Dementia Caregivers of the Future: A Socially Assistive Robot as your Nurse?

Do Socially Assistive Robots improve the independency of elderly people with dementia?

Kenza Smit (6213189)
Bachelor Thesis BSc Artificial Intelligence
7,5 ECTS
First Assessor: Niilo Valtakari
Second Assessor: Leendert van Maanen
June 18, 2020

Dementia Caregivers of the Future: A Socially Assistive Robot as your Nurse?

K.I. Smit

University of Utrecht

Abstract

Due to ageing populations, overcrowded nursing homes, and staff shortages, taking care of elderly people is among the major challenges currently faced. Considering that dementia is one of the major causes of dependency among older people, the applicability of technology in this sector is explored widely. Specifically, Socially Assistive Robots (SARs) are put to use to support daily activities and provide company for elderly people with dementia. This study investigated whether these SARs improve the independency of elderly dementia patients. Dementia and two types of SARs were introduced, after which interviews and experiments with these SARs were scored with the Individually Prioritized Problem Assessment (IPPA). The IPPA scores demonstrated that the difficulties that arise in activities of daily living were improved by using a SAR. Hence, the results indicated that SARs do improve the independency of elderly people with dementia. However, these robots could be of more assistance when more future advancements are implemented.

Keywords: Socially Assistive Robot (SAR); Robotics; Dementia; Elderly; Individually Prioritized Problem Assessment (IPPA); Tessa; Paro.

Introduction

The relative number of persons aged 65 years or older has been continuously growing in the past years and will keep on growing in the upcoming years. By 2050, the prospects of the United Nations are that 1 in 6 people will be over the age of 65 in the world, in contrast to 1 in 11 in 2019. Besides this, the number of persons aged 80 years or older has nearly tripled between 1990 and 2019 and it is expected that this will triple again by 2050, resulting in 426 million people over 80 years of age worldwide (United Nations, 2020).

These numbers result in a series of problems, of which overcrowded nursing homes is one. Even when only looking at The Netherlands, there are already more than 14.000 people waitlisted that cannot be placed in a nursing home or cannot get the care that they need (van der Geest, 2019). The number of people waitlisted is in addition growing with approximately 30 percent each year (Zorginstituut Nederland, 2019).

As a current solution for the overcrowded nursing homes and the long waitlists, elderly people need to keep living at home as long as possible. Caring for these people is currently done by relatives or home caregivers, but for home caregivers there is already a staff shortage and a high turnover of personnel, which will keep on growing. Almost half of the patients indicate that they experience problems due to the shortage of personnel, such as long waiting times, not getting the care they need, and bad communication (Kluijver, 2017).

At the same time, there are worldwide more than 50 million people with dementia, and 10 million new cases every year (World Health Organization, 2019). Dementia is a syndrome that is characterized by a decline in cognitive function that is worse than what is normally expected when ageing. Impairments in memory and thinking arise, and other mental functions are disturbed. Multiple conditions can lead to dementia, but Alzheimer's disease (AD) is the most common cause. This disease accounts for around 60% of all cases (National Collaborating Centre for Mental Health UK, 2020).

Dementia is one of the major causes of dependency among older people. Even though there does not exist a cure for dementia, much can be done to improve the lives of dementia patients and their caregivers and families (WHO, 2019).

This has led researchers to explore the applicability of technology for eldercare and more specifically for elderly people with dementia. The 'robot revolution', which is happening throughout many industries, is supposed to solve the growing

personnel shortage. Currently physically assistive robots dominate the healthcare sector, with examples such as robotic limbs, sophisticated wheelchairs, and robotic surgeons. Even though these robots are of great help for physical problems, they do not provide aid for mental and cognitive functions.

To support these functions, Socially Assistive Robots (SARs) are making headway. These are robots that provide assistance to human users through social interaction (Feil-Seifer & Mataric, 2005). It is possible to categorize SARs into two categories: service robots and companion robots. Service robots aid with daily activities, while companion robots are more associated with providing company and thus reducing loneliness (Abdi, 2018).

SARs of the service type are used increasingly to provide assistance to both patients with dementia and their caregivers. The robots assist in daily activities from the cognitive to the physical; for example, patients can be reminded of schedules and medication they need to take, or they can be given exercises. At the same time, companion SAR usage is gradually growing in daily life, mainly for the use of these robots in therapeutic sessions. Additionally, these robots are more and more put to action for social interaction growth (Šabanović, 2015).

These Socially Assistive Robots have great relevance for Artificial Intelligence. One of the main principles of Artificial Intelligence is to have human-robot interaction. In addition to being relevant for AI, these robots lead to an important field within Artificial Intelligence and Cognitive Psychology: Applied Cognitive Psychology. This field may be defined as the science of the cognitive processes involved in activities of daily living in order to design an environment that is well suited to human cognitive abilities.

Socially Assistive Robots need to be able to interact intuitively with humans and need to be able to solve problems in everyday life in order to facilitate their assistance for human patients. Therefore, they are an important area of research in AI and Applied Cognitive Psychology.

Previous research has focused mostly on the interaction and communication between SARs and people with dementia. But since dementia is one of the major causes of dependency among older people, this raises the question of whether these SARs are actually able to increase the independency of elderly people with dementia. Therefore, this research focuses on the research question: “Do Socially Assistive Robots improve the independency of elderly people with dementia, and can they be used to complement and partially replace the caregivers?”

To answer this question, literary research will be conducted. By comparing the needs in daily life activities of elderly people with dementia and the care provided by one service SAR and one companion SAR, and analyzing interviews regarding the experiences with the robots, it can be evaluated whether SARs improve the independency of elderly people with dementia. It is expected that these robots provide more structure and reminders in daily life activities. As a result of this, it is hypothesized that the elderly people with dementia show improved independency when using a Socially Assistive Robot.

Method

Multiple databases (WorldCat, Google Scholar, PubMed) were searched for publications about Socially Assistive Robots applied in elderly care, and more specifically in elderly care with dementia patients. Separate articles about Socially Assistive Robots and dementia were also taken into consideration. For the date of publication, no limitations were applied. Only articles written in English and Dutch were taken into account.

With these articles, this research first looked into dementia and the needs of dementia patients. The needs focused on in this research are the needs that occur in daily life activities, such as cooking and taking medicines. This research did not focus solely on the medical needs, since these needs apply more to physically assistive robots rather than service and companion SARs.

Thereafter, a detailed description of Socially Assistive Robots and what they can do and provide was made. Since there exist two types of

SARs, service and companion robots, a comparison was made between one service SAR (Tessa) and one companion SAR (Paro). This comparison showed some distinctions in the different types of SARs that are currently used and the differences in the care that they can provide. Many companies have made this type of robot, but a lot of them have not been tested extensively yet and not all the robots have the same functionalities. The SARs examined by this research were selected based on the amount of testing that already had been done with them.

Hereafter, interviews regarding experiences with the robots and experiments testing the SARs were analyzed. These interviews were conducted beforehand by researchers and foundations for elderly people with dementia. The criteria for selecting these interviews were that the questions should have been asked to the elderly that have used one of the SARs discussed or to the caregivers of these persons, and that these elderly persons had dementia.

For the experiments, the selection criteria were that these were conducted with one of the SARs, with an elderly person with dementia, and that they provided information regarding daily life activities. The analysis of the interviews and experiments was done by looking for common patterns in the data to identify the change that was initiated by using the SAR. Hereby, the conditions before and after using the SAR were taken into consideration.

As the final step, with all the gathered information, an assessment was made to see whether the SARs provide the assistance that is needed by dementia patients and if with this aid the independency of elderly people with dementia is improved. This assessment was aided by using the Individually Prioritized Problem Assessment (IPPA). The IPPA is used to assess the effectiveness of an assistive tool. This instrument of measurement can be used to examine to what extent the problems that an activity poses are solved by the tool (Wessels, Persson, Lorentsen, Andrich, Ferrario, Oortwijn, VanBeekum, Brodin, & De Witte, 2002).

To use the IPPA, only problems that patients and their caregivers indicate are assessed. Since these problems all contribute to a decreased independency, they were all taken into account.

The activities in which patients and their caregivers indicated problems were scored from 1 to 5, in which a score of 1 indicates that the patient does not have difficulty with the activity, and a score of 5 means that the patient has so much difficulty with the activity that it cannot be executed. The scoring was done twice by using the analysis of the experiments and the interviews. The score was indicated once before the patients started using the SAR, and once after the patients had used the SAR for some time. With these scores, it was possible to conclude whether SARs are able to improve the independency of elderly people with dementia.

Dementia

In the interest of understanding whether Socially Assistive Robots aid elderly people with dementia, it is essential to understand what dementia is and what symptoms occur. Therefore, an overview of the different stages of dementia and the associated symptoms for every stage is given in this section.

For patients with dementia, there is a decline in cognitive function that is worse than what is normally expected when ageing (WHO, 2019). Deterioration in memory, language, and decision-making arises, as well as other symptoms such as changes in mood (Health in Aging, 2020). This syndrome is generally divided into three stages: early, middle and late. Typically, the symptoms worsen over time, although the rate at which it progresses may vary.

In the early stage of dementia, a person may function independently. When in this stage, lapses in memory can be recognized. Common difficulties include coming up with the right word, forgetting information that was just read, and losing or misplacing objects. During this time, it is possible for patients to live well by focusing on their health and the meaningful aspects of their life (Alzheimer's Association, 2020).

The middle stage of dementia is on average the longest stage, which can last for many years. In this stage, patients generally start to require more care. Symptoms that occur most frequently are forgetting events and personal history, being unable to recall information, feeling withdrawn or moody, and experiencing changes in sleep patterns (Alzheimer's Association, 2020).

In this stage, the needs of dementia patients increase and they require more care. One of the most important strategies to manage certain common symptoms in dementia is having a predictable schedule. To avoid or minimize confusion, reminders should be clear, simple, and easy to recognize. It is also important to tell the patient what they should do, instead of what they should not do (Health in Aging, 2020).

Another key strategy is to ease agitation and aggression that may arise when a patient gets frustrated. This can be done by eliminating as many sources of stress in the home as possible, playing soothing music, and other activities that might alleviate stressful feelings. In case of agitated behavior, it is important to stay calm and try simple distractions (Health in Aging, 2020).

In the late stage of dementia, symptoms are severe. Patients may lose awareness of their surroundings, have difficulty communicating, and have a decline in their physical abilities. In this stage, patients often require continuous and extensive care. While patients may not be able to engage frequently in this stage, they still might benefit from certain forms of interaction, such as gentle touch and soothing music (Alzheimer's Association, 2020).

Socially Assistive Robots

In this research, two types of SARs were selected: service and companion SARs. Service robots aid with daily activities, while companion robots are more associated with providing company and social interaction. For the service SAR, the robot Tessa was selected. For the companion SAR, the robot Paro was chosen.

Tessa

Tessa is a service Socially Assistive Robot that looks like a plant pot (Figure 1). It was created for people that suffer from dementia by the Dutch company Tinybots. This robot is capable of speaking and is able to provide alerts, reminders, verbal guidance and encouragement to patients. The goal of using Tessa is to provide more structure in the daily life of dementia patients and letting them live more independently through activating the patient with its messages (RobotZorg, 2019).

Figure 1: Robot Tessa from the company Tinybots

Robot Tessa needs to be placed in a central spot in the house and should be connected to the local WIFI network. When connected, Tessa is ready to be used through an app. In this app, caretakers and family members can add a daily agenda and they can schedule times when reminders are given, no matter where they are. Even questions to the patient can be added and the answer will be shown in the app (Tinybots, 2018).

When it's time for an announcement or a reminder, Tessa always has the same structure: first it plays a tune, then tells the time, and next gives the message. An example of a message would be: "Good afternoon miss Parker! It's almost quarter past 12. Are you hungry already? The bread is on the kitchen counter. You can find the cheese that you like so much in the refrigerator."

Furthermore, besides giving spoken messages with reminders and guidance, Tessa has voice recognition. When it asks a yes/no question, it is able to recognize the answer and adapt what it says next. If no response is given to the question,

Tessa will repeat the question. Through the app, the caretakers and family can retrieve all the messages and the answers that were given by the patient.

The last functionality that Tessa has is playing music. In the app a playlist can be made, and it can be scheduled to play at any time. Before playing the music, it will ask the patient whether it is a good moment to play some music. When the answer 'yes' is detected, the music will start playing. Every 15 minutes Tessa will ask whether it should continue playing the music. When a 'no' is detected, the music stops.

The company Tinybots is continuously working on new developments for Tessa to have even better functionalities when working with patients. At this moment, the main development that is being worked on is more interaction. For this, a script database will be created, so that patients can have complete conversations with Tessa. In the future, more research can be done with these new functionalities (Tinybots, 2018).

Paro

The companion SAR selected for this research is Paro, a robot that looks like a baby seal (Figure 2). This robot was created by the Japanese company AIST to provide animal therapy in environments where live animals are not possible. The goal of using Paro is to reduce stress, stimulate interaction and improve socialization (Paro Robots, 2014).

Figure 2: Robot Paro from the company AIST

Paro is able to respond to patients through five kinds of sensors: touch, light, noise, temperature, and posture sensors. With these sensors, Paro recognizes how he is held, the direction of voices, and is able to understand its name, greetings, and praise. Because of this, Paro responds as if alive when interacting with patients. He moves his head, eyes, and tail, makes noises, and shows your preferred behavior (Paro Robots, 2014).

Since Paro is very soft and cuddly, he is used frequently in therapy sessions in which patients cuddle and talk with the robot. The objective of this is that patients feel calmer and at the same time that their social interaction increases when communicating with each other (RobotZorg, 2019).

Interviews & Scoring

The scoring of the patients was done by using the Individually Prioritized Problem Assessment (IPPA) that was validated by research from van Heerkens et al (2010). The IPPA is used to assess the effectiveness of an assistive tool. This instrument of measurement can be used to examine to what extent the problems that an activity poses are solved by the tool (Wessels, Persson, Lorentsen, Andrich, Ferrario, Oortwijn, VanBeekum, Brodin, & De Witte, 2002).

With this measurement, only problems that patients and their caregivers indicated were taken into account. These problems were scored from 1 to 5, in which a score of 1 indicates that the patient does not have difficulty with the activity, and a score of 5 means that the patient has so much difficulty with the activity that it cannot be executed. The scoring criteria that were used are shown in table 1.

TABLE 1
IPPA Score Criteria

Score	Description
1	No effort at all
2	A little effort
3	Tolerable effort
4	A lot of effort
5	Too much effort to execute the activity

Table 1: Individually Prioritized Problem Assessment (IPPA) score criteria

This scoring was done twice: once before the SAR was taken into usage, and once after the patient had used the SAR for a period of time. For the robot Tessa, the SAR was used for approximately three to six months. The robot Paro was used for multiple therapy sessions, each session lasting a few hours. Normally these scores are multiplied by the weighting factor importance. Since all problems are of equal importance in this research, this weighting factor was removed from the equation.

For robot Tessa 17 interviews were taken into account for the scoring. Since some participants indicated multiple problems in their daily life activities, a total of 29 activities were scored. Of the interviewees, 58.82% were female and 41.18% male. All participants were aged 65 years of age or above and were diagnosed with dementia.

For robot Paro 5 experiments with a total of 203 participants were taken into account. In the experiments, only one problem per participant was included. Approximately 67% of the participants were female and 33% male. The participants were all above 65 years of age and had a dementia diagnosis.

Details of the scores for Tessa can be found in Appendix A, with the scores of Paro in Appendix B. By way of illustration, one example of scoring for each of the robots is included in the next paragraphs.

Tessa

Patient V.B. was part of testing robot Tessa. She and her caregivers indicated that she had problems with going to appointments and that she often forgot to have meals. Both of these activities required a lot of effort from the patient to remember and execute, so a score of 4 was given to both of these problems.

After a few weeks, another interview was conducted with patient V.B. to compare how these activities had changed since the use of Tessa. The patient and her caregivers indicated that they feel like Tessa helped substantially. When Tessa reminds the patient to go to an appointment she does go. And when Tessa points out that it is time for a meal, the patient directly goes into the kitchen and prepares a meal. The amount of effort has dropped notably. However, executing the activities is not yet effortless. Because of this, a score of 2 was given to both of the activities. This means that the score of this patient has improved with 2 points after using Tessa.

Paro

For Paro, a similar way of testing was used. Patient A. and her caregivers expressed that difficulty when communicating with other patients was often experienced. The patient kept repeating the same demands, which caused that it took a lot of effort to communicate with other patients. Therefore, a score of 4 was assigned.

The robot was used in multiple therapy sessions combined with other patients. After a few sessions, an improvement in communication was noticed by the caregivers of the patient. She calmed down and started interacting with the other patients that were in the room.

However, the patient only did this when she was holding Paro. The sessions had no lasting effect on the patient. The amount of effort is still tolerable, and an improvement was seen, thus a score of 3 was given. This means that the score of this patient has improved with 1 point after using Paro.

Results

After analyzing the interviews and comparing the before and after scores of the patients (table 2; figure 3), it is seen that both SARs have a positive effect on the problems that the patients and their caregivers indicated.

The patients that were assisted by robot Tessa started with an average score of 4.14 (SD = 0.69) and at the end of the trials their average score dropped to an average of 2.55 (SD = 0.90). Which means that they come close to almost two points of improvement in the scores.

TABLE 2
Average Before and After Scores

	Before	After
Tessa	4.13 (SD = 0.69)	2.55 (SD = 0.90)
Paro	4.00 (SD = 0.07)	2.62 (SD = 0.61)

Table 2: The average Individually Prioritized Problem Assessment (IPPA) scores when using the Socially Assistive Robots (SARs) Tessa and Paro. Both the scores before and after using the SAR and their standard deviations are included. A score of 1 means that an activity takes no effort, while a score of 5 means that an activity takes so much effort that it cannot be executed. With the IPPA the effectiveness of an assistive tool can be assessed.

A Wilcoxon Signed-Rank test, with a significance level of $\alpha = 0.05$, was conducted to compare the before and after situations. With using robot Tessa, there was a significant difference in the scores before and after being assisted by the SAR, $z = 4.38$, $p < .001$.

The patients that used Paro show a similar improvement. Their average score before using the SAR was 4.00 (SD = 0.07), while this score improved to an average of 2.62 (SD = 0.61) after using Paro.

For the dataset for Paro, a Wilcoxon Signed-Rank test, with a significance level of $\alpha = 0.05$, was conducted. With this robot, there was also a significant difference in the scores before and after being assisted by the SAR, $z = 8.21$, $p < .001$.

These results suggest that both SARs do improve the problems that are encountered by patients and their caregivers. And in this way do improve the independency of elderly people with dementia.

When taking a closer look at the analysis of the interviews, some extra findings can be found. When examining the type of activities that the patients indicated problems with, it shows that Paro only provided positive effects for calming patients and improving socialization. On the other hand, Tessa supported activities of daily living in addition to reducing loneliness.

Another interesting finding in the analysis of the scores is that the patients that had no improvement in their score were all still living together with their spouse or were quickly worsening in their dementia towards the last stage. This was seen more clearly with the patients that used robot Tessa.

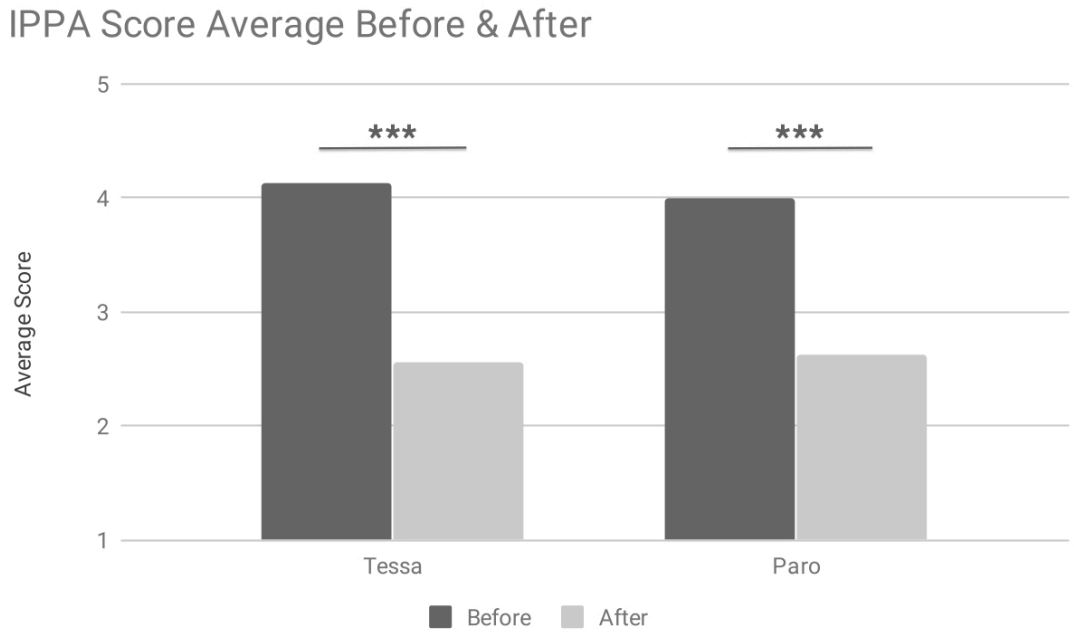

Figure 3: The average Individually Prioritized Problem Assessment (IPPA) scores when using the Socially Assistive Robots (SARs) Tessa and Paro. Both the scores before and after using the SAR are included. A score of 1 means that an activity takes no effort, while a score of 5 means that an activity takes so much effort that it cannot be executed. With the IPPA the effectiveness of an assistive tool can be assessed. *** = $p < .001$.

Conclusion & Discussion

This research aimed to identify whether Socially Assistive Robots are able to improve the independency of elderly people with dementia. Based on an extensive analysis of multiple interviews, it can be concluded that these robots do improve the problems that occur in the lives of dementia patients and hereby improve their independency.

The results indicate that Tessa assists with activities of daily living and loneliness, while Paro has calming effects and improves socialization. However, the positive effects diminish when the patients enter the late stage symptoms of dementia.

Since both SARs have specific functionalities, they are excellent additions to complement caregivers, but they are not able to fully replace them. However, these robots may reduce the workload of the families and caregivers of dementia patients. Which might give them the time to give the attention and help that is needed to improve the patients' lives.

A point of discussion might be that almost all experiments with Paro that were used in this research were previously scored, with the IPPA score, by other researchers. All the interviews about Tessa were scored by this research. Due to this, slight differences in the scores might have occurred.

Possible future research could be done by conducting an experiment in which various Socially Assistive Robots are tested with elderly people with dementia. The IPPA scoring, or another objective form of measurement, can be used to score these findings. By using one experiment, instead of comparing multiple different experiments, there is a smaller chance that slight differences in scores might occur.

Another possibility for future advancement could be the creation of a Socially Assistive Robot that has the features of both Tessa and Paro. In this way, these SARs might give broader assistance in the daily life of patients. When Tessa is developed further with more interaction, this could also cause more improvement in the activities of daily living.

This study implicates that Socially Assistive Robots are of great importance within Artificial Intelligence. Since one of the main principles of AI is to have human-robot interaction, improving these SARs and conducting further research is important.

Through efforts in AI and Applied Cognitive Psychology, SARs are improving in solving problems in everyday life. Within these fields, advancements are being made in designing an environment of daily living that is well suited to human cognitive abilities, especially in dementia care, and this progress will continue over the coming years.

References

Abdi, J., Al-Hindawi, A., Ng, T., & Vizcaychipi, M. P. (2018). Scoping review on the use of socially assistive robot technology in elderly care. *BMJ Open*, *8*(2). doi: 10.1136/bmjopen-2017-018815

Alzheimer's Association. (2020). Stages of Alzheimer's. Retrieved from https://www.alz.org/alzheimers-dementia/stages

Bemelmans, R., Gelderblom, G. J., Jonker, P., & Witte, L. D. (2015). Effectiveness of Robot Paro in Intramural Psychogeriatric Care: A Multicenter Quasi-Experimental Study. *Journal of the American Medical Directors Association*, *16*(11), 946–950. doi: 10.1016/j.jamda.2015.05.007

Boom, N. de & El Hajji, A. (2019). Zorgrobot Tessa. Retrieved from https://minoractiveageing-nine-de-boom88.webnode.nl/_files/200000258-b4cbfb5c43/TESSA%20Handboek%20goed.pdf

Feil-Seifer, D., & Mataric, M. (2005). Socially Assistive Robotics. *9th International Conference on Rehabilitation Robotics, 2005. ICORR 2005.* doi: 10.1109/icorr.2005.1501143

Geest, M. van der. (2019, September 13). Duizenden ouderen wachten op verpleeghuisplek of thuiszorg – 'Er is een dramatische situatie aan het ontstaan'. Retrieved from https://www.volkskrant.nl/nieuws-achtergrond/duizenden-ouderen-wachten-op-verpleeghuisplek-of-thuiszorg-er-is-een-dramatische-situatie-aan-het-ontstaan~bb352191

Health in Ageing. (2020). Dementia. Retrieved from https://www.healthinaging.org/a-z-topic/dementia

Heerkens, Y., Claus, E., Hagedoren, E. (2010). Opstellen richtlijnen voor functiegerichte aanspraak hulpmiddelen: basisrichtlijn hulpmiddelenzorg. Retrieved from https://www.wcs.nl/wp-content/uploads/2010_Basisrichtlijn_hulpmiddelenzorg-RiFA-fase1-19.pdf

Inoue, K., Wada, K., & Uehara, R. (2011). How Effective Is Robot Therapy?: PARO and People with Dementia. *IFMBE Proceedings 5th European Conference of the International Federation for Medical and Biological Engineering*, 784–787. doi: 10.1007/978-3-642-23508-5_204

Jøranson, N., Pedersen, I., Rokstad, A. M. M., & Ihlebaek, C. (2016). Change in quality of life in older people with dementia participating in Paro-activity: a cluster-randomized controlled trial. *Journal of Advanced Nursing*, *72*(12), 3020–3033. doi: 10.1111/jan.13076

Jøranson, N., Pedersen, I., Rokstad, A. M. M., & Ihlebæk, C. (2015). Effects on Symptoms of Agitation and Depression in Persons With Dementia Participating in Robot-Assisted Activity: A Cluster-Randomized Controlled Trial. *Journal of the American Medical Directors Association*, *16*(10), 867–873. doi: 10.1016/j.jamda.2015.05.002

Kluijver, B. (2017, November 30). Patiënt heeft last van tekort personeel. Retrieved from https://www.nursing.nl/patient-heeft-last-van-tekort-personeel/

National Collaborating Centre for Mental Health (UK). (2007). Dementia. Retrieved from https://www.ncbi.nlm.nih.gov/books/ NBK55480/

Paro Robots. (2014). PARO Therapeutic Robot. Retrieved from http://www.parorobots.com/

RobotZorg. (2019, August 14). Tessa, een sociale robot voor dagelijkse structuur. Retrieved from https://www.robotzorg.nl/product/tessa-sociale-robot/

RobotZorg. (2019, September 23). Paro snoezelrobot voor mensen met dementie. Retrieved from https://www.robotzorg.nl/product/paro-snoezelrobot-voor-demente-bejaarden/

Šabanović, S., Chang, W.-L., Bennett, C. C., Piatt, J. A., & Hakken, D. (2015). A Robot of My Own: Participatory Design of Socially Assistive Robots for Independently Living Older Adults Diagnosed with Depression. *Human Aspects of IT for the Aged Population. Design for Aging Lecture Notes in Computer Science*, 104–114. doi: 10.1007/978-3-319-20892-3_11

Schinkel, F. (2019). Robot Tessa helpt ouderen. Retrieved from https://www.gelderlander.nl/video/kanalen/destentor~c285/series/korte-reportage~s977/robot-tessa-helpt-ouderen~p63389?

Tinybots. (2018). Inspiratie en ervaringen dementie. Retrieved from https://www.tinybots.nl/miscellaneous/tinybots-inspiratie-en-ervaringen-dementie

Tinybots. (2018). Tessa: voor de momenten dat even niemand beschikbaar is, ondersteunt Tessa de zelfregie. Retrieved from https://www.tinybots.nl/

United Nations. (2020). World Population Ageing 2019. doi: 10.18356/9df3caed-en

Wessels, R., Persson, J., Lorentsen, Ø., Andrich, R., Ferrario, M., Oortwijn, W., … Witte, L. D. (2002). IPPA: Individually Prioritised Problem Assessment. *Technology and Disability*, *14*(3), 141–145. doi: 10.3233/tad-2002-14310

Windesheim. (2018). Sociale robot Tessa is stem in huis voor mensen met dementie. Retrieved from https://www.windesheim.nl/over-windesheim/nieuws/2018/september/sociale-robot-tessa-is-stem-in-huis-voor-mensen-met-dementie

World Health Organization: WHO. (2019, September). Dementia. Retrieved from https://www.who.int/news-room/fact-sheets/detail/dementia

Zorginstituut Nederland. (2019). Wachtlijsten langdurige zorg. Retrieved from https://istandaarden.nl/wachtlijsten

Appendix A: Scoring of Tessa

IPPA Tessa			
Participant	**Before**	**After**	**Improvement**
V.S Activities: Staying alone at home	The wife cannot leave her husband alone at home. He gets irritated and upset Score 5: The wife doesn't leave the house since her husband cannot stay alone at home. So, the activity is not executed	Tessa reminds the husband that his wife is away until a certain time. He remains calm and she feels confident to leave him alone at home now Score 2: The wife needs to program a message for when she's gone. So, a little effort. But now she is able to leave him.	From 5 to 2, so 3 points of improvement
K. Activities: Feeling sociable (emotional 'activity') Having structure in a day	Patients feels lonely and like she cannot talk to somebody Score 4: Patient feels very lonely, this is a lot to take on Patient has no structure in daily life. Because of this, she sometimes misses meals and forgets to shower Score 4: Having structure is very difficult for the patient. Missing meals is a very serious effect.	Tessa feels like a friend to her. She can talk to her. Score 3: Patient feels like she has a friend. But it is not a real person, so it is tolerable Tessa gives the patient reminders. Because of this, the patient has more structure and eats at certain times Score 2: Because of Tessa the patient has a more structured life. It is still a bit of effort, since executing the activities that the patient is reminded of need a little effort	From 4 to 3, so 1 point of improvement From 4 to 2, so 2 points of improvement

D.B Activities: Having meals	Patient occasionally forgets to have meals Score 4: Missing meals indicated that the patient has a lot of difficulty with reminding herself to have meals	Tessa reminds the patient to have meals. When the patient gets a reminder, she goes to the kitchen to make her meal Score 2: The patient has her meals, but making them takes a little effort	From 4 to 2, so 2 points of improvement
Going to appointments	Patient occasionally forgets to go to appointments Score 4: Missing the appointments indicated that the patient has a lot of difficulty with reminding herself to go to appointments	Tessa reminds the patient to go to appointments. When she gets a reminder, she goes. Score 2: The patient goes to the appointments, but to get there takes a little effort	From 4 to 2, so 2 points of improvement
Feeling sociable (emotional 'activity')	Patients feels lonely and like she cannot talk to somebody Score 4: Patient feels very lonely, this is a lot to take on	Tessa feels like a friend to her. She can talk to her. Score 3: Patient feels like she has a friend. But it is not a real person, so it is tolerable	From 4 to 3, so 1 point of improvement
V.B Activities: Going to appointments	Patient occasionally forgets to go to appointments Score 4: Missing the appointments indicated that the patient has a lot of difficulty with reminding herself to go to appointments	Tessa reminds the patient to go to appointments. When she gets a reminder, she goes. Score 2: The patient goes to the appointments, but to get there takes a little effort	From 4 to 2, so 2 points of improvement
Having meals	Patient occasionally forgets to have meals Score 4: Missing meals indicated that the patient has a lot of difficulty with reminding herself to have meals	Tessa reminds the patient to have meals. When the patient gets a reminder, she goes to the kitchen to make her meal Score 2: The patient has her meals, but making them takes a little effort	From 4 to 2, so 2 points of improvement

S. (About multiple patients) Taking medication	Patients often forget to take their medication Score 4: The patients find it really difficult to remember to take their medication	Tessa reminds the patients to take their medication, the caregiver checked whether they all actually took it and they did Score 1: Taken the medicines is now effortless. Executing the activity is not hard, only remembering	From 4 to 1, so 3 points of improvement
Having meals	Patient occasionally forgets to have meals Score 4: Missing meals indicated that the patient has a lot of difficulty with reminding herself to have meals	Tessa reminds the patient to have meals. When the patient gets a reminder, she goes to the kitchen to make her meal Score 2: The patient has her meals, but making them takes a little effort	From 4 to 2, so 2 points of improvement
Physical activity	A lot of patients do not have a lot of physical activity. They do not think about doing things, such as taking a walk Score 5: Patients do not execute the activity, because it is too much effort to think about	Tessa asks the patient if they want to go for a walk, since the weather is great. Patients go for walks often. Score 3: Physically it takes the patients a tolerable amount of effort, but with the reminder they do go out for walks	From 5 to 3, so 2 points of improvement
Helping the caregiver	Normally the caregiver needs to grab all the objects that are necessary for a session Score 5: Patients do not think about how they can help the caregiver, and they do not execute this activity	Tessa asks the patient to grab a few objects to help the caregiver. The patients then grab these objects Score 2: If the patients are asked by Tessa to do this, they grab the objects. It only takes a little bit of effort	From 5 to 2, so 3 points of improvement

D. Having meals Physical activity	Patient occasionally forgets to have meals Score 4: Missing meals indicated that the patient has a lot of difficulty with reminding herself to have meals Patient did not have any form of physical activity. Only sat in his chair. Score 5: Patients did not execute the activity, because it is too much effort to think about	Tessa reminds the patient to have meals. When the patient gets a reminder, she goes to the kitchen to make her meal Score 2: The patient has her meals, but making them takes a little effort Patient gets up more frequently. Goes for short walks, gets the newspaper. Score 3: It still takes quite a bit of effort, but it is tolerable. Patients also feels better now that he moves more	From 4 to 2, so 2 points of improvement From 5 to 3, so 2 points of improvement
M. Feeling sociable (emotional 'activity')	Patients feels lonely and like he cannot talk to somebody Score 4: Patient feels very lonely, this is a lot to take on	Tessa feels like a friend to him. He can talk to her. Tessa also reminds him that he can go to his neighbor to drink coffee together Score 2: Patient feels like he has a friend. Besides this, he has more social contact with actual people.	From 4 to 2, so 2 points of improvement
G. & K. (Dementia patient and her husband) Baking pancakes	G. has baked pancakes every Saturday, but now she cannot do it on her own anymore Score 5: it takes too much effort to execute the activity	When Tessa gives the instructions for baking, the instructions were not clear enough for her. Score 5: the patient still cannot execute the activity	From 5 to 5, so no improvement. It was also noted that G. got more passive, because she waited until Tessa told her what to do, even if she already knew what to do. She and her husband think that it is too soon for them to start using Tessa. If Karel is not there anymore, they think it would be good for help. It is noted that the patient would like it if Tessa was more interactive

A. Answering calls and texts from family	Patient frequently forgets to answer calls or texts from his family. His daughters worry a lot because he sometimes falls and cannot get up Score 4: because his daughters worry a lot when he does not answer	Tessa asks if everything is okay. Patient answers yes or no. His daughters get a message through the app. Score 3: He still does not answer calls or texts, but his daughters now know he is okay. So it is tolerable.	From 4 to 3, so 1 point of improvement
B. Physical activity	The patient has not a lot of physical activity. He does not think about doing things, such as taking a walk Score 5: Patient does not execute the activity, because it is too much effort to think about	Tessa reminds him weekly about the market. It has been years since he was there, but now he goes every week. He walks and has more contact with other people Score 2: It takes now almost no effort for the patients to be more active and walk.	From 5 to 2, so 3 points of improvement
Having structure	Patient has no structure in daily life. Because of this, he sometimes misses meals and forgets to shower Score 4: Having structure is very difficult for the patient. Missing meals is a very serious effect, especially since he also has diabetes.	Tessa gives the patient reminders. Because of this, the patient has more structure and eats at certain times Score 2: Because of Tessa the patient has a more structured life. It is still a bit of effort, since executing the activities that the patient is reminded of need a little effort	From 4 to 2, so 2 points of improvement

W. (Mr. has dementia, lives with his wife) Remembering the activities of the day	Patients keeps asking his wife what the activities for the day are. She has to keep repeating everything. Score 3: His wife feels like it is tolerable to keep repeating the activities. Still, she hopes that she can do this less	Tessa tells the patient multiple times per day what activities are coming up. And when it is time for an activity, he gets another reminder. His wife feels like he is calmer because of this Score 2: It still takes some effort, but it is an improvement for his wife	From 3 to 2, so 1 point of improvement. It was noted that after the patient his surgery he had a rapid decline in his functioning, Tessa did not help anymore because he could not understand its messages anymore
H. Having structure	Patient has no structure in daily life. He forgets what time it is and often he wanders through the hallways in the early morning. Score 4: Having structure is very difficult for the patient.	Patient stays longer in bed in the mornings. And goes to bed at a more reasonable time. The caregivers indicate that this is a big improvement for him. Score 2: It takes a bit of effort for the patient. But he does remain in bed	From 4 to 2, so 2 point of improvement
Listening to music	Patient always liked listening to music. But he now has difficulty with turning on the radio Score 5: Patient is not able to turn on the radio. The activity is not executed	Patient indicates that he liked that Tessa played music for him. The caregivers indicate that he often did not understand Tessa's question of whether it should play music Score 3: Patient liked the music, but according to the caregivers is still takes quite some effort. So it is tolerable	From 5 to 3, so 2 points of improvement It is noted that the patient would like it if Tessa was more interactive

Ma. Feeling sociable (emotional 'activity')	Patients feels lonely and like he cannot talk to somebody Score 4: Patient feels very lonely, this is a lot to take on	Tessa feels like a friend to him. He can talk to her. Score 3: Patient feels like he has a friend. But Tessa is not a real person, so it is tolerable	From 4 to 3, so 1 point of improvement
V.R. (Mrs. has dementia, lives with husband) Physical activity	The patient has not a lot of physical activity. She would like to increase this Score 4: The patient does think about wanting to have more physical activity. But actually doing it takes a lot of effort because she only thinks about it when she cannot go	Tessa reminds her when the weather is good to take a walk. She mostly works in her garden at these moments. Score 2: Walking is still a bit more effort for the patients. But working in the garden is no effort, and she already increases her activity	From 4 to 2, so 2 points of improvement
N. Listening to music Having structure	Patient always liked listening to music. But she now has difficulty with turning on the radio Score 5: Patient is not able to turn on the radio. The activity is not executed Patient has no structure in daily life. Because of this, she sometimes misses meals and forgets to go to appointments. Her son now helps her with reminding her for everything Score 4: Having structure is very difficult for the patient. Missing meals is a very serious effect	Volume of the music was too high and patient did not remember how to turn down the volume. So she has not listened to music afterwards Score 5: Patient still does not listen to music Patient got agitated when Tessa gave her reminders. She put a cloth over Tessa so she would not see it. Score 4: There is no difference in the structure of the days of the patients	From 5 to 5, so no improvement From 4 to 4, so no improvement

V. Feeling sociable (emotional 'activity')	Patients feels lonely and like she cannot talk to somebody Score 4: Patient feels very lonely, this is a lot to take on	Tessa feels like a friend to her. She can talk to it. Tessa also reminds him that she can go to her neighbor to drink coffee together Score 2: Patient feels like she has a friend. Besides this, she has more social contact with actual people.	From 4 to 2, so 2 points of improvement It is noted that the patients would like it if Tessa could interact more
Remembering the activities of the day	Patient sometimes forget which activities she has each day. Her daughter writes down the activities. Score 3: Writing the activities down is a tolerable amount of effort, but the daughter needs to help constantly	The dementia of the patient got in a later stage and her short-term memory seemed to be non-functioning. Because of this, none of the messages were remembered by the patient. Score 3: No effect of Tessa on the remembering	From 3 to 3, so no improvement
Wo. Feeling sociable (emotional 'activity')	Patients feels lonely and like she cannot talk to somebody Score 4: Patient feels very lonely, this is a lot to take on	Tessa feels like a friend to her. She can talk to it. Score 3: Patient feels like she has a friend. But it is not a real person, so it is tolerable	From 4 to 3, so 1 point of improvement

Activities: Feeling sociable, Remembering the activities of the day, Having structure, Listening to music, Physical activity, Answering calls and texts from family, Baking pancakes, Having meals, Helping the caregiver, Taking medication, Going to appointments, Staying alone at home (12). Mostly ADL (activities of daily living)

17 participants: 10 female, 7 male. All aged 65 years of age or older.

Appendix B: Scoring of Paro

IPPA Paro			
Participant	**Before**	**After**	**Improvement**
Ms. A Communicating with other patients	Patient keeps repeating the same demands, because of this she has difficulty with communicating with other patients Score 4: It takes the patient a lot of effort to communicate with the other patients	While using Paro, the patient calmed down and started interacting with the other patients that were in the room Score 3: The patient started communicating with the other patients, but she only did this when she was using Paro	From 4 to 3, so 1 point of improvement
Mr. B Communicating with other patients	Patient is often tense and lacking in initiative. He does not communicate with other people Score 5: Patient does not execute the activity	The patient showed no changes in behavior after using Paro Score 5: Patient still does not execute the activity	From 5 to 5, so no improvement
Ms. C Feeling calm	Patient is agitated easily and is always worried Score 4: It takes a lot of effort for the patient to feel calm	Patient cradled Paro constantly and relaxed. She preferred staying with Paro instead of joining any other activities Score 2: The patient shows a lot of improvement in the effort that it takes to calm down	From 4 to 2, so 2 points of improvement
Ms. D Feeling calm	Patient is very sensitive; she does not feel at ease in most situations Score 4: The patient often does not feel calm	Patient relaxed and kept cradling Paro. She did forget about Paro sometimes, but when her attention was drawn to Paro again, she relaxed Score 3: The patient calms down with Paro. But it takes some effort to remember that she has Paro	From 4 to 3, so 1 point of improvement

Experiment Therapeutic Intervention (n=69) Feeling calm	Patients were restless, agitated, or stressed Score 4	After two months of using Paro, a positive effect was shown. Patients were calmer. Score 2	Average difference of 2 (The experiment itself was scored with the IPPA → Concluded a significant effect)
Experiment Care Support Intervention (n=17) Focusing Feeling calm	Care providers experiences difficulties in providing ADL-care (activities of daily living) tasks Score 4	No improvement was measured Score 4	Average difference of 0 (The experiment itself was scored with the IPPA → Concluded no significant effect)
Experiment Quality of Life (n=53) Feeling calm Feeling happy	Patients experienced high levels of tension and sadness Score 4	A small positive development was measured Score 2.5	Average difference of 1.5 (Experiment concluded a significant effect)
Experiment Agitation and Depression (n=60) Feeling calm Feeling happy	Patients experienced high levels of agitation and depression Score 4	The symptoms of the patients declined slightly Score 3	Average difference of 1 (Experiment concluded a significant effect)

Activities: Feeling calm, feeling happy, focusing, communicating with other patients

Participants: 203. Approximately 67% of the participants were female and 33% male. The participants were all above 65 years of age and had a dementia diagnosis.