Studying the acceptance of a robotic agent by elderly users

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Abstract

Abstract – Goal of this study is to examine the influence of social abilities of a robot on elderly user's attitude towards and acceptance of the robot. Experiments were set up in eldercare institutions where an interface robot with simulated conversational capabilities was used in a Wizard of Oz experiment. The robot was used 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. Furthermore, results did show a correlation between perceived social abilities and some aspects of technology acceptance, but this did not relate to the more and less socially communicative conditions.

1. Introduction

In the coming decennia, the industrialized countries face a dramatic growth in the elderly population combined with labor shortages in the healthcare sector. This has inspired a number of researchers to explore the applicability of intelligent systems in general and robotic products in particular to be used in assisted-living environments [26, 33]. For robots, the functionalities are related to supporting independent living [15] by supporting basic activities (eating, bathing, toileting, getting dressed) and mobility, providing household maintenance, monitoring of those who need continuous attention and maintaining safety [3, 23]. Some studies also focus on the companionship a robot might provide [35, 33], or on the environment where they can be used and on the factors that influences user acceptance [16, 18].

Still, if robotic products are to be used in the (near) future by elderly users, they have to be accepted by them. Recent studies on interaction with robots stress the importance of social intelligence [4, 5, 8, 10, 13] even more so in a health- and eldercare environment. It shows a more social intelligent robot will be more effective in it's communication and it can therefore be expected to be easier and more pleasant to interact with and therefore would be indeed accepted easier [12].

However, most research related to social intelligence in human-robot interaction concerning elderly people is based on either theoretical considerations or qualitative findings from a small set of users (see [32], [15], [18] and [21]).

In this paper, we present a field experiment that investigates the influence of perceived social abilities on the acceptance of a robotic interface by elderly users. The experiment was carried out in eldercare institutions 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 a description of our experiences on conducting experiments in eldercare institutions. After this, we will present the results, a discussion of the findings and conclusions.

2. Related Work

Research involving explicit tests of robots or agents with elderly users has been carried out by Wada et al. [35] and Shibata et al. [28]. These studies concerned a seal shaped robot named Paro that was positioned 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 prove that elders felt more positive after a few sessions. This was done by measuring the moods of the participants, both with a face scale form 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 Montemerlo et al. [22], Pollack [25] and Pineau et al. [24]. The robot was used in open-ended interactions, delivering sweeties 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. 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 acceptance did play a significant role is described by De Ruyter et al. [12]. It concerned a robotic interface (the iCat made by Philips), which was tested in a Wizard of Oz experiment where the robot was controlled remotely by an experimenter. The participants were asked to program a DVD-recorder and to participate in an online auction, by using the iCat interface. They were exposed to an introvert and an extravert version of the iCat interface to see whether this difference in interaction would lead to different scores in degree of acceptance. To measure acceptance, the UTAUT questionnaire (Unified Theory of Acceptance and the Use of Technology, [34]) was used. UTAUT is a model that 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. The aim of the study was to find out to what extent participants would use the iCat at home after having experienced it. To see whether participants would perceive the extravert iCat to be more socially intelligent, a social behavior questionnaire (SBQ) was developed and used. The results showed that the extravert iCat was indeed perceived to be more socially intelligent and that this version also was more likely to be accepted by the user.

This experiment was done in a laboratory setting, with adult, but not elderly participants. It resembles the experiment we want to do, but our focus is on elderly participants (aged 65 and older) that experience a robot in the familiar environment of their nursing home.

In the context of using robots for elders, it is relevant to look at user interaction with on-screen agents, as it is reported [2], [29-31] 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. [3]. 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.

3. Theoretical Concepts

3.1. Social abilities for robots

In research concerning social aspects of autonomous interactive systems there are several definitions of the concept of social intelligence [14]. 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 [4] (extended by Fong et al. [14]): 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) [19]. 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 [4], [9] well. These five constructs also appear to be relevant abilities in the study by De Ruyter et al. [12].

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. [29-31].

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) [12], [130], [3]:

- 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.

3.2. 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. [34] 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 [12].

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 feel demonstrate more conversational engagement by being more expressive [32] and thus we can use behavioral clues as an indication of conversational acceptance [1].

4. The experiments

4.1. 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) There 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.

4.2. Setting

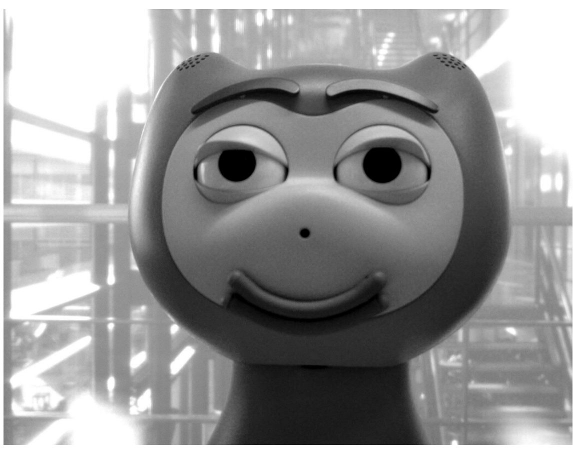
The experiments were carried out at eldercare institutions in Lelystad and Almere, the Netherlands in November and December 2005. Participants were 28 elderly inhabitants in the first experiment and 40 elderly inhabitants of the institutions, living more or less independently, or needing daily care and who volunteered for the study. In the final analyses, we only used data produced by the second experiment. From these final data some participants were not included because of disturbances during the observation session and severe hearing problems. We asked the nursing staff to 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.

4.3. The robotic agent

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. [12].

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.

The iCat can be connected to a home network supporting the control of various in-home devices such as the light switch, VCR, TV, radio, window shutters, heating and to access the Internet.



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.

4.4. 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.

4.5. 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).

TABLE 1: THE QUESTIONNAIRE ON ACCEPTANCE AS USED IN THE EXPERIMENTS

Code	Question
CE	1) Have you ever used a computer?
CE	2) Do you still sometimes use a computer?
CA	3) Did you feel uncomfortable talking to a robot?
PE	4) Do you think iCat would be useful to you?
PE	5) Do you think iCat would help you do things?
EE	6) As you have noticed, you control iCat by speech. Do you think you can easily communicate with it that way?
EE	7) Do you think you can quickly learn how to control iCat?
EE	8) Do you think iCat is easy to use?
SI	9) Do you think many people would find it nice if you would have an iCat?
SI	10) Are these people who's opinion you value?
SI	11) Are these people who are important to you?
SI	12) Do you think the staff would find it nice if you would have an iCat?
SA	13) Did you find iCat a pleasant conversational partner?
SA	14) Would you consider iCat to be social?
SA	15) Would you trust iCat if it gave you advice?
SA	16) Would you follow iCat's advice?
SA	17) Do you feel understood by iCat?
AT	18) Do you think it is a good idea to use iCat?
AT	19) Would you like to use iCat?
SE	20) Do you think you could work with iCat without any help?
SE	21) Do you think you could work with iCat if you could call someone for help?
SE	22) Do you think you could work with iCat if you had a good manual?
ANX	23) Do you feel at ease with iCat?
ANX	24) If you were to use iCat, would you be afraid to make mistakes or break something?
ITU	25) If you could have iCat, would you want it immediately?
ITU	26) If you could have iCat, would you want it in a view months?
ITU	27) If you could have iCat, would you want it in a few years?

UTAUT:	PE	performance expectancy
	EE	effort expectancy
	SI	social influence
	AT	attitude toward using technology
	SE	self-efficacy
	ANX	anxiety
	ITU	intention to use
Other:	CE	computer experience
	CA	conversational acceptance
	SA	social abilities

The final questionnaire contained 27 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'). This means that there were three constructs added for this special context: 'social abilities', 'conversational acceptance' and 'computer experience'. The issue of conversational acceptance was only represented by one question in the questionnaire, but also measured extensively by our observation model.

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 [1], [6], [20], [27] and [32]) 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.

5. Experiences

We were able to do this experiment in two eldercare institutions in the Dutch cities of Almere and Lelystad, in November and December 2005. The first experiment, which was in Almere, was meant as a pilot, with a relatively small group of 28 participants. The second experiment in Lelystad featured 40 participants. In this section we will describe these experiments and briefly discuss their outcome (a more profound analysis will be published elsewhere).

5.1. First (pilot) experiment

Our pilot experiment made it very clear that we had a lot to learn. Due to setbacks and organizational mistakes we received usable data of only 11 of the 28 participants.

First, there were organizational issues, due to our inexperience with setting up an experiment cooperating with the nursing staff. For example, as soon as we were ready to let the participants into the testing room, there appeared to be no one waiting. We had to get them out of their apartments ourselves, which took a lot of time, also because some participants were not dressed yet.

Also, a lot of participants came during an earlier or later session than the one they were invited to.

Secondly, there were issues concerning the mental state of the participants that we took too little into account: about half of the participants had forgotten about the experiment and many of the remaining half had forgotten what it was about. Besides, some participants forgot during the experiment what it was about, just a few minutes after we had explained. Also, for many participants the questionnaire was longer than their memory of the session lasted.

Third, there were behavioral issues that we didn't take into account due to inexperience with dealing with groups of elders: some participants refused to work on the given task with the robot; they simply started a conversation with it, ignoring all instructions. Also, some participants walked away as soon as it was time for the questionnaire, because they didn't find it a necessary thing.

Finally, we found many participants thought we were trying to sell the robot, even after we explained that this was not a sales presentation. Later we learned that the room we used was indeed often used for sales presentations. Some participants left because of this, because the robot was too expensive for them. We could not convince them that it was not our intention to sell anything.

5.2. Second experiment

Our second experiment featured 40 participants, divided into 4 groups of 8 and 2 groups of 4. Exactly half of the participants (2 groups of 8, 1 group of 4) were exposed to the more sociable version and the other half to the less sociable one. We had asked the nursing home staff to select participants who's memory would last long enough to be able to complete the questionnaire The experiment was prepared much more thoroughly and we asked more assistance from the caregivers at the eldercare institution. They made sure that everyone arrived, appropriately dressed, at the right session at the appropriate time. We used more explicit flyers explaining the purpose and set-up of the experiment and we had extra people to keep the elders informed and entertained while they were waiting for their encounter with the iCat or in line for the questionnaire after the encounter..

After their sessions, the participants were interviewed using only the UTAUT related questionnaire, expanded with four questions on perceived social abilities. We decided that it would be too much to add the SBQ.

5.3. Lessons learned

Considering our experiences we recognized the following issues as being crucial to successfully set up an experiment in an eldercare environment to gather user experience data:

(1) *Collecting user experience data in an eldercare environment*
We succeeded in collecting user experience data that will be subject to further analyses. We learned however, that this demands a very strict organization as in our second experiment.

(2) *Ensuring cooperation and participation*
The participation of caregivers is essential. They are the ones who know the different participants and how to ensure their participation. We needed them not only to bring the participants to the experiment, but also to stay with them while they were waiting.

(3) *Selection of participants*
Elders who are suffering dementia can in many cases participate in an experiment like ours, but if they have forgotten their experiences by the time they are questioned about it, this might lead to unreliable data. If these participants are identified before the experiment, it remains possible to use other methods to gather data on their experiences. If the questionnaire is essential, like in our case, only participants that will remember their experiences long enough should be selected

(4) *Communication with participants*
Participants have to be well informed about the purpose and procedures both before and during the experiment. They have to be aware that they are participating in an experiment and that a questionnaire is part of the protocol.

(5) *Limiting questionnaires*
There is a limit to the length of a questionnaire elders have patience for. Although there are of course differences between individuals, a questionnaire containing up to 30 questions is about as much as many elders can take.

6. Results

6.1. 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 [11].

The constructs were formed by joining the scores for the questions that represented it. An exception to this was the SI construct: it represented by four questions, but two are dependent questions so only the first and last one were incorporated in the scores.

As table 2 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 2: 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		

This table 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 3, there was a significant difference found between the two conditions on the question 'Did you feel uncomfortable talking to a robot' (question 3 in table 1, related to 'conversational acceptance') 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 3: 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 during the sessions (note that the sessions for both conditions were equally long) shows that, none of these differences for individual behaviors are to be seen as significant (see table 4), although there are remarkable differences and there is a certain pattern of more expressiveness.

TABLE 4: 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 5), 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 5: 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

6.2. Results concerning gender and computer experience

We found a remarkable difference concerning gender: as table 6 shows, on the question if one would want the iCat immediately if it were possible, male participants appeared more eager than female participants:

TABLE 6: 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 experience using a computer (questions 1 in table 1, together with question 2 representing the construct of computer experience), which also showed a significant gender related difference that may be typical to this generation:

TABLE 7: 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

6.3. Correlations

The questions asked to the participants on their perception of social abilities did not result in significant differences between the conditions. However, as table 8 shows, the answers to the questions on perceived social abilities, joined in the (non-UTAUT) social abilities construct did show correlations with some of the UTAUT constructs and with the question on feeling uncomfortable talking to a robot.

TABLE 8: CORRELATION BETWEEN PERCEIVED SOCIAL ABILITIES AND FEELING UNCOMFORTABLE TALKING TO A ROBOT AND UTAUT CONSTRUCTS

Construct	Pearson Correlation	Sig. (2-tailed)
feeling uncomfortable	-0,337	0,045
performance expectancy	0,210	0,219
effort expectancy	0,580	0,000
social influence	0,332	0,048
Attitude toward using technology	0,473	0,004
self-efficacy	0,264	0,120
Anxiety	-0,453	0,006
intention to use	0,201	0,241

6.4. 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.

7. 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 [7]. 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, especially since correlation analysis shows that there is indeed an influence of perceived social abilities on acceptance issues although this did not result in significant differences between the two conditions. Besides, the results from research done by De Ruyter et al. [12], 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.

Other differences between our project and the research by De Ruyter et al. concern the participants and the kind of tasks. Of course our participants were all elders for whom the experiment might have been a more overwhelming experience – perhaps overwhelming the effects of perceived social abilities. The tasks in the experiments by De Ruyter et al. were more complex and therefore the role of the robot was more explicitely to accomplish these tasks.

Besides such difference concerning the experiment itself, there was a difference in the instruments used. De Ruyter et al. modified UTAUT less then we did and used statements instead of a questionnaire, which could have influenced the outcome.

The Wizard of Oz setting that was used could also be subject to discussion (see [17] 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.

7. Conclusions

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. Although in our experiments the social skills did not result in a higher score on issues concerning technology acceptance, correlation analysis showed there is indeed an influence of perceived social abilities on acceptance. 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 and specifically to elderly users. Future research specifically addressing elderly users may involve the further investigation of specific influences on acceptance and 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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