONDITIONS

condition	N	Mean	t	Sig. (2-tailed)
more social	17	1,00		
less social	19	1,53	-3,7500	0,0015

The observation analysis concerning conversational expressiveness shows that although there are remarkable differences, none of these are to be seen as significant (see table 3 - note that the sessions for both conditions were equally long).

TABLE 3: TOTAL COUNTS AND T SCORES ON CONVERSATIONAL EXPRESSIVENESS REGARDING THE MORE AND LESS SOCIALLY COMMUNICATIVE CONDITIONS

Totals for all participants:	more social (N=17)	less social (N=19)	t	Sig. (2-tailed)
Nodding head	66	54	0,3946	0,6958
Shaking head	16	15	-0,1261	0,9005
non-verbal greeting	2	0	1,4552	0,1628
'don't know' gesture	3	0	1,0000	0,3306
move away	0	4	-1,7253	0,1037
approach robot	17	7	1,6170	0,1152
Smile	42	30	1,1380	0,2631
Laugh	26	9	1,8477	0,0775
Surprise	2	0	1,4552	0,1628
show irritation (frown)	1	2	-0,5045	0,6189
verbal greeting	36	21	1,9004	0,0672

However, if we look at the total number of times a specific behavior occurred for the different conditions (table

4), there is a significant difference both in total expressions and in the total amount of expressions that can be categorized as positive expressions (all behaviors except shaking head, move away and show irritation).

TABLE 4: TOTALS AND T SCORES ON BEHAVIORAL OBSERVATIONS REGARDING THE MORE AND LESS SOCIALLY COMMUNICATIVE CONDITIONS

Mean:	more social	less social	t	Sig. (2-tailed)
Positive	10,0526	7,0588	2,450	0,020
Negative	0,8947	1,2353	-0,986	0,333
All items	11,0526	8,2941	2,063	0,047

B. Other results

We found a remarkable difference concerning gender: as table 5 shows, on the question if one would want the iCat immediately if it were possible, male participants appeared more eager than female participants:

TABLE 5: T SCORE ON FEELING COMFORTABLE TALKING TO A ROBOT REGARDING MALE AND FEMALE PARTICIPANTS

gender	N	Mean	t	Sig. (2-tailed)
male	11	1,45		
female	25	0,72	2,1717	0,0426

We also asked participants if they had any experience using a computer, which also showed a significant gender related difference that may be typical to this generation:

TABLE 6: T SCORE ON EXPERIENCE WITH A COMPUTER REGARDING MALE AND FEMALE PARTICIPANTS

gender	N	Mean	t	Sig. (2-tailed)
male	11	1,64		
female	25	1,24	2,2607	0,0373

C. Observations

Interviewers reported that four male participants who indicated they would want the robot if it would be available to them noted that they would love to learn how it worked and possibly learn how to program it. They did not mention the presented functionalities as the reason to want the robot.

Furthermore, a remark noted by four female participants indicating they would not want to use the robot if it would be available was, that they generally would not want any technology that would help them too much in doing and remembering things. They would prefer to try to remember and do as much as possible without any help until there would really be no way out but to use technology.

Another interesting observation was that many participants had a conversation that was not only beyond the given tasks but also far beyond the presented possible functionalities of the robot. They demanded it to make coffee, they informed about its wellbeing and one participant even told he would love to have a swimming pool in the new building for this eldercare institution, hoping it could talk to the management about it.

VI. CONCLUSIONS AND DISCUSSION

No significant differences were found between the two conditions for the UTAUT constructs and the influence of social abilities on acceptance of a robotic interface as a new technology by elderly users could not be confirmed.

However, data concerning acceptance of the robot as a conversational partner do show some significant differences: elders are more comfortable with a more sociable robot and behavior analysis shows that elders are invited to be more expressive by a more sociable robot.

We have to note that connecting a higher conversational expressiveness (indicating a higher form of conversational involvement) to acceptance is not the only way to interpret these data. Responding with more expressive behavior to a communication partner who is more expressive can also be linked to what researchers on human-human communication have reported as the chameleon effect [27]. This form of behavior copying could indicate that participants like the iCat and accept it as a conversational partner, but this does not mean the less social condition leads to a lower acceptance.

Furthermore gender seems to play a role. This might be a generation-related phenomenon. It is important to consider that robots for eldercare will be applied to a generation that might be different from the present one.

The research reported in this paper focused on the influence of perceived social abilities on acceptance. In the study, the experiment was designed and behavior was simulated in such a way that a set of specific abilities was involved (such as nodding, apologizing for mistakes and smiling). Although our results indicate that people felt more comfortable when talking to a more socially communicative robot, these experiments show that both the concept of social abilities itself and measuring these abilities remain subject to further development. In future research it will be important to address specific social abilities and measure the effects these abilities have on user behavior and acceptance. The results from research done by De Ruyter et al. [6], who asked participants to interact with a robot for about 30 minutes, did show significant differences in acceptance due to perceived social abilities. This suggests that it may be necessary to collect data on longer-term interaction.

The Wizard of Oz setting that was used could also be subject to discussion (see [28] for arguments against it). One could argue that it is a way of cheating participants and that it gives an unreal impression of the actual possibilities of the technology. However, Wizard of Oz experiments with prototype technology are an accepted way of carrying out user research and offer the opportunity to study user experience at an early stage in the development process.

The findings indicate that elderly users were generally comfortable in communicating with the iCat interface. Better-developed social skills seemed to improve the level of comfort in interacting with the robot. In order to carry out further research on the influence of human-robot social interaction on acceptance, a more sophisticated model of social abilities will be developed in future research that can be applied to human-robot interaction. Future research specifically addressing elderly users may involve the further exploration of relevant application areas such as continuing education, support for social activities, providing practical, medical, psychological and emotional support as well as comparing the interaction experiences for different types of robots and on-screen agents.

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