Attitude of elderly towards a robotic game-and-train-buddy: evaluation of empathy and objective control

A.M. van Ruiten[1], D. Haitas[1], P. Bingley[2], H.C.M. Hoonhout[2], B.W. Meerbeek[2], J.M.B. Terken[1]

[1] University of Technology
Den Dolech 2, 5612 AZ Eindhoven, The Netherlands
{a.m.v.ruiten, j.m.b.terken}@tue.nl, daphne@haitas.gr

[2] Philips Research
High Tech Campus 34 (WB 51), 5656 AE Eindhoven, The Netherlands
{peter.bingley, jettie.hoonhout, bernt.meerbeek}@philips.com

Abstract: The number of elderly people will grow rapidly in the next decades. A common concern of elderly is the ability to stay independent. Personal service robots could be used to assist elderly in daily activities. To investigate whether elderly are willing to except these kinds of robots, we studied the perception and attitude of elderly users towards this technology. Since the level of empathy and of objective control is expected to play an important role in the interaction with robots, it is studied whether these factors have an influence on the attitude of elderly towards robots. Thirty-one participants interacted with three different versions of the robot, which functioned as a game-and-train buddy. The attitude towards the game-and-train buddy in all conditions was positive. The results show that the level of empathy and the level of control did not have a significant main effect on the attitude of users towards the robot.

Keywords: robot, empathy, control, elderly, acceptance, attitude, games

1 Introduction

In 2005, 10 percent of the world population was 60 years or older and it is estimated that this will increase to 22 percent in 2050 [1]. Worldwide, the number of elderly will increase from 673 million in 2005 to almost two billion by 2050. The aging of the population has severe consequences for our society, for example increasing costs of (health)care and a growing demand for caregivers. But it also has some personal consequences for the elderly themselves. Important needs for elderly people, such as remaining autonomous, maintaining social ties and experiencing pleasure, become more difficult to realize because of age-related decline in functioning. For example, there is a decline in perception – vision and hearing, and a decline in movement control, including slower responses and less precise movements [2]. Moreover, increased age is associated with decline in cognitive functioning, e.g. a decline in memory, attention and speed of information processing. A decline of cognitive and/or physical abilities can easily lead to difficulties in performing everyday tasks, making one more dependant on caregivers and other forms of support.

Different types of personal robots are being developed to assist elderly in their daily lives. These include mobile robot assistants, robot companions, therapeutic robots, and socially assistive robots (see for an example [14]). An important aspect of personal robots is their ability to interact with people in much the same way as human-human interaction [3]. More and more robots are designed with human-like characteristics, such as facial expressions, speech recognition, body movements and even emotions, since these characteristics are expected to play a role in the acceptance of robots and in the perception of people towards robots. To better understand the effects of these characteristics on acceptance, it is important to investigate the perceptions and attitudes of users towards these robots. Here ‘attitude’ refers to the evaluation of a particular entity, which can be an object, person, situation, institution or event. Eagly and Chaiken [4] defined attitude as 'a psychological tendency that is expressed by evaluating a particular entity with some degree of favour or disfavour'.

There are several factors that can play a role in forming attitudes and perceptions towards using robots. An important element in the relation between human and a robot could well be empathy [5]. Empathetic behaviour can be defined as the ability to understand another's feelings, share in another's feelings, and communicate to another by verbal or non-verbal means [6]. The level of objective control the user has is also important in human-robot interaction [8]. The level of autonomy the robot has, determines how much control remains for the user.

In this paper we present a study investigating the attitude of elderly towards a robot, more specifically a robot acting as a game-and-train buddy, aiming to entertain them with games, while at the same time engaging them in a cognitively stimulating activity.

2 Methods

The objective of the study was to explore the attitude of elderly towards a game-and-train robot, in specific the effect of empathy and level of control on their attitude. The research questions addressed were (1) What is the attitude of elderly towards iCat as a game-and-train robot? (2) What is the effect of the level of control on the attitude of the users towards iCat? (3) What is the effect of empathetic behaviour of iCat on the attitude of users towards iCat?

2.1 Experimental design

In total, 31 persons (21 men, 10 women) participated in the study. Except from three persons, all participants were older than 65 (these three persons were 57, 59, and 63 years old); the average age was 69 years. All 31 participants were retired and living independently (not living in an institution like an elderly home). In the experiment the two independent factors empathy and control both had two levels. This resulted in four conditions: neutral-high control, neutral-low control, empathetic-high control, and empathetic-low control. The study was an unbalanced incomplete block design, in which all participants were presented with three conditions. We decide to use this

experimental design, since presenting all four conditions would make the sessions too long and with three interactions the participants could still obtain a good impression of the levels of both factors.

2.2 iCat as game-and-train-buddy

In the study, the participants played the game 'Mastermind' with iCat. The "Interactive Cat" or iCat is a robot developed by Philips Research in order to study personal robotic applications and human-robot interactions [7]. The robot is 38 cm high and able to move different parts of its head using 13 servos. This allows the interactive robot to express several facial emotions, like anger, disgust, happiness and fear. The robot has a stereo microphone to locate sound sources, to record sound and to enable speech recognition. A built-in webcam makes it possible for iCat to recognize objects and people. Finally, the robot has touch sensors and multi-colour LEDs in the ears and feet, for sensing when the user touches the robot and for communicating information to the user via coloured light. Several applications can be realized with iCat, such as a messenger-robot or a TV-assistant [8].

In our version of the game, iCat creates a hidden code, consisting of an array of four differently coloured pegs, and the participant has to guess the code in at most 10 attempts, receiving feedback after every attempt. iCat thus acted as a 'game master'. The game Mastermind addresses several cognitive functions: hypothetical testing, deductive reasoning, logic and visual attention [9-10].

2.3 Design of empathy and control in iCat

In this experiment, empathetic behaviour is described as the ability to understand and feel for another's situation, thoughts and feelings and to respond affectively upon this in an accurate way. The two versions of iCat differed on three aspects: speech content, pitch (voice characteristic) and facial expressions, to express the two levels of empathy (see table 1). The selection of these three aspects was based on findings in literature, and also taking into account the possibilities in this respect of iCat.

In order to vary the level of control, there was a different dialogue approach for the low and high control conditions. The participants in the low control condition had the possibility to give commands to iCat (low control for iCat). In this way, the participants had the initiative in the dialogue. They could give four different commands to iCat: tell instructions, play game, check guess and stop game. iCat responded to these commands by giving a response or performing a specific action. However, due to the nature of the dialogue, it was difficult to realize fully low control: iCat still had to ask some questions. Therefore, it is better to refer to this condition as low and mixed user control. The participants in the high control condition could not give commands (high control for iCat). In this condition, iCat had the complete initiative and asked all the questions (see table 1).

In the four conditions the different levels of empathy and control were combined.

Table 1: Design-criteria for the four different conditions. These criteria were all based on a review of relevant literature (details can be obtained via the authors).

	Low control/ mixed control	**High control**
Objective control	o User directed approach: the user gives commands o Some questions are asked by iCat	o System directed approach: iCat asks all the questions. iCat has the initiative. User answers questions

	Empathetic iCat	**Neutral iCat**
Empathy	Empathetic behaviour of the iCat o *Facial expressions*: more facial expressions, smiling behaviour, looking at the participant, nodding and facial expressions in line with the dialogue. o *Speech content*: personal feedback, emotional verbs, encouragement, vocalization agreement o *Voice characteristics*: moderate pitch	Neutral behaviour of the iCat o *Facial expressions*: less facial expressions, neutral face, less looking at the participant, less nodding and more general facial expressions. o *Speech content:* limited feedback, no encouragement, no vocalization agreement. o *Voice characteristics*: low pitch

2.4 Measurements & Procedure

Participants took part in the test individually, and the sessions took place in the HomeLab of Philips at the High Tech campus in Eindhoven, The Netherlands. The HomeLab enables user experience research in a realistic (i.e. home-like) environment [11].The experiment consisted of three interactive trials with iCat. iCat differed in these three trials on the level of empathy of iCat and the level of control the users had during the interaction with iCat. In all three trials the participants played the game Mastermind with iCat. If the code was guessed correctly in less then four tries in a given session, the participant was asked to play another game with the same version of iCat. One trial with iCat lasted approximately 15 minutes. After each trial participants were asked to complete a questionnaire containing 20 questions to determine the attitude towards the robotic game-buddy (adapted from [12]). Furthermore, there were 6 questions related to the users' perceived control (adapted from [13]) and 10 questions measuring perceived empathy of the iCat. All the items were measured with a 5-point Likert scale, ranging from 'totally not agree' to 'totally agree'. After the three sessions with iCat, the experimenter conducted an interview with the participants that contained a series of questions about their general

impression of iCat as a game-and-train-buddy. Altogether the experiment lasted approximately one-and-a-half hour per participant.

3 RESULTS

Due to technical problems, the sessions of five different persons had to be discarded from the analysis, resulting in 88 remaining sessions. These interactions were equally divided over the conditions, which resulted in 22 measures in each condition.

3.1 Quantitative data

An ANOVA on the perceived empathy questionnaire items did show a significant main effect of the level of empathy on perceived empathy, F (1,27) = 10.09, $p < .01$. The median of the empathetic iCat (Mdn = 2.95) is higher than the median of the neutral iCat (Mdn = 2.75), which indicates that the users perceived the empathetic iCat as more empathetic than the neutral iCat.

The level of control on perceived control also showed a significant main effect: F (1,24) = 4.89, $p < .05$. The median of the low control group (Mdn = 3.50) is higher than the median of the high control group (Mdn = 3.33), which indicates that the participants in the low control (of iCat) condition perceived that they had more control themselves during the interaction with iCat and that the participants in the high control (of iCat) condition perceived that they had less control during the interaction with iCat.

To answer our main research question, a univariate analysis of variance (ANOVA) was conducted that tested the effect of empathy and control on the attitude of elderly towards iCat as a game-and-train-buddy. There was no significant main effect of the level of objective control on attitude, F (1,24) = .20, $p = .662$. The medians of both groups are nearly similar and high, around 4.00 on the attitude scale (which was a 5-point scale). Moreover, there was no significant main effect of the level of empathy on attitude, F (1,27) = 3.05, $p = .092$. The medians of these two groups are also almost similar and high, approximately 4.00 on the attitude scale.

3.2 Qualitative data

After the three sessions with iCat, a semi-structured interview was conducted with the participants. The analysis of the interview data includes the answers of all 31 participants.

The participants were asked to make a comparison between the three versions of iCat that they had seen. Most people found it difficult to answer the question whether they had a specific preference or dislike for one of the three iCats that they had interacted with. Also, most persons did not have a strong opinion about whether they liked a specific level of empathy or control (see table 2). Most people

that had a preference preferred the low control situation, but there was only a slight difference between the two levels of control. Some reasons that were mentioned for a preference for low control were 'there is more interaction' and 'you can take more initiative yourself'. Participants who preferred high control mentioned that 'it works easier and faster without commands'. There was no clear preference for the empathetic versus the neutral iCat. Those participants that had a preference for the empathetic iCat, mentioned that it was friendlier and was more responsive, as the main reasons for their preference.

Table 2: Preference and dislike per factor, numbers indicate how many people gave that answer

	Preference	**Dislike**
Control	High: 6 Low: 8 No opinion: 12	High: 8 Low: 4 No opinion: 14
Empathy	Empathetic: 10 Neutral: 2 No opinion: 14	Empathetic: 2 Neutral: 6 No opinion: 18

The participants were also asked some questions related to gaming and iCat as a game-and-train buddy. Fourteen participants mentioned that they like to play games. Frequently mentioned examples of games that were played by the participants are puzzles (Sudoku), computer games, and cards. Twenty-two persons said that they had already played the game Mastermind before, but most of them mentioned that it was a long time ago. The others had never played the game before. Many people (19) said that they liked playing Mastermind, since it is a game that requires reasoning. Furthermore, almost all of the participants (27) indicated that they performed certain activities in order to stimulate mental activity. Solving puzzles (Sudoku), reading books, working on the computer, and doing sports were most frequently mentioned as activities performed to stimulate mental activity. In general, the participants had a positive attitude towards playing games with iCat. Examples of positive reactions were that it was nice, enjoyable, and an interesting alternative when there is no other person to play games with. Some negative points that were mentioned were that it is nice to play a game with a human (1) and that after a while iCat does not have added value anymore in comparison with playing games on a computer (3). Some of the participants' suggestions for improvement were: less repetition in the interaction with iCat, more and faster responses, and the possibility to play more games. Finally, some people mentioned that iCat can be useful for other applications, such as an alarm clock, medicine-reminder, and a calendar with reminder function.

4 DISCUSSION AND CONCLUSION

In the experiment, the effect of the level of empathy and the level of control of iCat on the attitude of elderly towards iCat as a game-and-train-buddy was tested. The results from the questionnaire showed that the attitude of the participants towards both the neutral and empathetic iCat was practically equally positive. The same effect holds true for the level of control: the results from the questionnaire showed that the attitude towards iCat is similar for the low-and high control interactions. Overall, the users are positive about the low- and high control interactions. The results of the interview also showed that there is no clear preference for one specific level of control or empathy, but the results confirmed that in general the participants had a positive attitude towards playing games with iCat. A positive attitude of elderly towards robotic technology was also found by Cesta and others [14] who investigated application scenarios for mobile robots that assist in everyday tasks.

There are some possible reasons for not finding significant effects of level of control and empathy on users' attitude towards the robot. One explanation can be that the participants did interact with iCat for the first time: It was a new experience for them. Since interacting with a robot was a completely new experience for the participants, they might have evaluated the general concept of iCat rather than the different interactions. In general, participants were very positive about the concept of iCat as a game-and-train-buddy, which could have resulted in positive scores on attitude for all different versions of iCat. Surprisingly, half of the participants mentioned that they see iCat more as a machine than as a robot with human-like characteristics. This seems to be in contrast with findings from previous iCat studies with children and younger adults (18-60 years) [8], [15]. Further research is needed to investigate whether age indeed has an influence on the perception of human-likeness in robots. Since half of the participants in our study think that robots can not have human-like characteristics, they found it difficult to rate the level of empathy. They also found it difficult to evaluate the level of control, because they believe that a robot is fully controlled by the person who programmed it. Another explanation for not finding an effect of the level of control and empathy on the attitude towards iCat could be that the differences between the four versions of iCat were not big enough. Although the results of the questionnaire show that the participants did see a difference between the levels of control and empathy, it could be that these differences were too small to have an effect on the attitude towards iCat. Third, the type of application could have had an influence. It might be possible that in other applications, such as medical applications, the effects of empathy and control play a bigger role than in a game-and-train buddy application.

To conclude, this study indicates that elderly have a positive attitude towards a robotic game-and-train buddy. Although this is a promising finding, many issues need to be investigated in more detail in the future. The present study covered only short-term interactions in a laboratory setting. It would be interesting to investigate how elderly would experience iCat if they interact with it for a longer time in their own homes. Therefore, long-term field studies are being planned. Since the results show that elderly indeed are concerned about their mental health and that they do perform certain activities to stimulate their cognitive abilities, the application of a game-and-train-buddy is considered to address a need. Further light on this need, and on the

possible role of such an application will be explored in more detail in the field trial. However, other ways in which robots could assist elderly in their daily lives and help them to stay independent longer need to be investigated as well, so in the future, the game-and-train buddy might evolve into a true companion and useful assistant in all kinds of everyday activities.

Acknowledgments. We would like to thank the following people: the members of the iCat-project team for their support and interest, the HomeLab-team for their technical support during the experiment and all the participants for their time and effort to participate in the experiment.

References

1. United Nations (2005). *www.un.org/esa/population/ publications/WPP2004/2004Highlights_finalrevised .pdf* (Last visited March 17, 2007)
2. Fisk, A. D., Rogers, W. A., Charness, N., Czaja, S. J., & Sharit, J. (2004). *Designing for older adults. Principles and creative human factors approaches.* Boca Rato, Florida: CRC Press.
3. Thrun, S. (2004). Towards a framework for human- robot interaction. *Human computer interaction, 19* (1 & 2), 9-24.
4. Eagly, A., & Chaiken, S. (1993). Psychology of Attitudes. (pp. 1) NY: Harcourt, Brace Jovanovich.
5. Paiva, A., Dias, J., Sobral, D., Aylett, R., Sobreperez, P., Woods, S., et al. (2004). *Caring for agents and agents that care: Building emathetic relations with synthetic agents.* Paper presented at the Third international joint conference on Autonomous agents and multiagent systems, New York, USA.
6. Bavolek, S.J. *http://nurturingparenting.com/research_validation/developing_empathy_in_ families. pdf.* (Last visited June 26, 2007).
7. Breemen van , A. J. N. (2004). *iCat: a generic platform for studying personal robot applications.* Paper presented at the IEEE SMC, Den Haag.
8. Meerbeek, B., Hoonhout, J., Bingley, P., Terken, J. (2006). *Investigating the Relationship between the Personality of a Robotic TV Assistant and the Level of User Control*, In: Proceedings RO-MAN06 (pp. 404-410).
9. Tanguay, P.B. (1999). *www.nldontheweb.org/ Cognitive.htm* (Last visited June 12, 2006).
10. Peterson, I. (1999). *http://www.sciencenews.org/pages /sn_arc99/10_9_99/mathland.htm* (Last visited March 17, 2007).
11. Van Loenen, E., De Ruyter, B. & Teeven, V. (2006). ExperienceLab: Facilities. In Aarts, E. & Diederiks, E. (Eds.), *Ambient Lifestyle: From Concept to Experience* (pp. 47 – 53). Amsterdam, The Netherlands: BIS Publishers.
12. Larsen, L. B. (2003). *On the usability of spoken dialogue systems.* Aalborg university.
13. Novak, T.P., D.L. Hoffman, and Y.F. Yung (2000), "Measuring the Customer Experience in Online Environments: A Structural Modeling Approach," *Marketing Science*, Winter, 19(1), 22-44.
14. Cesta, G. et al, (2006), The RoboCare Assistive Home Robot: Environment, Features and Evaluation, The RoboCare Technical Report, RC-TR-0906-6
15. Verhaegh, J., (2004). iCat, an intelligent user-interface robot with character. An evaluation of robot personality and personality preference in child-robot interaction. Unpublished master thesis, University of Maastricht.