Measuring the influence of social abilities on acceptance of an interface robot and a screen agent by elderly users

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ABSTRACT

Personal robots and screen agents can be equipped with social abilities to facilitate interaction. This paper describes our research on the influence of these abilities on elderly user's acceptance of such a system. Experiments were set up in eldercare institutions where a robotic and screen agent with simulated conversational capabilities were used in a Wizard of Oz experiment. Both agents were used with two conditions: a more socially communicative (the agent made use of a larger set of social abilities in interaction) and a less socially communicative interface. Results show that participants who were confronted with the more socially communicative version of the robotic agent 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. This effect was less strong however, with the screen agent, suggesting that embodiment plays a role in this. Furthermore, results did show a correlation between social abilities as perceived by participants and some aspects of technology acceptance for both systems, but this did not relate to the more and less socially communicative conditions. Evaluating the experiments and specifically the use of our acceptance model we suggest that this particular context of robotic and screen agents for elderly users requires the development of a more appropriate acceptance model which not only features technology acceptance, but also conversational acceptance.

Categories and Subject Descriptors

H.5.2. [**Information Interfaces And Presentation**]: User Interfaces - *Evaluation/methodology.*

General Terms

Measurement, Human Factors, Standardization, Theory

Keywords

User interfaces, Geriatrics, Technology acceptance model, Robot

acceptance

1. INTRODUCTION

The expected growth of the elderly population and labor shortage in healthcare have inspired a number of researchers to explore the applicability of intelligent systems in general and robots and screen agents in particular to enable elderly people to live more independently [1-3] The functionalities are generally related to supporting independent living by supporting mobility, basic activities like eating, bathing, toileting, getting dressed , providing household maintenance, monitoring and maintaining safety [1-4] Some studies also focus on the companionship a robot might provide, or on the environment where they can be used and on the factors that influences user acceptance [3, 5, 6], [7]. Still, if robots are to be used in the (near) future by elderly users, they have to be accepted by them and although a large category of elders may be open to facilitating technologies, technology acceptance remains a delicate matter that demands the use of sophisticated models [1, 8-10]. This may be so for both robotic and screen agents: since research on the use of screen agents, reports that responses to physical and virtual embodied agent systems is similar [11] to robotic agents it seems apparent that the influences on acceptance are similar. Both are in fact systems that people often tend to engage to as if it were personalities as they appear to do with mediated systems in general [12].

A particular influence we are interested in is that of (perceived) social intelligence. Recent studies on interaction with robots and screen agents stress the importance of social intelligence even more so in a health- and eldercare environment [13-17]. This implies that a more social intelligent agent will be more effective in its communication - it can be expected to be easier and more pleasant to interact with and therefore would be indeed accepted more easily.

However, many of these studies, especially those on social intelligence in human-agent interaction concerning elderly people, is based on either theoretical considerations or qualitative findings from a small set of users [1, 3, 7, 18].

In this paper, we present two experiments in eldercare institutions to gather quantitative data investigating the influence of perceived social intelligence on the acceptance of a robotic and screen agent by elderly users. The experiments were carried out with an interface robot (robotic agent) called iCat and a screen agent called Annie, both 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 it was simulated for the used interfaces and present how acceptance was measured. This is followed by a description of the set up of the experiments. After this, we will present the results, a discussion of the findings and conclusions.

2. RELATED WORK

Research involving tests of robots or agents with elderly users has been carried out with a seal shaped robot named Paro. In earlier studies [refs], it was positioned in a group of elders where they could interact with it, mainly by caressing and talking to it [5, 19]. 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. More recently, research with Paro focuses on collecting physical data on elders that have been exposed to the robot to measure its effect on their wellbeing [20]. Other experiments that took place in an eldercare institution concerned a robot named Pearl [21, 22]. 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 robot would be accepted. In case of Paro it would merely be beneficial as a pet (a study by Libin and Cohen-Mansfield [23] shows that a robotic pet is preferred over a plush toy cat) and in case of Pearl it would be used as an actual assistant. However, these studies were not addressing the issue of robot acceptance by collecting quantitative data.

Related research in which acceptance did play a significant role is described by De Ruyter et al. [24]. 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. This experiment was done in a laboratory setting, with adult, but not elderly participants. 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, [25]) 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.

The same robot was used in an experiment by Looije et al. [26] where it featured as a personal assistant for people with diabetes. Results showed that participants appreciated a more intelligent

agent and a greater chance of usage for a more social robot.

Research concerning experiments with screen agents for elders is reported by Bickmore and Picard [27]. The study focuses on the acceptance of a relational agent (a screen agent that simulates to have a personal interest in the user) appearing on a computer screen and functioning as a health advisor for older adults. Findings (scores on questions related to affection, trust and acceptance) indicate 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. Other research with the same agent [28] is focused on the ability to function in long term relationships in which social abilities also appear essential. It is linked to the notion of social presence [29, 30] that people feel in interaction with systems and although it is not measured in the experiments presented in this paper, it can play a role in interpreting the responses of people when social abilities are perceived.

Research comparing robots and agents generally shows that people respond to them in a similar way [11, 31, 32]. However, there might be differences in trust and it might be that the embodiment of a robot is more appealing and therefore people will invest more effort in communicating with it [refs].

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) [1, 21, 22], [24], [25] and acceptance of the robot as a conversational partner with which a human or pet like relationship is possible (social acceptance) [5, 7, 19, 27]. 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. AGENTS AND SOCIAL ABILITIES

3.1 Defining social intelligence and social abilities

In research concerning social aspects of autonomous interactive systems there are several definitions of the concept of social intelligence [16]. For the purpose of this study, our view of social intelligence and sociability will fit the description given for *socially communicative* robots within the classification by Breazeal [13] (extended by Fong et al. [33]): 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. These social cues are in this study social abilities, embodied in the behavior of the robotic or screen agent.

3.2 Listing relevant abilities

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) [34]. This tool usually is applied in social research, mostly on scholars and students, often related 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 [13, 16]. Similar constructs also appear to be relevant abilities in related studies [24, 35, 36]. In comparable studies [24, 31], [32] we also found Trust and Competence to be relevant concepts in human-agent interaction, so we added those to our list.

This leads to the following social abilities to be relevant in human-agent interaction: (1) cooperate, (2) express empathy, (3) show assertivity, (4) exhibit self control, (5) show responsibility, (6) gain trust and (7) show competence

In a recent study by Lee et al. [37] a similar attempt to list social abilities departs from Sternberg et al.'s prototypes of socially competent behavior, based on lay people's observations [38]. Although this is a very different list, the process to translate it into specific acts that can be mapped onto and agent's body (in case of Lee et al. the subject is an android) it faces the same problems which is addressed as the criterion of 'embodifiability'. Only limited acts can represent a specific ability and some abilities can not be represented because of the limitations of the specific agent or the context. In section V we will describe our attempt to face this issue and explain how we embodied the above mentioned abilities.

3.3 Embodiment of social abilities

Lee et al. [37] present a list of 27 behavioral codes with operational definitions that pass their criterion of 'embodifiability'. Although it is based on a different listing on perceived social behavior and is directed towards the specific category of androids, it covers the possibilities of embodiment of the above listed social abilities. With the specific agents (not mobile, limited possibilities of body movement) and the context of our experiments (just a short time to get acquainted and a very limited set of tasks to perform) we found only the following five behavioral features to be applicable (the numbers refer to the above listed abilities):

- 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).

Most items are more or less represented - only the feature 'exhibit self control' (4) is not represented at all. In section V we will demonstrate how the behavior was actually implemented.

4. USER ACCEPTANCE OF AGENTS IN ELDERCARE

Research on how and why individuals adopt new information technologies has lead to several approaches with different focuses. In an attempt to construct a unifying model that incorporates the most widely used approaches, Venkatesh et al. [25] included the theoretical models that employ intention and/or usage as the key dependent variable. The result of this process is the UTAUT (Unified Theory of Acceptance and Use of Technology) model

which has also been used in previous research in acceptance of robots [24, 26].

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 in section II, 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 [39] and thus we can use behavioral clues as an indication of conversational acceptance [40].

5. EXPERIMENTS

5.1 Hypotheses

The aim of this study is to evaluate the effect of social abilities in a robotic and screen agent on its acceptance by elders. In this specific experiment, acceptance was measured both as functional acceptance by using a technology acceptance model and conversational acceptance by using relevant questions and observations. The social abilities were implemented using the behavioral features as listed previously (III).

The hypotheses for this experiment were:

(1) The implementation of social abilities has a measurable influence on the acceptance of an agent by elders in an eldercare environment.

(2) An agent in which more social abilities are implemented will be perceived to be more social by its users.

(3) The influence of social abilities on acceptance will be similar for a robotic and screen interface.

5.2 Experimental methods

All experiments were carried out at eldercare institutions in Lelystad and Almere, the Netherlands. The experiments with the robotic agent took place in November and December 2005, those with the screen agent in may 2006

5.2.1 Subjects

Participants for each agent 42 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.

5.2.2 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.

5.2.3 Instruments

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 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 (SA) (also to be answered on a five point scale), two questions on experience with computers (CE) (to be answered with yes or no) and one question concerning the extent to which people felt (un)comfortable when talking to a robot (CA) (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. Table 1 lists the questions.

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 [35], [39], [40], [41] and [42]) 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.

Table 1. The questionnaire 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 system?
PE	4) Do you think the system would be useful to you?
PE	5) Do you think the system 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 be pleased 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 be pleased 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 few months?
ITU	27) If you could have iCat, would you want it in a few years?

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

Items are translated – the list used in the experiments is in Dutch.

5.3 Agents

5.3.1 The robotic agent

The robotic agent we used in our experiment is the iCat ("interactive cat"), developed by Philips, also used in the experiments by De Ruyter et al. [24] and Looije et al [26]. 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 tosimulate 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. We used the iCat with a female voice.

Fig. 1 The iCat

5.3.2 The screen agent

The screen agent was developed for our tests by students of the Instituut voor Information Engineering in Almere, Netherlands. It features a female character being able to move the same facial parts as the iCat. It was used on a 17 inch lcd screen in combination with a webcam (attached to the screen), a microphone and two speakers.

Fig. 2 Screen agent Annie

5.3.3 Embodiment of social abilities in both agents

For both agents the difference between the more social and less social condition was realized with the following behavioral features:

- The agent in the more social condition would gaze straight at the conversation partner, the agent in the less social condition would look past the participant.
- The agent would make a mistake by saying good morning when it would be afternoon or the other way round. When this would be made clear, the agent in the more social condition would admit this mistake, the agent in the less social condition would not.
- The agent in the more social condition would smile when appropriate and express cheerfulness in its movements, the agent in the other condition did not do this.
- The agent in the more social condition remembered the participant's name and use it – the agent in the less social condition would not.
- The agent in the more social condition would support the conversation partner by nodding and blinking, the agent in the less social condition would not do this.
- The agent in the more social condition would be better in turn taking by waiting until the conversation partner finished speaking, the agent in the less social condition was less polite.

6. RESULTS

The first step in our analysis is to compare the effect of the two conditions on the acceptance of both agents. Then we will study correlations between constructs. Our focus in this is to find out whether a higher perception of social abilities correlates with a higher score on other constructs. Finally we present the results of a factor analysis on the combined scores, which enables us to evaluate the relation between questions and constructs.

6.1 Comparing the two conditions

6.1.1 Questionnaire

Before analyzing the scores for the more and less socially communicative conditions, we calculated Cronbach's Alpha for the UTAUT constructs to check internal consistency. Although some researchers consider an alpha higher than 0.62 high enough, generally in psychology, an alpha of 0.7 and higher is considered acceptable, [43]. The constructs were formed by joining and mediating the scores for the questions that represented it. An exception to this was the SI construct: it represented by four questions, but two (questions 10 and 11) 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 for both agents, implying that we should not take these constructs into account because of low internal consistency.

To analyze the differences on the scores for the constructs, we used paired T-test. As is shown in Table 2, in fact none of the UTAUT-constructs showed a significant difference for the two conditions for neither of the agents. Also the scores on the five non-UTAUT questions related to social abilities (SA) did not show any significant differences for the two conditions.

Nevertheless, there is a pattern of higher score on constructs for the more social condition.

Table 2. Cronbach's alpha and t-scores on two conditions

Construct	Robot			Screen agent		
	Alpha	t	Sig. (2t)	Alpha	t	Sig. (2t)
PE	,7649	-0,1327	0,8953	,8921	0.838	0.408
EE	,8610	0,3622	0,7195	,6376	0.973	0.338
SI	,2997*			,5060*		
AT	,8889	0,4961	0,6230	,7575	0.677	0.503
SE	,8942	0,4567	0,6509	,6500	0.429	0.670
ANX	,4303*			,1153*		
ITU	,8954	0,4036	0,6891	,8483	1.108	0.276
SA	,7466	1,477	0,149	,7656	1,605	0,118
all constr.	,9346			,9120		
all items	,9084			,9299		

*Internal consistency for construct too low.

As Table 3 shows, a significant difference was found between the two conditions of the robotic agent 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 is a question with answers on a 3-point scale). All (17) participants who experienced the more social condition reported to feel comfortable (or 'not uncomfortable') about it, while 47% of the (19) participants that encountered the less social condition reported to feel a little or very uncomfortable. However, Table 3 also shows that this difference did not occur in the results for the screen agent.

Table 3. T score question on Conversational Acceptance

Condition	Robot				Screen agent			
	N	Mean	t	Sig. (2t)	N	Mean	t	Sig. (2t)
more social	17	1,00	-3,75	0,0015	18	1,28	-0,263	0,794
less social	19	1,53			18	1,33		

Table 4. Two conditions for the combined scores

Construct	Cronbach's Alpha	t	Sig. (2-tailed)
CA (q3)		2,223	0,029
PE	,8357	0,540	0,591
EE	,7737	0,900	0,371
SI	,4825*		
AT	,8269	0,807	0,423
SE	,6450*		
ANX	,2248*		
ITU	,8746	1,026	0,308
SA	,7145	2,046	0,045
All constr.	,8824	1,280	0,205

Listed are UTAUT constructs, plus the question on feeling uncomfortable talking to the robotic agent (CA) and the non-UTAUT construct of Social Abilities (SA)

After looking at these results for the robotic and screen agent, we combined the scores for both agents, calculated Cronbach's Alpha and performed a t-test on the results (see Table 4). The non-UTAUT construct of Social Abilities shows a significant difference between the conditions, indicating the more social condition would be indeed recognized as such. A two-way ANOVA on the combined scores (Table 5) confirms our findings, with significant scores for Conversational Acceptance and Social Abilities where the conditions are compared (no interaction effects between *robot* and *condition* were found).

Table 5. *Two-way ANOVA for all constructs*

source	variable	F	sig.
system	ca	,003	,955
	pe	,461	,499
	ee	,075	,785
	sa	,015	,903
	at	,246	,622
	se	2,185	,144
	itu	,413	,523
condition	ca	7,834*	,007
	pe	3,125	,082
	ee	1,081	,302
	sa	4,033*	,049
	at	,845	,361
	se	,521	,473
	itu	1,440	,235

6.1.2 Behavior observation

The different types of expressive behavior by participants during their interaction with the agent were counted and analyzed to measure conversational expressiveness, indicating conversational acceptance. Tables 6 and 7 show that, although none of these differences for individual behaviors are to be seen as significant (which is not surprising considering the small amounts), there are remarkable differences and there is a certain pattern of more expressiveness.

Table 6. Conversational expressiveness for the robot

Behavior	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
Frown	1	2	-0,5045	0,6189
Verbal greeting	36	21	1,9004	0,0672

Table 7. Conversational expressiveness for the screen agent

Behavior	more social (N=17)	less social (N=19)	t	Sig. (2-tailed)
Nodding head	83	50	2,526	0,016
Shaking head	9	10	0,015	0,988
non-verbal greeting	3	2	0,603	0,551
'don't know' gesture	2	10	-1,576	0,124
move away	5	6	-0,137	0,892
approach robot	6	17	-2,251	0,031
Smile	47	32	1,915	0,064
Laugh	16	17	0,157	0,876
Surprise	1	4	-1,309	0,199
Frown	11	11	0,293	0,771
Verbal greeting	23	21	0,822	0,417

If we look at the total number of times a type of behavior (positive/negative) occurred for the different conditions (Table 8), 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 frown).

Table 8. T sores on categorized behavioral observations

Agent	Robotic agent		Screen agent		Combined	
	t	Sig.	t	Sig.	t	Sig.
Positive	2,450	0,020	2,017	0,052	2,902	0,005
Negative	-0,986	0,333	0,457	0,650	-0,471	0,639
All items	2,063	0,047	2,024	0,051	2,607	0,011

6.2 Correlations

To see how the scores on constructs interrelated we performed a correlation analysis, using the scores on UTAUT constructs, the construct of Social Abilities (SA) and the question on feeling uncomfortable talking to a robot.

Table 9. Pearson correlation between perceived social abilities and constructs for the robot

Construct	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

As Table 9 shows, the score on the (non-UTAUT) construct of social abilities did show correlations with some of the UTAUT constructs and with the question on feeling uncomfortable talking to the robotic agent. The scores for the screen agent show a correlation of Social Abilities with every item (Table 10).

Table 10. Pearson correlation between perceived social abilities and constructs for the screen agent

Construct	Correlation	Sig. (2-tailed)
feeling uncomfortable	0,517	0,001
performance expectancy	0,584	0,000
effort expectancy	0,625	0,000
social influence	0,536	0,001
Attitude toward using technology	0,744	0,000
self-efficacy	0,522	0,001
Anxiety	0,751	0,000
intention to use	0,729	0,000

6.3 Comparing the two agents

Comparing the results of the robotic agent to those of the screen agent using t-tests, we found no significant differences between the scores for the constructs (neither for the more social, nor for the less social condition). For the individual questions we also did not find any significant differences except for question 24. On the question if they would be afraid to make mistakes or break something the score for the robotic agent was much higher for both conditions (see Table 11 – note that this concerns a reversed score: more negative response scores higher).

Table 11. T score question on being afraid to make mistakes or break something comparing both agents

Agent	N	Mean	t	Sig. (2-tailed)
Robotic	36	4.06		
Screen	36	4,83	-3,108	0,003

6.4 Combining the scores of both agents

To detect relationships among the questions beyond the existing constructs and to be able to explore alternative constructs by detecting hidden factors which underlie the questions, we performed a factor analysis. We used the combined scores of the agents and omitted questions 10 and 11 from the results, because these were dependent questions in the SI-construct. The questions on the Intention to Use were also not involved, because of their unique interrelation (they ask the same question, just the time is varied) and can thus form a construct that other constructs are to relate to. After a principal component analysis (see Table 12) we were able to distinguish five factors on which the responses to the questions loaded.

We regrouped the questions according to these factors, thus forming new constructs (Table 13). The first construct we called Performance and Attitude (PA). It measures how respondents 'see themselves' both practically and socially in the light of the new technology. It features the questions 4, 5, 12, 18 and 19. We kept the questions 25, 26 and 27 apart from this, because these Intention to Use questions were to remain an independent key construct that other constructs were to relate to.

The second construct we called Effort, Ease and Anxiety (EEA). It measures how easily people think they can adapt, learning how to work with the technology and overcoming eventual anxieties. It features questions 7, 8, 20, 21, 22 and 24.

The third construct we called Trust (TR). It features questions 15 and 16 on how well they trust the system when it advises them.

Table 12. Rotated component matrix for the combined scores

Question/ Construct	Component				
	1	2	3	4	5
3 CA				,645	
4 PE		,782			
5 PE		,781			
6 EE			,498		
7 EE	,782				
8 EE	,629				
9 SI				,667	
12 SI		,704			
13 SA				,629	
14 SA			,720		
15 SA					,846
16 SA					,851
17 SA			,759		
18 AT		,726			
19 AT		,581			
20 SE	,770				
21 SE	,750				
22 SE	,798				
23 ANX				,534	
24 ANX	,481				

Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. For questions loading on more components the highest score is listed.

The fourth construct is called Sociability and Understanding (SU). It measures how how sociable they rate the system and includes how well they feel understood. It features questions 6, 14 and 17. The fifth construct we called Enjoyment (ENJ). It incorporates questions 3, 9, 13 and 22 and measures how pleased people feel and how pleased they think others will feel with the new technology. The last construct would still be Intention to Use. As stated earlier, this remains a construct for other questions and constructs to relate to.

Applying Cronbach's Alpha to the newly formed constructs (Table 14) shows that overall they appear more consistent than the UTAUT constructs, although there is one weaker construct. The t-scores are generally higher, but still not leading to significant differences.

7. DISCUSSION

It is a remarkable development that our senior citizens might become the pioneers of a new era in which the company of robots becomes as usual as the use of cars. They might be among the first to get emotionally close to screen agents and robots. Our results on conversational acceptance suggest that this closeness will be slightly more probable for robots than for screen agents – it might be embodiment does have a say in this.

We are certain that while developing autonomous interactive systems like robots and screen agents for elderly users it is crucial to work on the implementation of social abilities in order to optimize interaction and acceptance.

Table 13. Newly formed constructs

Construct	Questions
Performance and Attitude (PA)	Do you think the system would be useful to you? Do you think the system would help you do things? Do you think the staff would be pleased if you would have this system? Do you think it is a good idea to use the system? Would you like to use the system?
Effort, Ease and Anxiety (EEA)	Do you think you can quickly learn how to control the system? Do you think the system is easy to use? Do you think you could work with the system without any help? Do you think you could work with the system if you could call someone for help? Do you think you could work with the system if you had a good manual? If you were to use the system, would you be afraid to make mistakes or break something?
Trust (TR)	Would you trust the system if it gave you advice? Would you follow the system's advice?
Sociability (SO)	As you have noticed, you control the system by speech. Do you think you can easily communicate with it that way? Would you consider the system to be social? Do you feel understood by the system?
Enjoyment (ENJ)	Did you feel uncomfortable talking to a system? Do you think many people would be pleased if you would have this system? Did you find the system a pleasant conversational partner? Do you feel at ease with the system?

Table 14. Two conditions for the combined scores - Cronbach's alpha and t-scores for the alternative constructs

Construct	Cronbach's Alpha	t	Sig. (2-tailed)
PA	,8607	0,793	0,431
EEA	,8477	0,355	0,724
SO	,6186*		
TR	,8860	1,892	0,063
ENJ	,7029	1,929	0,058
ITU	,8746	1,026	0,308
all constructs	,8406	1,539	0,129

*Internal consistency for construct too low.

Our study did show a significant influence of these social abilities, in conversational acceptance and correlations, but remarkably not in scores of UTAUT constructs as was done in other studies that used (an adapted version of) UTAUT as an acceptance model [24], [26]. This can be attributed to the relative shortness of the time that our participants were interacting and the simplicity of their tasks. This suggests that it may be necessary to collect data on longer-term interaction in which the experience of working with an agent goes beyond the first impression: results might in our case have been troubled somewhat by the 'overwhelmingness' of it.

Also the simplicity of the tasks might be something to take a

closer look at. It enabled us to set up a very strict scenario, allowing few surprises, but it also gave participants less of an impression of what an agent could do for them.

Besides such differences concerning the experiment itself, there was a difference in the instruments used. The other experimenters modified UTAUT less then we did and used statements instead of a questionnaire, which could have influenced the outcome.

Nevertheless our experiments did show the relevance of looking beyond technology acceptance when dealing with autonomous interactive systems and incorporate social acceptance. Besides, it demonstrated how a behavior analyses can complement a questionnaire based model. This is especially the case when dealing with elderly participants, because many of them are difficult to interview, either because of difficulty remembering what happened moments ago or because of difficulty focusing on anything longer than few minutes. To our experience, a questionnaire with 27 items is about the maximum.

The behavior analysis also lead to what might be one of the most surprising results of our experiment: participants were more expressive when interacting with a more expressive robot or screen agent (though the affect for the screen agent appeared less strong). This type of chameleon effect [44] has also been registered other research where it could be related to social acceptance [45].

The need to look for influences beyond technology acceptance is also illustrated by our factor analysis. We demonstrated how a re-arrangement of questions possibly results in more solid model, although this has of course to be confirmed by further research, involving not only tests that predict acceptance, but also data concerning acceptance in real use situations.

8. CONCLUSIONS

The results show a significant correlation of social abilities with factors that influence acceptance, but the influence of social abilities has only been partly confirmed by the present research. We could however confirm that systems in which social abilities were incorporated were recognized as being more sociable.

Regarding the differences between the robot and screen agent, we conclude there are some differences that have to be accounted for. The effect of participants being more expressive when interacting with a more expressive agent appears to be stronger for the robot than for the screen agent. Besides, when dealing with the robot, participants were more afraid to do something wrong or break something, which might in some cases increase anxiety.

Concerning the acceptance model used, our experiments show that when dealing with robots and screen agents, a model that does not only focus on technology acceptance but also on conversational acceptance can be a more appropriate instrument.

9. ACKNOWLEDGMENT

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