The Influence Of Perceived Adaptiveness Of A Social Agent On Acceptance By Elderly Users

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Abstract— **In this paper we describe the development and exploration of the concept of Perceived Adaptiveness, based on observations in previous experiments with a robotic companion in eldercare and on findings in related research. We integrated this concept in our technology acceptance methodology for robotic eldercare companions and found in experiments with a robotic agent and a screen agent (n=30 for both) that adaptiveness of the system as perceived by elderly users is indeed a relevant item. It can be viewed as a direct influence on the usefulness of the agent as perceived by the users.**

I. Introduction

When presenting a robot to elderly users, we often observed a certain disappointment when users realized a robot was offering a functionality that was not (yet) needed by them. For example, if we demonstrated a robot that could monitor them, control several devices have small conversations and help them remember things, some would reject it because they wouldn't use anything that would help them remember things as long as their memory was still working. However, when the robot was perceived to be adaptive (it would only help remember if this was found necessary by the user) we observed relief and sometimes excitement.

In our project, in which we aim to develop a methodology for predicting and explaining acceptance of social robots and screen agents (companions) used in eldercare [1], we are currently experimenting with both robots and screen agents. Motivated by our observations, which are supported by related research that stresses the importance of adaptiveness in assistive technology [2, 3], we measured the amount in which adaptiveness of a social agent was perceived within two acceptance studies with different agent types: a robot and a screen agent. We hypothesized that for both systems Perceived Adaptiveness could be related to perceived usefulness and to the intention to use the system.

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For our study, we define perceived adaptiveness as 'The perception that the technology is either autonomously adapting or can be adapted to the needs and situation of its user.'

After discussing related work, we will present our experiments in which we explored the concept of adaptiveness and established its importance and its place in an acceptance model for robots and screen agents in eldercare.

II. Related Work

Research related to our project concerns experiments with robots in an eldercare environment, research on technology acceptance involving robots and research concerning elderly users and involving adaptiveness or adaptabilty. We will discuss these different aspects in the subsequent paragraphs.

A. *Robots and screen agents in eldercare*

Projects addressing the development of conversational robots for experiments in eldercare are either focussing on possibilities and requirements or on measuring the responses tot it by performing experiments with specific robots.

An example of the latter is the research done with a seal shaped robot called Paro. These experiments showed that a robot could have the same beneficial effect on elders that a pet can have, making them feel happier and healthier [4-6]. A more recently developed robot with similar pet-like functionalities is the Huggable[7].

Another example of a robot developed specifically for eldercare experiments is 'nursebot' Pearl, a robot that could actually provide advanced assistance to elders, although its functionalities were merely simulated [8, 9].

A more recently developed robot to be applied in eldercare is Care-o-bot. This robot has is intended to provide assistance in many ways, varying from being a walking aid to functioning as a butler [10, 11].

The Robocare project concerns the development of a domestic environment with an assistive robot for elderly people. Research focuses on design issues and technical requirements for both the robotic agent and the environment of which it is a part [12, 13].

Research concerning experiments with screen agents for elders is reported by Bickmore et al. [14, 15] 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.

These different examples suggest that robots and screen agents (physical and graphical robots) could both perform as social actors and fulfill practical functions, although the focus obviously differs within the different projects: some are merely targeting user requirements, while other projects research user responses.

B. *Technology acceptance and robots*

Since the first introduction of the technology acceptance model (TAM) in 1986, it has become one of the most widely used theoretical models in behavioral psychology [16]. In its most basic form it states that Perceived Usefulness and Perceived Ease of Use determine the behavioral Intention to Use a system and it assumes that this behavioral intention is predicting the actual use. The model has been used for many different types of technology and has been extended with other factors that supposedly influenced Intention to Use or usage. In 2003, Venkatesh et al. published an inventory of all current models and factors and presented a new model called UTAUT in which all relevant factors would be incorporated [17].

In research with acceptance models, the main instrument to measure these influences is a list with questions or statements. A number of items that measure the same influence can be grouped as a measure of more general constructs. The validation of a model typically includes a long term observation of the actual use of the technology, which makes it possible to relate scores on Intention to Use to actual usage [18].

The UTAUT model has been used in related research on acceptance of a conversational robot as described by De Ruyter et al. [19] 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 operator while the participants perceived it to be autonomous. This experiment was done in a laboratory setting, with adult, but not elderly participants.

The results showed that the extravert iCat was perceived to be more socially intelligent and was also more likely to be accepted by the user than a more introvert version.

C. *Adaptiveness and adaptability*

Coming of age is often described as a process in stages – and every stage has its specific needs [2]. Assistive technology should be adaptive to the stage the user is in, which means it does not provide assistive functionalities until the user really can't do without it [20-22]. Although this concept is mentioned and explored in several studies, also concerning robotic technology, it has not yet been measured as a construct in a technology acceptance model.

III. EXPERIMENTS

In this section we will describe two experiments in which we tried different agent systems on elderly users and gathered data both on how users perceived the system after a short encounter with it (first part) and on the actual use of the system (second part). With the first part we could establish the relationship between Perceived Adaptiveness and the constructs within our acceptance model it is hypothetically related to, with the second part we could validate the model by relating intention to use to actual use. The first experiment concerns a robotic agent, tested in an eldercare institution where it could be used for five days. The second part concerns a screen agent, installed on the pc's of elderly users still living independently who used it for ten days.

A. *Hypotheses and questionnaire*

In our research, we used the construct of Perceived Adaptiveness (PAD), represented by three questions (see Table I) in a questionnaire containing statements that demanded a reply on a five point Likert scale. The other constructs used in our applied hypothetical model are Perceived Usefulness (PU), Perceived Ease of Use (PEOU) and Intention to Use (ITU).

TABLE I – STATEMENTS (TRANSLATED FROM DUTCH) FOR PERCEIVED ADAPTIVENESS, PERCEIVED USEFULNESS, INTENTION TO USE AND PERCEIVED EASE OF USE

Construct	Statements
Perceived adaptiveness	I think the agent can be adaptive to what I need I think the agent will only do what I need at that particular moment I think the agent will help me when I deem it necessary
Perceived usefulness	I think the agent is useful to me I think the agent can help me with many things
Intention to use	I think I'll use the agent the next few days I am certain to use the agent the next few days I'm planning to use the agent the next few days I think I'll use the agent for this amount of minutes: 0 l up to 5 l 5 to 15 l 15 to 30 l more then 30
Perceived ease of use	I think the agent is easy to use I think I can use the agent without much help I think I'll quickly learn how to work with the agent

For *the agent* we wrote *iCat* for the participants that used the robotic agent and *Steffie* for those who used the screen agent.

We hypothesized the score for Perceived Adaptiveness would not only relate to the score for Intention to Use, but also to the scores for Perceived Usefulness, since adaptiveness can be seen as an aspect of usefulness of a system.

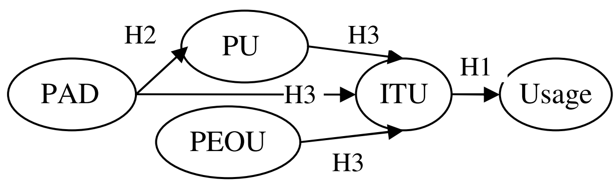

Figure 1. Applied model

We tested the following hypotheses:

- H1 Usage is predicted by Intention to Use
- H2 Perceived Adaptiveness is a determining influence on Perceived Usefulness.
- H3 Intention to Use is determined by Perceived Adaptiveness, Perceived Ease of Use and Perceived Usefulness

As Table I shows, we used a list with three to five statements for each construct that test participants could reply to on a five point scale (totally agree – agree – don't know – do not agree – totally do not agree).

We wanted our participants to fill this list out themselves if possible.

B. *Experimental setup for the robotic agent*

1) *System*

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. [19] and within our own project. 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. It can be controlled with animation software, running on a separate computer. There is a camera installed in the iCat's nose which can be used for different computer vision capabilities.

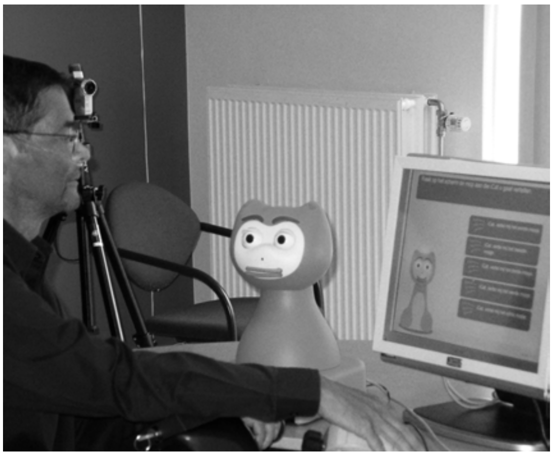

Figure 2. Test participant using iCat with touch screen

For this experiment, we used a setup in which the robot was connected to a touch screen as is shown in Figure 2.

It could be used for information and for fun: the participants could ask for weather forecast, a television program overview or a joke by pressing the appropriate choices from a menu on the screen. The information was then given with pre-recorded speech by the iCat, for which we used a female voice. The recording was done with a text to speech engine.

We designed this experiment with the iCat to take place in two eldercare institutions in the city of Almere in the Netherlands with the first part consisting of a short test, during which participants were to meet a robot and work with it for a few minutes individually.

2) *Subjects*

There were 30 participants, recruited both by eldercare personnel and by students. Their age ranged from 65 to 94, while 22 of them were female and 8 were male. Some of them lived inside the eldercare institutions, some lived independently in apartments next to the institutions.

3) *Procedure*

Participants were brought into a room were they were instructed to simply play with the robot for about three minutes. Subsequently they were brought to another room where they were given a questionnaire. They could ask for help if they were unable to read the statements.

After these sessions were completed, we left the robot for public use in a tea room. On the screen were buttons with the names of the test session participants and one extra button saying "I'm not listed". Passers by were informed by a note that anyone could use the robot and that they could start a session by pressing the button with their name on it or the "I'm not listed" button if their name was not on the screen.

C. *Experimental setup for the screen agent*

1) *System*

Steffie is a screen agent designed in Flash and developed as a part of a website (www steffie.nl) where she features as a talking guide, explaining the internet, e-mail, health insurance, cash dispensers and railway ticket machines.

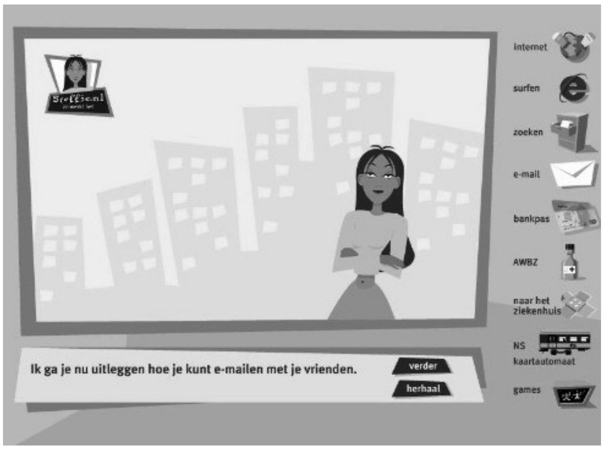

Figure 3. Screen agent Steffie

We used an offline version of the application, kindly provided to us by the developers. We used this version on the pc's of participants.

We added an entrance page on which there were the names of possible users. If the user chose a name, it was recorded in a log file and if the user ended the session, it wrote the ending time in the log file. Also, if the user did not use the application for 90 seconds, it closed and wrote the time in the log file with the addition 'auto', so the difference between automatically and manually closed sessions was evident.

2) *Participants*

Participants were 30 elderly users who owned a pc. Their age ranged from 65 to 89 and they were all living independently. Of the 30 participants, 14 were female and 16 were male.

3) Procedure

The participants were visited by a researcher who installed the Steffie application on their pc. Subsequently they were to try out the application for a minimum of two and a maximum of three minutes. After this they were to fill out our questionnaire. After ten days, the researcher returned, copied the log file and deleted the application from the pc.

The usage data for both systems was collected by using the log. For the iCat, the log was compared to video footage the check if the users were the person they claimed to be when logging in.

IV. RESULTS

In both experiments the test session and the questionnaire were completed by 30 participants. When analyzing the replies to these statements, we used Cronbach's alpha to test the reliability of the constructs. In psychology, an alpha of 0.7 and higher is considered acceptable [23]. As Table II shows, the constructs were highly reliable.

TABLE II – CRONBACH'S ALPHA FOR USED CONSTRUCTS IN THE EXPERIMENTS WITH THE ROBOTIC AGENT AND THE SCREEN AGENT

Construct	Robotic agent	Screen agent
Perceived Adaptiveness	,834	,834
Perceived Usefulness	,787	,787
Intention to Use	,947	,947
Perceived Ease of Use	,886	,886

Next, we looked at the correlation for the constructs and usage measured in minutes in both experiments (Tables III and IV).

TABEL III – CORRELATION SCORES FOR THE ROBOTIC AGENT

Construct		ITU	PAD	PU	PEOU
PAD	Pearson Corr.	,544**	1	,936**	,442*
	Sig. (2-tailed)	,002		,000	,015
PU	Pearson Corr.	,504**	,936**	1	,468**
	Sig. (2-tailed)	,005	,000		,009
PEOU	Pearson Corr.	,633**	,442*	,468**	1
	Sig. (2-tailed)	,000	,015	,009	
Min.	Pearson Corr.	,625**	,325	,657**	,625**
	Sig. (2-tailed)	,000	,079	,000	,051

TABEL IV - CORRELATION SCORES FOR THE SCREEN AGENT

Construct		ITU	PAD	PU	PEOU
PAD	Pearson Corr.	,608**	1	,493**	,386*
	Sig. (2-tailed)	,000		,006	,035
PU	Pearson Corr.	,861**	,493**	1	,697**
	Sig. (2-tailed)	,000	,006		,000
PEOU	Pearson Corr.	,585**	,386*	,697**	1
	Sig. (2-tailed)	,001	,035	,000	
Min.	Pearson Corr.	,623**	,344	,410*	,035
	Sig. (2-tailed)	,000	,063	,025	,856

There was a very strong correlation between Perceived adaptiveness and Perceived usefulness, especially for the robotic agent. We decided to take a look at Cronbach's alpha for the combined construct. as shown in Table V.

TABLE V - CRONBACH'S ALPHA FOR THE COMBINED CONSTRUCTS OF PERCEIVED ADAPTIVITY AND PERCEIVED USEFULNESS

Construct	Robotic agent	Screen agent
PAD + PU	,841	,776

Indeed, the score for the combined constructs is high and for the robotic agents it is even higher than the scor for each of the constructs.

Although all constructs correlate with Intention to Use, we checked if a regression analyses on the combined scores for both agents would confirm this. As table VI shows, only the 'classical' model with Perceived Usefulness and Perceived Ease of Use determining Intention to Use could be confirmed.

TABLE VI – REGRESSION ANALYSIS ON CONSTRUCTS DETERMINING INTENTION TO USE

	Beta	t	Sig.
(Constant)		-1,008	,318
PU	,422	3,901	,000
PEOU	,409	3,778	,000
PAD	,158	1,011	,316

V. DISCUSSION

First of all, we note that for both agents, the correlation scores show a strong relation between Intention to Use and actual use measured in minutes. This means we can indeed use this model to study acceptance.

With the strong correlation it seems clear that the concept of Perceived adaptiveness should be represented within a technology acceptance model for eldercare companions. It is however unclear if it should be an extension of Perceived Usefulness. Possibly tests on different types of companions with different functionalities could provide more clarity.

For both agents, the correlations are strong between all constructs. Nevertheless, there are some differences – although the goal of our study is to find similarities, not differences:

- Perceived ease of use correlates strongly with usage measured in minutes for the robotic agent, but not for the screen agent.
- Perceived Usefulness correlates stronger with usage measured in minutes for the robotic agent.
- The relationship between Perceived Adaptiveness and Perceived Usefulness is stronger for the robotic agent.

Because the agents, their functionalities and the environment in which they were used differed, it is hard to explain these differences. However, all three can be more or less explained by the fact that the screen agent's mere function was to inform and the robot was merely entertaining people because its information was very brief and could easily be found elsewhere. The screen agent was simply perceived useful, also by those who were not going to use it and the ones who used it did not mind the ease of its use.

It has to be said that strong correlation between Perceived adaptiveness and the other constructs does not necessarily mean that a more adaptive system is to be accepted better. In earlier experiments we compared responses to a robot with more social abilities to the same robot in a less sociable condition. Participants who showed a higher appreciation for the robot's social abilities did score higher on acceptance, but this appreciation did not significantly correlate with the two conditions. We suggest an experiment comparing responses to a more adaptive robot to those of a less adaptive condition of the same robot could provide more substantial evidence for the relevance of this concept.

VI. Conclusion

Our first two hypotheses can be accepted based on correlation analysis: Perceived Adaptiveness has a determining influence on Perceived Usefulness and Intention to Use predicts the actual use of the agent. The third hypotheses can only be partly accepted: Perceived Usefulness and Perceived Ease of Use are determining Intention to Use, but our regression analysis excludes Perceived Adaptiveness as a determent of Intention to Use.

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