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Abstract Social Robotics is becoming more relevant for the healthcare sector as an increasing amount of research and development is invested by researchers and practice. One research area where additional research would help the acceptation and adoption of social robots is intramural care where people with dementia live. The current body of knowledge on this topic can be described as nascent. In this study, we add to the body of knowledge regarding the design and enactment of social robots like the one used in this study, the Tessa robot, with the goal to improve acceptation and adoption of social robots in dementia care. To do so, we conducted a case study at a healthcare organization, featuring semi-structured interviews, observations and talking mats. During this case study, an experiment was carried out in which a Tessa robot was used in intramural care with three clients suffering from dementia. The most important finding of this study is that for the robot to be accepted and effective it must be implemented properly in the existing healthcare processes, otherwise it might serve as a companion, but will not relieve the workload of healthcare workers.

Keywords: social robot, dementia, case study, intramural care, tessa

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1 Introduction

The overall life expectancy in the world is increasing steadily for the last decades (Roser, Ortiz-Ospina, & Ritchie, 2019). For example, since the 1950s, average life expectancy in The Netherlands has increased by 10 years from 71 to 81 years (van der Aalst, 2019), which is similar to other western countries. An aging population introduces new social challenges related to physical and mental issues, one of these issues is dementia. The estimated number of people with dementia worldwide is ~ 46.8 million people. Every 3.2 seconds someone is diagnosed with dementia (Bouwhuis, 2016). It is estimated that this number will double every 20 years and by 2030 there will be ~ 75 million people living with dementia worldwide (Domínguez-Rué & Nierling, 2016). At the time of writing this paper there is no medicine available that completely supresses or eliminates dementia symptoms nor does a cure exist. However, there are forms of treatments that can partially suppress the symptoms and thus improve the quality of life of a client. An example of this is Animal Assisted Therapy (AAT), in which animals are used in therapy sessions (Downes, Dean, & Bath-Hextall, 2013).

Research indicates that, in some countries, there are not enough health-care workers (HW's) available. Which, in turn, could result in a decline in the quality of care for people with dementia (Domínguez-Rué & Nierling, 2016). Due to the shortage, a majority of HW's (~60%), has to work extra shifts, often with fewer people (van der Aalst, 2019). The number of on-call workers is also increasing due to these shortages. More than two thirds of the on-call workers indicate that the workload has increased in the past year. This puts the quality of care under pressure, and it affects the mental and physical well-being of HW's. Already 71% of HW's indicate experiencing more stress (van der Aalst, 2019).

Social robots could support HW's and potentially aid people with dementia. In this paper, the definition of a social robot is used: "*a physically embodied robot that communicates autonomously with humans and other autonomous physical robots in a way that is conducive to its own goals and those of its environment*" (Duffy, 2003). In the situation of an aging population and shortages in health care workforce, social robots can attribute to the well-being of the aging population suffering from dementia (from here on referred to as: clients) by supporting and taking over certain tasks from HW's. Social robots can be used, for example, for monitoring clients and for the use of therapy

(Valentí Soler et al., 2015a). The sensors of social robots can respond to changes in the environment (movements, sound), allowing them to interact with clients. Potential advantages that complement HW's are, for example, that robots can work longer and take up less space and need less care (Valentí Soler et al., 2015a).

The Dutch government made funds available to improve the quality of care in nursing homes, with funds rising to a structural amount of € 2.1 billion per year in 2021 (van der Aalst, 2019). Part of this budget is spent on home automation, which includes social robots. This financial stimulus led to multiple nursing homes in the Netherlands that started experimenting with social robots in their healthcare processes. One of these social robots is called Tessa, a flowerpot like robot (Robotzorg, 2021). The Tessa robot is a social robot that talks and is designed to support the daily structure of people with a cognitive disability and to provide suggestions for certain activities to them (Robotzorg, 2021).

In the light of the aforementioned social challenges, Tessa could assist and take over care tasks from HW's, thereby reducing current high workload's, and improving the quality of care. Although social robots hold great potential, there are still challenges regarding the acceptance and effectiveness of social robots in dementia care. Therefore, this exploratory study aims to answer the following research question: '*How can the acceptance and effectiveness of the Tessa robot for both HW's and clients with dementia be improved?*'

This paper is structured as follows. In the next section the background and related work are discussed. Then, in section three, the utilized research methods are detailed. In section four, the data analysis is explained. This is followed by the results in section five. The paper is concluded by presenting the discussion in section six, which is followed by the conclusions in section seven. Finally, future directions for future research are presented in section eight.

2 Background and Related Work

In this section, we further ground the potential of social robots in the context of HW's that care for elderly people with dementia. Acceptance and involvement of stakeholders is one of the key aspects when responsibly designing and implanting technology (Friedman, Kahn, Borning, & Huldtgren, 2013). Earlier research has shown that usefulness, adaptability, enjoyment, sociability, companionship, and perceived behavioural control are important variables in social robotic acceptance (de Graaf & Ben Allouch, 2013). Furthermore, to determine whether and how social robots actually meets real-world needs, it is important to study these robots in ecologically valid settings (de Graaf, Somaya, & van Dijk, 2016). In general, people have positive attitudes towards social robots and are willing to interact with them, according to a large, standardized study with a combined sample of over 13,000 participants (Naneva, Sarda Gou, Webb, & Prescott, 2020). Research in elderly care reveals that the attitudes of elderly towards social robots are more often positive than negative (Savela, Turja, & Oksanen, 2018), the same holds for people with dementia (Whelan et al., 2018). These findings are promising for our study as we aim to experiment with social robots in the natural environment, whereby the perspective of stakeholders is important for the successful implementation of this new technology.

2.1 The needs of clients suffering from dementia

The physical needs of people with dementia are more often met than the emotional needs (Miguel et al., 2016), (Visser & Vandemeulebroucke, 2018). Personal contact with care workers or family has a positive effect on people with dementia, it reduces the chance of loneliness and depression (Miguel et al., 2016). Other studies show that, by increasing the daily structure and amount of personal contact, dementia symptoms are less likely to develop further (van Beek, Frijters, Wagner, Groenewegen, & Ribbe, 2011), (Mordoch, Osterreicher, Guse, Roger, & Thompson, 2013). With these contributions, we would like to bring attention to the influence of dementia associated motivational and emotional disorders on the positive affective state that interactions with social robots are able to prompt. Social robots could utilize existing methods that support these issues such as exercises, images, and sound (Qwiek, 2021).

2.2 The needs and acceptance of (in)formal HW's

The (technological) support that is most used in dementia care is often limited to a mobile or desktop interface (Alnanih & Ormandjieva, 2016). The main focus of these tools is to help entertain and keep people with dementia active. However, there are few supportive solutions that relieve the (in)formal HW's (Tyack & Camic, 2017), (Cheng, 2017). Until now, social robots have not been used extensively in healthcare (Turja, Van Aerschot, Särkikoski, & Oksanen, 2018).

For robots to be accepted and used, it is essential that HW's are included in the design process of the social robots (Góngora Alonso et al., 2019a), (Moharana, Panduro, Lee, & Riek, 2019), (Robillard, Cleland, Hoey, & Nugent, 2018). Compared to elderly people investigated in different studies, HW's are generally less positive about using social robots in their context, however, after exposing HW's to a social robot, positive attitude towards a social robot seems to be higher (Savela et al., 2018). Although, not all HW's have a positive attitude regarding social robots; the acceptance of robots in healthcare seems to be strongly linked to the HW's moral considerations (van Kemenade, Hoorn, & Konijn, 2018).

In the context of this research, social robots are studied to relieve HW's from repetitive tasks such as reminding clients with regards to, e.g., exercises, food or drink moments, and social activities, which matches the work of (Góngora Alonso et al., 2019; Valentí Soler et al., 2015). This also stems from the fact that healthcare organizations are not seeking to replace HW's by social robots, but to lower work pressure for them (Valentí Soler et al., 2015).

2.3 Social Robot: Tessa

Previous studied related to the Tessa robot in a dementia care context have been conducted. In 2019, (Casaccia et al., 2019) set up an eWare platform for the Tessa robot based on qualitative and quantitative data collection from dementia clients, (in)formal HW's and healthcare managers. The functionalities of the Tessa robot seem to meet the needs of HW's and people with dementia (Casaccia et al., 2019), (Miguel et al., 2016), (Johnson et al., 2020). For example, a recurring theme is daily structure, something that all stakeholders and dementia clients in particular benefit from (van Beek et al., 2011), (Mordoch et al., 2013), (Miguel et al., 2016).

Scientific research has yet to be conducted into the effectiveness of the Tessa robot. As mentioned in the previous section, the increase in the number of people with dementia (caused by aging) will not decrease (Domínguez-Rué & Nierling, 2016), which means that research on technological support, such as the Tessa robot, is necessary. Effectiveness of Tessa will be measured by taking into account both the interaction between the robot and the client, and the reduction of workload for HW's.

3 Research Method

The research field of social robotics related to the application of social robots in nursing homes is relatively nascent; either relatively small qualitative samples are analysed, or large meta-level reviews are conducted (Savela et al., 2018; Whelan et al., 2018). When a research field is nascent, new constructs still need to be identified and relations between these constructs should be established (Edmondson & Mcmanus, 2007), which is often characterized by exploratory (qualitative) research. To achieve this, a case study at a nursing home was executed. Case study research is a technique that can be used to explore a broad scope of complex issues, particularly when human behaviour and social interactions are of importance (Pervan & Maimbo, 2005). This study comprised a holistic case study approach (Runeson & Höst, 2008), focusses on the context of nursing homes for people with dementia (permanent and closed care facility). This way, the intervention (Tessa) can be evaluated in the natural context for which it is designed. Also, when the boundaries between the intervention (Tessa) and the context are not clearly evident, multiple sources of empirical evidence are used (Pervan & Maimbo, 2005), which is taken into account in our case study approach.

The people with dementia in our case study, gave consent to participate in this research themselves, as well as via their responsible healthcare worker and their direct family members. In this cases study we will focus on both the people with dementia (clients) as well as the HW's related to these clients in combination with the Tessa robot. During this case-study, data was collected using three different methods: 1) semi-structured interviews, 2) naturalistic observations, and 3) Talking Mats. All data was collected in The Netherlands between August 2020 and December 2020.

3.1 Case Study

This case study was conducted in close cooperation with a large healthcare organization in the Netherlands that operates multiple facilities for different types of healthcare with a total of 777 FTE's, which was based on convenience sampling. The clients that participated on our study were selected and approached by the healthcare organisation. To study the social robot and its users in the most natural context, each client was provided a Tessa robot in their living room for twelve days.

3.2 Semi-structured interviews

The first method of data collection in this case study are semi-structured interviews, which allow the research team to gather qualitative data during two phases. The first phase is utilized to elicitate requirements from HW's regarding the workings of the Tessa robot. The second phase is utilized to gather data on the acceptance and the effectiveness of the Tessa robot. During the course of eight weeks, four digital and seven physical interviews were conducted with HW's, which were selected in cooperation with the management of the organization, taking into account that the HW's are connected to the selected clients in the experiment and known each other. The goals of the interviews with HW's were to learn about the various daily activities and the needs of both the HW's and the clients. Whilst conducting the interview an interview protocol was utilized, which increases repeatability and comparability of the results (Castillo-Montoya, 2016). Also, different protocols were used before and after the experiment. The protocol's themes and corresponding questions focused on: 1) current experience with social robots, 2) perceived value of social robots, 3) added value of Tessa in the context of the HW, 4) involving clients and HW's in the development proces, 5) pro's and con's of Tessa after the experiment, 6) preceived value for the client, and 7) experienced values for HW's. The questions were open-ended, allowing for discussion and relevant deviation when deemed nessesary by the researchers. The interviews have been audio recorded and transcribed after the interview, for which all participants provided verbal consent. The average length of the interviews was 28 minutes, the longest being 44 minutes and shortest being 8 minutes.

3.3 Observations

The second method of data collection in this case-study are naturalistic observations. The goal of these observations was perceiving and recording the effects that the Tessa robot had on the clients. One observation has been conducted per client. To ensure reliability, it was made sure that all clients had been using the Tessa robot during a timeframe of equal length (twelve days). Each observation was held on the Monday of the second week of use, after seven days of usage, where two observers independently filled in the protocol. All three duo's of researchers were different as well to mitigate potential bias. Every client had a daily schedule with activities that take place on each day. This schedule was manually programmed onto each Tessa-robot by the research team, based on the schedule received by the responsible HW. Programming the robot was performed using mytinybo.io, which is a platform used to synchronize commands with the robot, via Wi-Fi. Based on this, it would announce these activities at predetermined times, during the experiment. The announcements start at 8AM and end at 10PM, with at least one announcement every hour. The observations were organized during 10AM and 2:30PM. During the observations, a predetermined observation protocol was used. The protocol was created using the Interactive Behaviour Codification System (Andrés, Pardo, Díaz, & Angulo, 2015). This system is used for grading the interactive behaviour between humans and robots, which makes it very suitable for the observations as part of this case study. The form consists of eight distinct categories (perceived emotions, proxemics, gaze, etc.), which are then each divided in sub-categories (such as joy, focused gaze, etc.). For each observation moment, two research team members individually filled in the protocol, to improve reliability.

3.4 Talking Mats

Talking Mats is a technique which helps people with cognitive disabilities communicate during interview sessions (Murphy, Gray, Cox, & Joseph Rowntree Foundation, 2007). This method is easy to prepare, suitable to be conducted during the covid-19 pandemic and meets the criteria for better communication for the clients. Talking Mats consists of three kinds of cards:

1. Subject – what the conversation is about and what the options are paired to. In this case: the Tessa robot.
2. Options – in this case, the announcements, which Tessa made to the clients. A total of eight images have been made and used, one for each type of announcement.
3. Scale – the clients were able to communicate their opinion of the different options by pairing the cards with the respective grades, which reflect their emotions and feelings about a subject: negative, neutral or positive.

The cards with the different options were then presented to the client. The session was conducted in cooperation with a HW, who was experienced in communicating with the clients. Due to covid-19 restrictions, the cards were not placed by the client themselves since this would cause unnecessary physical contact. After a card was placed at one of the three gradings, a picture was taken to capture the results. This was repeated for each subject.

4 Data Analysis

All interviews were recorded, transcribed and coded independently by three researchers. This process was conducted redundantly to eliminate coding bias as well as to improve the validity of the results (Armstrong, Gosling, Weinman, & Marteau, 1997). Coding was performed in AtlasTI. To analyse the transcriptions, the Toulmin's framework was utilized (Toulmin, 2003), which consists of three elements: 1) Claims, 2) Grounds, and 3) Warrants. Finally, all codes were merged, and an assessment of the intercoder-agreement was made. Where no agreement was initially reached, the coders partook in a session where the codes were discussed, and consensus was reached, also described by Campbell as a "negotiated agreement" (Campbell, Quincy, Osserman, & Pedersen, 2013).

To study the interaction between the client and the Tessa robot, an observation-protocol (Andrés et al., 2015) was used. The protocol utilizes the following variables that are recorded by each observant; 1) type of instruction, 2) emotions, 3) proxemics, 4) gaze, 5) communication, 6) facial expression, 7) body gestures, and 8) interaction with the robot.

The data resulting from the observations was different than expected, because clients often were not in the room when the robot made an announcement. Therefore, in addition to the interaction with the robot, the presence of the client when the robot made an announcement was measured in percentages and included as well. This created a new angle to be explored during the interviews with HW's after the experiment.

The recorded responses of the clients resulting from the Talking Mats method were compared. This allowed for a comparison of clients' views. The views served as additional input for the interview protocol used for the interviews that were held after the experiment with HW's. The questions discussed as subjects during the talking mats sessions with the clients were based on the full range of pre-programmed announcements executed by Tessa during the experiment, which in turn were based on the personal day-to-day programmes.

5 Results

In the following sections we will present the results of each technique utilized seperatly.

5.1 Semi-structured interviews (before the experiment)

This sub-section focuses on the interviews before the experiment. Of the 1062 total codes, the coders independently reached an agreement of 871 eligible codes. Which means an initial percentage match of 82.02%. In the observer agreement model of Landis and Koch (Landis & Koch, 1977) this falls into the "Almost Perfect" category, making the coding process reliable.

Prior to the experiment, separate interviews were held with five HW's working at the healthcare organisation. Additionally, an interview was held with a HW that had over two years of working experience with the Tessa in extramural dementia care. The knowledge gained from these interviews has been translated into functional requirements for the experiment and Tessa robot. Below we present the predominant requirements mentioned in the data.

Input requirements:

- (In)formal HW's must be involved in the set-up of the robot because a personalized Tessa gets more response from the client compared to a standard Tessa;
- The physical and mental condition of the client must be good enough that he or she can hear and understand the Tessa properly. Formal HW's must be included in the selection process to derive suitable clients for the experiment;
- Formal and informal HW's must be instructed in the form of a training and / or by providing a manual. This enables HW's to become properly prepared and self-reliant regarding how to handle the Tessa;

- Other minor requirements that detail the day-programme of a particular client. For example, one of three clients required announcements to smoke, while another client required announcements about coming for lunch as the client usually forgets that particular moment.

5.2 Observations

In total, three researchers made observations during four and a half hours in the living room of the client. This method aimed at measuring the effectiveness of the Tessa robot by observing the response of the client.

The Tessa robot succeeded in provoking a reaction out of one of the three clients. This was concluded because one of the clients responded twice to an announcement given by the robot. In an average of 88% of the announcements intended to relieve the HW's, the HW's themselves had already verbally given an announcement to the client before Tessa's announcement had triggered. As a result, both the client and the HW were regularly not in the room when Tessa made an announcement. On average, the clients were only present during roughly half of the announcement made by Tessa. Furthermore, only client 1 reacted 2 out of 6 times, in a neutral sense. The results of this process are presented in Table 1.

Table 1: Observation results

Client	Present	Absent	Attendance %
1	6 (no reaction)	5	55%
2	5 (no reaction)	2	71.4%
3	2 (2 reactions)	6	25%
Total	**50%**	**50%**	

In the cases where the clients were present at the announcements, two of the three clients did not give a verbal response to the announcements from the Tessa robot. One type of announcement required verbal confirmation (the request for music) from the clients before the Tessa could proceed with the action. When the client gave an answer, the robot's microphone activated too late, which happened twice in the situation of client 3.

5.3 Talking Mats

The talking mats resulted to be effective in measuring the opinion of the clients; the research team managed to address all topics and gather a value for each of them. The results of the Talking Mats were as follows: 5.6% of the questions were answered with a negative value. The remainder of values registered consist of 47.2% neutral responses and 47.2%positive responses. Figure 1 shows the results per client. The horizontal axis represents the subject of the Tessa activity. Not all clients smoked cigarettes. Not everyone had to set the table either, so the number of questions per client differed by a maximum of two (minimum 11, maximum 13 questions).

Client 1 had no further comments during the Talking Mats interview, she did not want to part ways with Tessa after the experiment. The HW told her she will receive a new robot one week after the experiment was completed. She told us client 1 was glad to have the robot back. **Client 2** indicated twice that he views the Tessa robot the same as the HW's. He also said that he will miss the music when Tessa is gone. This was later discussed with his HW, which indicated that she had never heard him respond to Tessa and music has never been played by the robot. All negative results were posed by **client 3**. During the talking mats session, this client indicated that 1) he thinks Tessa is too noisy and 2) he thinks Tessa, in general, is nonsense. In some cases, the client experienced the robot as disturbing because he was busy with something else. The HW indicated that the client does not allow himself to be commanded by a speech robot and that this is probably the cause of the negative values. The client indicated that he does what he wants and does not have to listen to the Tessa robot. The client did indicate that he understands the purpose and good intentions of the Tessa.

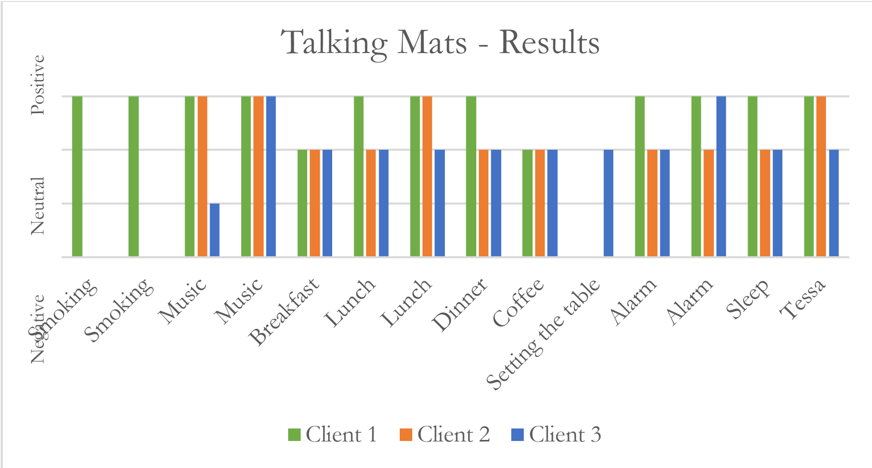

Figure 1: Talking mats results per subject

5.4 Semi-structured interviews (after the experiment)

After the experiment, interviews were held with seven HW's who worked with the Tessa robot, being three digital and four physical interviews. This led to additional requirements with regards to the context the Tessa is used in. Due to space constraints, not all requirements could be listed. Below we present the predominant requirements mentioned in the data.

Validation requirements:

- Involving HW's: Understanding the physical and mental health of clients is not only important. It is also important for creating support. One of the HW's had doubts beforehand about the usefulness of the robot. After seeing and experiencing the robot in use, she understood its purpose and was willing to use it.
- The HW's' trust in the Tessa robot: HW's continue to check on the clients whether they actually go to the living room, after the Tessa gives instructions to do this. In fact, HW's often already instructed clients from the room before the robot can give the instruction.
- The Tessa robot is not enough for every client to be stimulated, especially those who suffer from a more advanced stage of dementia. For example,

some clients need physical support in order to follow up on an instruction, which they do not always have access to.

6 Discussion

This study and its results could be influenced by several limitations. The first limitation concerns the influence of the HW's, which had often already reminded the client to get lunch or had already given a cigarette before Tessa provided an announcement. The HW's thereby limited the possibility for the Tessa robot to support the clients. As a result, it can be concluded that the Tessa robot must be implemented properly in the existing healthcare processes in order to determine its effectiveness. This meant that the effect of the announcements from Tessa could not always be measured properly. This could affect the overall validity of the measured effect Tessa might have had in this context. The results of the observations were different than expected but contributed to one of the most important findings of the study: the implementation of the Tessa robot in the existing healthcare processes in which HW's are an essential stakeholder is necessary to be able to use the Tessa effectively.

A second limitation concerns the clinical situation of the clients. Tessa's supplier indicated that it is important that Tessa's users have a good short-term memory and good hearing. The clients who participated in this experiment were at an advanced stage of dementia. As a result, one could argue that the clients with a similar clinical situation are not part of the target group for the Tessa robot. This was discussed with the HW's, that indicate that there are also clients who are in a less advanced stage of dementia. This limitation grounds further research using clients with a different clinical situation.

A third limitation concerns the size of the experiment. Three clients participated in this experiment. While one could argue that the qualitative explorartory approach allows for such sample size, the outcome of the current approach are difficult to generalize outside of this specific context.

7 Conclusion

The goal of this research was to identify how the acceptance and effectiveness of the Tessa robot could be improved. To achieve this, the following research question was answered, '*How can the acceptance and effectiveness of the Tessa robot for both HW's and people with dementia be improved?*'

Our study shows that both acceptance and effectiveness are influenced by the HW's and the clients. Several interviews revealed prejudices of HW's about the use of (social) robots. By making both HW's and clients more aware of the robot, not only the acceptance but possibly also its effectiveness of the robot could increase. This could potentially best be achieved by means of a learning program for the HW's. The HW's could attend a kick-off session and a simple, visual manual, that helps them to understand Tessa's purpose and functionalities. It is presumed that the effectiveness increases because the HW's can take the announcements into account and thus know when and how to rely on Tessa. Additionally, the findings show that, to increase the use of the Tessa, a hardware and software update is needed, e.g. improvement of the microphone capabilities as well as the addition of more interaction capabilities on top of the current response options. The functionalities currently are limited, with the consequence that for the target group described in this paper the robot could be effective as a companion, without achieving the goal of relieving announcement tasks of HW's. Furthermore, it can be concluded that the stage of dementia has a great impact on the experience with Tessa. For clients in an intramural care unit, the disease is often more advanced than for people in home care (often extramural). This has an effect on how people respond to Tessa's announcements. The robot failed to respond to a majority of answers from the participants. Most importantly, for the robot to be accepted and effective, it must be implemented properly in the existing healthcare processes, otherwise it might serve as a companion, but will not relieve the workload of healthcare workers.

8 Future Research

The findings provide multiple opportunities for future research. The first opportunity is to investigate how to increase the trust of HW's in social robots. Those results might allow social robots to be used more effectively in healthcare. The second opportunity is to investigate the Tessa in home care (extramural). Clients who receive home care are often classified in a lesser advanced stage of dementia and are therefore more independent. Another opportunity emerged from the interviews and observations, where HW's believe that the robot needs a humanoid shape that can stimulate the clients better (e.g., arms and legs). Future research could therefore focus on whether the Tessa robot can be modified or whether another robot is more suitable for activating people with dementia. The last opportunity for future research is the speech recognition of the Tessa robot. As indicated earlier, Tessa is now limited in its communication by its constrained interpretation abilities. The Tessa can only understand "yes" or "no" when a music moment has been scheduled. It would be interesting to see whether a robot with speech recognition stimulates clients more, as they get a response to the things they say to Tessa. Moreover, during the observations, it happened several times that the clients already answered before the microphone of the robot was turned on. Such delayed interactions significantly hampered the effectiveness of Tessa. Future research should focus on improving the speech recognition so that the microphone is switched on, taking into account the privacy and safety aspects of the client.

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