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Stefan van den Eijkel

Dorien Foppen-De Graaf

Robbert Schuurmans

Stefan van Genderen

Koen Smit

See next page for additional authors

Authors

Stefan van den Eijkel, Dorien Foppen-De Graaf, Robbert Schuurmans, Stefan van Genderen, Koen Smit, and Sam Leewis

SOCIAL ROBOTS IN ELDERLY HEALTHCARE: A BURDEN OR A GIFT?

STEFAN VAN DEN EIJKEL,[2] DORIEN FOPPEN-DE GRAAF,[2] ROBBERT SCHUURMANS,[2] STEFAN VAN GENDEREN,[2] KOEN SMIT[1] & SAM LEEWIS[1]

[1] HU University of Applied Sciences Utrecht, Institute for ICT, Digital Ethics, Utrecht, Netherland; e-mail: koen.smit@hu.nl, Sam.leewis@hu.nl
[2] HU University of Applied Sciences Utrecht, Institute for ICT, Utrecht, Netherland; e-mail: name.surname@student.hu.nl

Abstract The healthcare sector is currently under enormous pressure and the COVID-19 pandemic does not improve this situation. The quality of healthcare will be negatively impacted when this pressure continues in the longer term. In 2050 it is expected that a total of 2.1 billion people will be aged 60+ years old. To overcome the increasing demand for healthcare by this age group, various studies are being conducted into various technological solutions, such as social robots. In this study, the Alpha Mini social robot was used in an experiment to research which tasks a social robot could assist with, to reduce the work pressure of healthcare professionals and to help the elderly live longer at their own homes. The experiment was carried out using interviews with healthcare professionals and informal caregivers about the demonstrated Alpha Mini. In addition to the experiment and interviews a survey was sent out to 237 healthcare organizations in the Netherlands to identify the 1) work pressure, 2) daily tasks, 3) social robot experiences, and 4) the features a social robot should have to gather requirements. The experiment failed due to work pressure at the healthcare organization. The survey resulted in 181 respondents. The results suggest that tasks such as reminders, setting alarms and physiotherapy have a great potential to help the healthcare professional in reducing their work pressure and tasks, and the elderly to be able to stay living longer at their own home.

Keywords: social robot, elderly healthcare, healthcare professionals, requirements

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1 Introduction

A serious deficiency in the number of healthcare professionals is becoming a worldwide issue and the current COVID-19 pandemic does not improve this situation (Greenberg et al., 2020; Henkel et al., 2020; World Health Organization, 2020). The healthcare sector is under enormous pressure, and if it endures, it will badly impact the quality of healthcare worldwide (World Health Organization, 2020). The forecast is that in 2030 there will be 1,4 billion elderly people of 60+ years old worldwide and in 2050 this number will increase by approximately 66% to 2,1 billion elderly people of 60+ years old (World Health Organization, 2020). The Netherlands is among the top countries (along with e.g. Switzerland, Germany, France, Austria, Finland, Norway) of Europe in terms of the quality of healthcare rated in a yearly report published since 2005 (Arne Björnberg & Ann Yung Phang, 2019). In line with the global growth of the number of elderly people, the ageing population of the Netherlands also continues to increase (NOS, 2020), which is why it is expected that in 2041 there will be 4.7 million people over the age of 65 compared to the current 3.2 million in 2021. This increase in the coming 20 years will only cause extra demand for healthcare in the Netherlands (Schumacher, 2017), raising the total healthcare costs to 19-31% of the annually gross domestic product (GDP) of the Netherlands (Albert van der Horst et al., 2011). In comparison and for illustrative purposes 31% of the GDP of the Netherlands is the entire GDP of Hungary (The World Bank Group, 2021). To overcome the increasing problem of demand in healthcare, studies are being conducted into various technological solutions such as a smart pill dispenser (Medido, 2021), sensors (Joshi et al., 2014), smartwatch (Vivago, 2021), social robot (Hoorn, 2017), and home automation (Harmo et al., 2005) to help elderly live longer at home. Previous studies have shown that social robots can have a great potential to assist in addressing the current issues in healthcare (Abdi et al., 2018) (Bemelmans et al., 2012), (Kachouie et al., 2014) (Broadbent et al., 2009) (Breazeal, 2011) (Phu & Garbrah, 2020). With the social robot, care could be performed more efficiently and effectively by healthcare professionals (Forlizzi et al., 2004). The social robot could help ensure that elderly persons in healthcare continue to receive good care, adding the possibility for elderly persons to live longer at home (Forlizzi et al., 2004).

A social robot is a robot that, through the usage of various technologies, such as speech recognition, face recognition, and emotion recognition, can perform non-physical tasks like providing reminders, providing information like the news or the weather and stimulate physical activity (Joshi et al., 2014). Research shows that a daily structure is very important for elderly people because it provides a sense of tranquillity (Góngora Alonso et al., 2019). It has been demonstrated that social robots were able to assist elderly persons with their daily structure (Góngora Alonso et al., 2018). More specifically, in elderly care, the social robot can assist in tasks such as reminding of medicine usage, act as an alarm, connecting with family and friends, and help with the maintenance of physical activity (Forlizzi et al., 2004). In this study, a social robot is defined as a humanoid robot (Duffy, 2003) in the role of an assistant in healthcare. The social robot is not meant to replace the healthcare professionals, but to assist them with their daily tasks (Góngora Alonso et al., 2019; Robinson et al., 2014). With the assistance of social robots, healthcare professionals will have more time for other tasks (e.g. that focus on safety and hygiene and medication adherence) (Robinson et al., 2014).

The goal of this research is to identify which tasks a social robot can assist with and how the social robot could accomplish that, in providing care for elderly persons in healthcare at home, helping healthcare professionals to work more efficiently and help elderly persons to live longer at home. To achieve this goal, an answer is needed to the following research question: '*How can a social robot help provide care more effectively, so that healthcare professionals can spend more time on tasks that they would like to perform, but now do not have enough time for and help the elderly to be able to live longer at home?*'. This was done by conducting expert interviews and a survey.

The paper is structured as follows: in the Background and Related work, previous research on social robots and elderly care related healthcare will be discussed. Next, in the Research Method section, the used methods will be detailed used to provide an answer to the posed research question. This is followed by the Data Collection and Analysis section where the qualitative and quantitative data and analysis are elaborated. Then, in the Results section, the findings of this research will be presented, which are followed by the Discussion section, the Conclusion section, and lastly, directions for Future Research are presented.

2 Background and Related work

Social robots are becoming more popular among researchers and in practice (Campa & Campa, 2016; Share & Pender, 2018). Various applications of social robots exist in healthcare (Share & Pender, 2018), education (Belpaeme et al., 2018), and hospitality (de Kervenoael et al., 2020). An example of a social robot that has been used in home healthcare observations (Bouwhuis, 2016), is the Tessa Robot (Tinyrobot, 2015). This social robot is designed as a flowerpot. Due to its design, it is small, practical, and affordable. The eyes consist of led lights which it uses as facial expressions. The Tessa Robot can play music, provide reminders, can tell the weather forecast and can ask the user questions. However, the response is limited to "yes" and "no" (Tinyrobot, 2015). Another social robot, the NAO robot, is often used in groups, where talks and exercises are done with the social robot (SoftBank Robotics, 2020). Its design focusses heavily on human interaction through the use of camera's, microphones, speech recognition, and touch sensors. It has the ability to walk, sit, and move its arms and head. There is also the Alpha Mini, which is the same size as the Tessa Robot, but has abilities like walking and moves its arms like the NAO (UB Tech, 2021). The Alpha Mini robot has been released just for a little over a year now (2020), so not a lot of research is conducted with this robot. Therefore, in this study, the Alpha Mini robot will be used. The Alpha Mini is more humanized and has more movement abilities which differentiates it from the Tessa robot. While one could argue that other social robots do exist in practice (e.g., Pepper, Sophia, Asimo), the social robots described in this paper are more suitable for home care by healthcare workers due to their size, practicality and (deployment) costs for both elderly people as well as healthcare organizations.

2.1 Acceptance & Adoption of Social Robots

One of the reasons that social robots have not been widely adopted is that users are not involved during development, causing their requirements and wishes not being accounted for (Turja et al., 2018). Another reason is that a lot of users have never had any or low experience with social robots (Turja et al., 2018). Studies (Flandorfer, 2012; Frennert & Östlund, 2014) show that people with experience with social robots are more positive towards the idea of using them.

2.2 Elderly People and Social Robots

The elderly are influenced by the usage of new technology by people in their near vicinity, such as healthcare professionals, family members and friends (Tempels, 2016). Elderly blame themselves if they have issues using new technology and do not want to be a strain to their near vicinity (Tempels, 2016). This behaviour represents an important factor in the adoption of new technology by elderly people. However, this is not the only factor that influences the adoption of the elderly. In total, there are 13 factors to decide if the elderly are positive or negative towards new technology such as the social robot (Tempels, 2016). The 13 factors are as followes: The positive factors are 1) independence, 2) daily life, 3) trust, 4) safety, 5) benefits, 6) ease of use, and 7) observed features. The negative factors are 8) knowledge, 9) privacy, 10) fear, 11) relations, 12) practical doubts, and 13) health and demographic factors. Other research confirm Tempels' findings (Tempels, 2016) for social robots (Alaiad & Zhou, 2014; Robillard et al., 2018). These contributions show that elderly people can be motivated to use new technology if people in their near vicinity assist and motivate them in using and trying it (Tempels, 2016). In general, all these aspects raise the importance of including all stakeholders during the design process and elderly people gaining more experience with social robots by using them with the assistance of others close to them.

3 Research Method

For this research, a mixed-method approach is utilized containing qualitative data (Hennink et al., 2020) and quantitative data (Sofaer, 2002). The Mixed-method approach integrates the data during data collection, analysis, or discussion and allows for the creation of a more holistic view of the problem space.

3.1 Experiment and Interviews

Before the start of each experiment, a semi-structured interview (Qu & Dumay, 2011) was held with a healthcare professional and informal caregivers, in order to gather their opinion on social robots in healthcare. This was used to define a baseline for comparison against the final interview at the end of each experiment. After each demonstration, a second semi-structured (Qu & Dumay, 2011) interview was held with the same interviewee, in order to identify potential benefits and limitations

concerning the usage of the Alpha Mini robot. All interviews utilized an interview protocol and were recorded with the informed consent of the interviewees. The interviews were transcribed and coded in order to identify the possible benefits and limitations of the utilization of a social robot in healthcare. For each interview, two coders coded the transcribed interview separately. Next, the two coders compared and discussed the coding results and combined them into one final version. For the demonstration, healthcare professionals were asked to send a daily structure for each elderly person. The daily structure for each elderly person contains timestaps and actions. An example of a daily structure can be found here. The daily structure was programmed on the robotsindezorg.nl (Interactive Robotics, 2021) platform for each individual elderly person. To demonstrate the Alpha Mini, it was installed at the home of the selected elderly person through a supplier of the Alpha Mini robot. The Alpha Mini robot was used in the home of the elderly person for a period of seven weeks with the assistance of healthcare professionals and informal care givers. During this timeframe, the Alpha Mini robot tried to assist the elderly persons retaining their daily structure trough reminders and personal additions, such as a hairdresser appointment and family visitations.

3.2 Survey

A survey was created and validated, based on the current body of knowledge as well as input from a healthcare professional that was not involved in the social robot experiment, conducted trough a separate interview to identify elderly care characteristics and the usage of social robots. These characteristics included 1) work limitations, 2) work pressure, 3) daily tasks, 4) past experiences with social robots, 5) embodiment preferences of the social robots, and 6) their view on the usage of social robots in healthcare. The survey contained a total of 25 questions divided in six sections: 1) introduction, 2) general questions, 3) tasks, 4) social robot characteristics, 5) social robot and reminders, and 6) social robot appearance. After validation and verification by the healthcare professional, the survey was sent via email to healthcare organizations specialized in elderly care for expert sampling. The reason that expert sampling is chosen for this survey, is because it has a better way of constructing the views of experts in elderly healthcare (Etikan, 2017).

4 Data Collection and Analysis

The data collection for this study occurred over a period of three months, between November 2020 till January 2021. The implementation of the Alpha Mini robots was planned for November 2020. The interviews were held from the first weeks in November 2020. The survey was published from December 2020 till January 2021.

4.1 Demonstration of the Alpha Mini Robots and Interviews

In order to demonstrate the Alpha Mini robot, a request of participation was sent to healthcare organizations that were in direct contact with the supplier of the Alpha Mini robot. If a healthcare professional was interested and the elderly person gave their approval, a request was submitted for the implementation of the Alpha Mini robot.

Out of the five requested implementations, only one was successful. The main issues that caused unsuccessful implementations were caused due to misplacement, deterioration of the elderly persons' health, and misuse at the side of the elderly person. Due to this, the results of the experiment are deemed invalid and not taken into account in the results of this study. However, for transparency reasons, this activity is described in the paper.

4.2 Survey

Based on the input of healthcare professionals, a list of healthcare organizations (n = 237) specialized in elderly care, nursing homes and elderly home care in the Netherlands was formed. Additionally, the researchers utilized their network to distribute the survey to healthcare organizations such as mentioned earlier in this paper. The data analysis of the survey data was conducted using SPSS v27.

5 Results

In this section, the results from the data collection and analysis are presented and will be further discussed. The results will be divided into four sub-sections: tasks, work pressure, elderly people, and social robot requirements. In total, a total of 181

participants submitted the survey out of which 12 were excluded because they were not healthcare professionals, resulting in 169 valid responses

5.1 Tasks

The category 'Tasks' covers the tasks healthcare professionals could not perform due to lack of time. This also included the tasks the social robot could assist with. The top five tasks that are not performed due to lack of time are (as shown in figure 1): 1) making conversation, 2) listening to music, 3) physiotherapy, 4) helping elderly persons with reminders, and 5) extra tasks (calling the general practitioner or the pharmacy). When asked in the survey, which tasks the robot could assist with, the top five most given answers were: listening to music, making conversation, providing reminders, physiotherapy and preparing medication, as shown in figure 2.

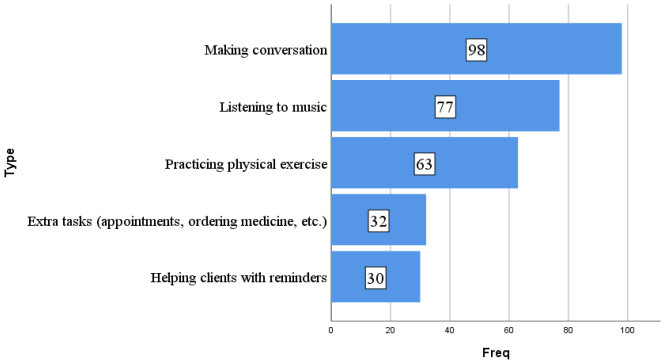

Figure 1: Top 5 tasks that are not performed when there is not enough time left

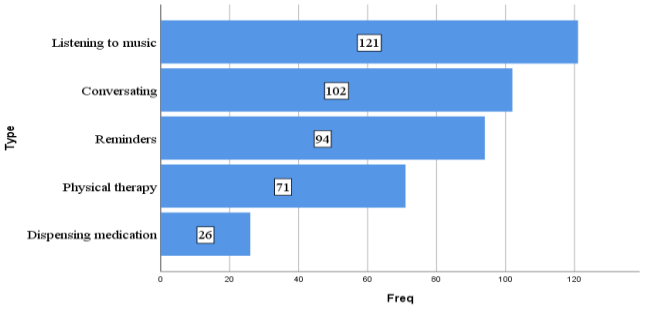

Figure 2: Five most given answers where the robot could assist with

5.2 Work pressure

The category 'Work pressure' covers the work pressure experienced by healthcare professionals or informal caregivers. The majority (n = 154) of the healthcare professionals indicated that they experience work pressure. In the survey, the following question was posed, "*Do you think a social robot can assist you with certain tasks?*". The majority (n = 134) indicated that a social robot could help reducing work pressure.

5.3 Elderly people

The category 'Elderly people' covers whether the usage of reminders could help the elderly live longer at home and what other functions a social robot could help the elderly to live longer at home. In the survey, the majority (n = 148) of the healthcare professionals indicated that a social robot could assist the elderly with reminders, as shown in figure 3.

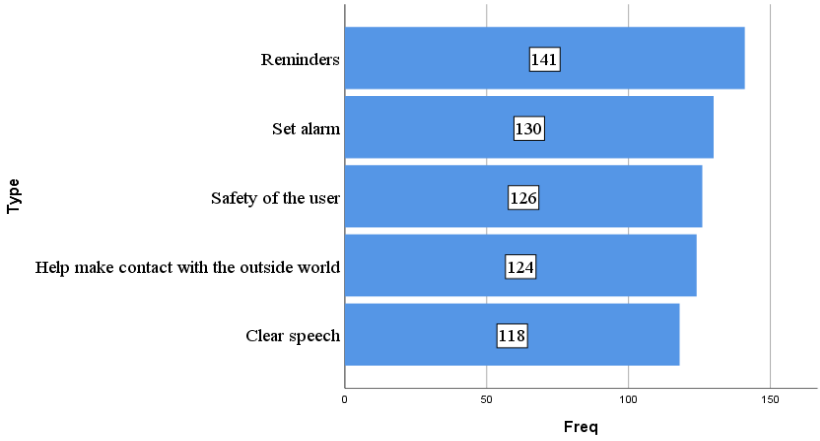

Figure 3: Features that could help elderly people stay home longer

5.4 Social robot requirements

The category 'Social robot requirements' covers the requirements of a social robot from the perspective of the healthcare professionals, as it is important for the social robot to be accepted by the users (Tempels, 2016). The answers from the healthcare workers on the questions about certain requirements and embodiment features of a

social robot are: if the eyes of a social robot mimic human-like behaviour (blinking, look at the elderly person and winking) would scare the elderly person (Yes n = 21, No n = 149*)*, if the social robot should move its torso and arms when speaking (Yes n = 142, No n = 27*)*, what type of voice a social robot should have (Male n = 7, Female n = 133, Sexless n = 29*)*, and if a notification sound should be played before a reminder (Yes n = 126, No n = 43*)*.

6 Discussion

The interviews, experiments and survey results revealed a number of interesting findings for implementation of social robots in elderly healthcare. These concerns, for example, the acceptance of the social robot among the elderly and healthcare workers, but also about the tasks that a robot could assist with. These topics will be discussed in more detail below.

6.1 Tasks and work pressure

It is considered worrisome that, sometimes, certain tasks such as washing elderly people or physiotherapy are not performed due to a lack of time. The majority (n = 154) of the healthcare professionals already indicate that they experience work pressure. The research showed that the social robot can reduce workload in the daily structure, such as reducing work pressure, assist with their daily tasks, and further improve the healthcare system. Healthcare professionals indicated that the social robot has the potential to assist them in tasks like listening to music, conversating, reminders, and physiotherapy. This supports Forlizzi's study, which indicates that a social robot can support the care worker in providing care (Forlizzi et al., 2004). Interestingly, these are also most of the tasks that are not performed when there is a lack of time.

6.2 Elderly people

Implementing the Alpha Mini robot could lead to elderly people live longer at home trough features such as reminders, alarms, and ensuring the safety of the user. Healthcare professionals indicated that there is currently no way to check if an elderly person took their medicine. The healthcare professional also indicated that it is important that the healthcare professional or informal caregiver and the elderly person are prepared for the implementation of a social robot to further improve the

success of such implementations at the home of the elderly person. This proves the findings of Tempels that people in the near vincinity of elderly people strongly impact the success of an implementation of new technology (Tempels, 2016).

6.3 Social robot requirements

The findings of Turja indicated that it's important for stakeholders to be involved in the development of a social robot to improve adaption of social robots in the healthcare sector (Turja et al., 2018). Our findings showed that healthcare professionals have several requirements for social robots in elderly healthcare. The vast majority (n = 134) of healthcare professionals indicated that the social robot could assist elderly people with their daily structure through reminders. Furthermore, the healthcare professionals prefer (n = 133) a social robot with a female voice and that the social robot should first play a notification sound before telling a reminder (n = 126). Other features such as the eyes, ability to move its torso/arms while talking answers were divided between the healthcare professionals. Some (n = 21) did find that, for example, the eyes would be scary for an elderly person but the common idea was that it greatly depends on the individual if it is perceived as scary. Adding the possibility to change or disable certain features, for example, the eyes on an individual basis would be a feature to prevent this issue and to make it more compatible for a specific elderly person.

7 Conclusion

In this research, we aim to answer the following research question: 'How can a social robot help provide care more effectively, so that healthcare professionals can spend more time on tasks that they would like to perform, but now do not have enough time for and help the elderly to be able to live longer at home?' In order to do so, the goal of this research is to identify which tasks a social robot can assist with and how the social robot could accomplish that, in providing care for elderly persons in healthcare at home, helping healthcare professionals to work more efficiently and help elderly persons to live longer at home. Trough the survey data we identified that there is a big potential for the use of social robots in elderly healthcare, especially in its use for assistance in retaining their daily structure trough providing reminders. It seems that the reminders have great potential to help healthcare professionals reducing their work pressure and tasks. Also, it seems that the elderly will be able to

live longer at home, but the data collected does not provide a definitive answer to this. However, the data does show how a social robot could assist healthcare professionals and identifies which requirements should be taken into account for the further development of the Alpha Mini robot.

7.1 Limitations

This research has multiple limitations. The first limitation was caused by Covid-19 restrictions like restricted access to the elderly and impacted the implementation of social robots at the homes of elderly persons. Therefore, the researchers couldn't install, demonstrate and observe the social robot in combination with the elderly, so it had to be outsourced to the supplier of the Alpha Mini robot. This meant that the observation data was all second-hand data gathered through intermediaries. This is a threat to validity and reliability, which resulted in omitting the data from the results and the conclusions in this paper and study. The second limitation was also caused by Covid-19 restrictions. A lot of nursing homes and healthcare professionals did not have sufficient time for the experiment, causing the social robot implementations to be cancelled. The third limitation is related to the survey design, which caused the researchers to not be able to do certain analyses required to prove the trustworthiness and the significance of the results, therefore we solely discuss the descriptive data of the survey in this paper. However, the literature (Moharana et al., 2019; Turja et al., 2018) suggests that there needs to be more attention towards the requirements for healthcare professionals while designing a social robot, which this research still has contributed to and our results provide sufficient insights into. Although it seems that the use of a social robot has potential in elderly healthcare, there is still plenty of research left to conduct.

7.2 Future research

Future research should focus on observations with social robots for reminders and assisting elderly people with their daily structure, which was intended in this study. In future research, elderly people need to be involved in the design process of the social robot, because the elderly are the user of the social robot, next to healthcare workers. This should be directly observed in future research to get more reliable results on the efficacy of a social robot in this context. Future research should also focus on creating architectures based on requirement categories so that a framework

can be created. Such a reference framework could then be utilized to address requirements in different situations, making knowledge on requirements for utilizing social robots situationally applicable.

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