INF2260

Tray on Wheels

Human Robot Interaction for Seniors

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Acknowledgements

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1. Introduction

Ingvild is 79 years old. She has been living on her own since her husband passed away 5 years ago. Except for a woman who comes over once a week to clean her apartment, Ingvild does all the housework and shopping on her own. However, she finds herself getting tired more easily. She has just made herself a nice dinner with consisting of meat cakes, broccoli, potatoes and a pitcher of water to wash it down. Unfortunately, it is all too much to carry in one trip, so she presses the button on her kitchen counter, and a few moments later, the Tray on Wheels enters the room and stops next to her. She puts her plate of food, her jug of water and glass onto the tray. Then she walks into her living room, sits down in front of her table and presses a button there. Just like before, the tray arrives in just a few moments, Ingvild unloads it and presses the button that sends it back to its charging station. Then she begins to eat, having gotten her food with minimal effort.

1.1 Who we are

We are a three man group, consisting of Daniel Gloppestad Bajer, Tarjei G. Olsen, and Christopher A. Ubøe, our supervisor is Jo Herstad. All three of us are students of informatics at the University of Oslo. Christopher and Daniel are both part of the *Design, use and interaction* program, Christopher is a bachelor student whereas Daniel is a master student. Tarjei is a bachelor student of the *Language and communication* program.

1.2 MECS

The MECS (Multimodal Elderly Care Systems) project is a NFR (Norwegian Research Council) funded research project, starting 2016 and ending in 2019. The purpose of MECS is to "create and evaluate multimodal human supportive systems that are able to sense, learn and predict future events." That is to say that they want to research technologies and methods that can be used to improve the safety of the elderly without having to have them under constant supervision. This is a large undertaking which includes bachelor, master, and Ph.D. students. The overall goal of the project is very broad and can be broken down into several work packages.

In an attempt to effectively answer their questions, MECS has reached out to several university and groups (public and private) and asked them for help in researching this topic. To that end, our group has taken on the task of research a project which has been dubbed *Human Robot Interaction for seniors*

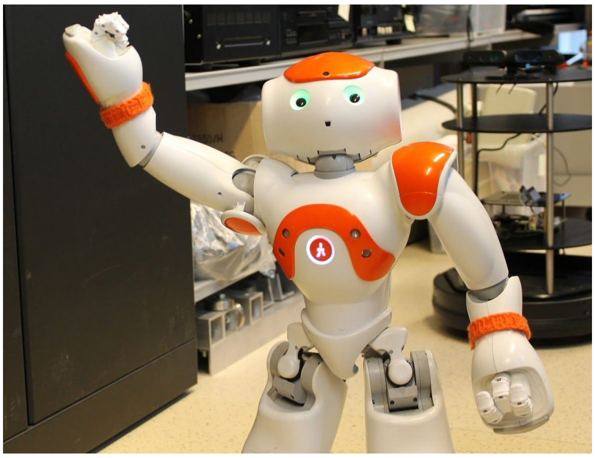
1.3 User Group

The target group of our project consists of the elderly who still live at home. The effects of time make elderly citizens less capable of completing the regular tasks they need to be able to live at home. When this starts happening, many feel obliged to move to elderly care centers, despite the fact that they do not wish it. These are the people whom we wish to focus on, and ultimately help maintain their current lives and independence for as long as possible through the use of technology.

However, something that must be taken into account is not only the physical limitations of our user group, but their technical ones as well. Unlike many people today, they did not grow up surrounded by digital technology. What might to us be considered an innocuous piece of technology, they may have considered life altering when they first saw it. With that in mind, we need to be sure that our use of technology is not overwhelming.

1.4 Our project

At its most basic level, the goal of our project, *Human Robot interaction for seniors,* can be described as "how can robots be placed within the homes of seniors?" However, that is a broad question with many different facets that need to be answered. The first thing our group did was try and define what a robot was.



After seeing Merriam-Webster's definition of a robot ("Definition of ROBOT" 2016) and discussing it, we came up with a definition which met our satisfaction: A robot is a machine that can be given tasks (of varying complexity) and complete said tasks without human supervision or instruction. In addition, it should be, in some way, capable of movement. This definition allows us to exclude things, such as computer programs, which can complete tasks but are not capable of movement, and remote controlled vehicles, which require human supervision.

In contrast, this allows us to include devices such as Roomba vacuum cleaners, self-driving cars, and even Data, the android from *Star Trek.*

As our project progressed, our goal for this project continued to change and grow based upon what we learned. Initially, we wanted to know what kind of robot the elderly wanted and potentially building it. But the more research we did, the more we realized how broad a topic we had chosen, and decided we had to narrow it down as we moved forward. So as we advanced, our goals changed. We started focusing less on the actual robot and more on the interaction with it. Forms of interaction such as voice sensors, motion sensors, proximity sensors, screens, and ultimately deciding on the use of button interaction.

The research question we are addressing with this project is about ways of interacting with robots. We started out with some rather broad research questions, investigating HCI in a more general sense, and revised the research question throughout the semester. After several iterations our project chose to focus on the research question:

How can interaction with a robot through a button best be designed for elderly users?

By narrowing the broad range of issues down to this specific question, the foundation of this project became more comprehensible as to what we would eventually contribute to the MECS project. Some subordinate questions arose, which we believed to be relevant.

- In what type of HCI scenarios are buttons best suited?
- How can we make the button interface intuitive for the elderly?
- Where should the button be placed in relation to the user?

2. Theory and methods overview

This chapter presents the theory used for this project, both from the curriculum and other sources. How the theory was applied is described outside of this chapter, mostly in chapters three, four and five.

Taking the research project and the target group into account it was natural for us to choose research through design (Zimmerman and Forlizzi 2014). The goal of our project was to make a contribution to the MECS project. So the output of our research through design should be something that can be of use to the other involved parts of the MECS project. One aspect that research through design offers is that the problem area and the research questions are adapted as the process goes on. Doing research through design we tried to use the steps provided by Zimmerman and Forlizzi. They are:

- *Select, Design, Evaluate, Reflect and disseminate, Repeat*

These steps show that research through design is recommended to be performed as an iterative process and it also fits together with being able to redefine and adapt the problem area as the process goes along.

As is further described in the process chapter, the idea of using a button as an interaction mechanism developed later in the process. We were recommended (Janlert 2014) by our supervisor, and it proved useful for the design of our button. Janlert points out that the feedback of a button is important and that there are many different ways for buttons and switches to convey their state. Janlert also focuses on what the user intends by pushing the button. This is related to whether the user feels that it just initiates an action or actually performs an action by using the button. A physical button provides several types of feedback to the user. It gives the user haptic feedback, you can feel that something is happening, the button is being pressed. It gives audial feedback of some extent, you can hear that the button is being pressed often with a clicking sound. It also gives visual feedback, you can see that the button is pressed, and with many kinds of buttons you can also see the state it is currently in visually.

To help us analyze our data we chose to have looked at (Fink et al. 2013) where a vacuum cleaning robot was studied. The study follows several families that live with a robot at home and points to several factors that are important for users to want a robot at home. We used these factors as guidelines for our project when we created interview questions and other sessions with the seniors. The aspects listed by Fink are:

- Usefulness and how useful the robot is perceived to be.
- Physical space required for the robot to function properly
- Ease of use and how easy it is to learn to use the robot.
- Compatibility with habits and routines. How well the robot fits into the habits of the persons that are going to use it.

- Reliability and attachment. To what extent the user likes and gets attached to the robot. This is often related to the robots reliability. If it’s reliable it’s more easily well liked.
- Social Compatibility, to what extent the people the user know and is surrounded by like and approve of the use of the robot.
- Economical compatibility, how affordable and energy efficient the robot is.

Our approach to solve our problem was qualitative. We based our methods on (Lazar, Feng, and Hochheiser 2010) 8,10,11, 14 and 15. These chapters proved valuable for a qualitative approach and they deal with topics regarding interviews, focus groups, analysing data, and working with different kinds of humans.

Because of our early involvement in the MECS project and our goal for the project to serve as an early exploration of the topic and problem area, we found that it was sufficient for us to use an informal analysis method for the data collected through our interviews and focus groups. To do this we chose to categorize our comments into different categories. Inspired by (Fink et al. 2013) principles we reshaped and formed our own categories that were best fitted for our project. We involved categories like *New ideas* because we were also developing a prototype and not only testing an existing prototype like Fink did in his research. The categories we used were:

Ideas towards design, Reliability and attachment, Negative towards technology in general, Positive towards technology in general, Negative towards usefulness, Positive towards usefulness, Off-topic.

To create these categories our approach can best be described as emergent coding. We did not create the categories before our data collection. Through conducting the data collection we gained an insight and were able to create categories enabling us to revisit the data and analyze it.

The interviews we conducted during our design process were semi-structured. The reason for this was that we wanted to be open for the ideas the participants may provide, which a semi-structured interview facilitates for by not limiting the person being interviewed too much. We used interviews both for initial exploration and for further development. We also used focus groups aswell, also semi-structured.

Towards the end of our design process we also conducted a usability test. For the usability test we planned a scenario to be explained to the potential users and tested for our prototype. Doing this we still collected qualitative data. This seemed the best to us because of the nature of our project, our goal being to create discussion and facilitate for exploration of ideas. Although this was the final test of our project we didn't consider it a summative test. Our goal was not to validate the prototype as it was at that point in time. We viewed it as a formative test because the main purpose of our prototype is to serve as an object to promote discussion, and the existing potential to develop it further though this is not something we will do during this project. The steps we based our usability test on were 1. Develop the test plan 2. Set up the test environment 3. Find and select participants 4. Prepare test materials 5. Conduct the test sessions 6. Debrief the participants 7. Analyze data and observations 8. Report findings and recommendations (Rubin and Chisnell, 2008) in (Lazar et al. 2010)

Based on (Lazar, Feng, and Hochheiser 2010) and the chapters on working with humans and working with participants with impairments we also focused on another aspect. We had to take into account that we were going to interact with our target group, seniors. Working with elderly required for us to act in a certain way. We put extra care into making consent forms and also explaining what they meant orally. The reason for doing this was that our participants might not understand a consent form or be familiar with it. We also knew that our user group could be in bad physical shape so not stressing or wearing them out was also something we focused on, and tailored our methods towards.

3. Process

We started our design process by *selecting* an area of research. In the beginning this was a very broad topic, but as time progressed we fine tuned our focus.

The next step was doing background research and getting information on our user group. This is described as the *design* phase of research through design. This is a phase we that we repeated several times throughout the process alternating between it and *evaluation*. We considered several ways of gathering data on our user group. Typically, when one starts a research project, one knows what they are trying to accomplish, though not necessarily how. For this project, it is the reverse. We knew that we had to use robotics as part of our solution, but we did not know what our solution was going to be.

The purpose of the project was to find out what sort of robotics the elderly would be comfortable having in their home. With that in mind, we decided interviews were the best option, allowing us to gain more in-depth information, even if interviews such as this are less time efficient (Lazar, Feng, and Hochheiser 2010).

3.1. First round of interviews

We decided to make our interview style semi-structured, primarily because we were not entirely sure what kind of information we were looking to find. Based on our own personal experiences with the elderly, none of us felt incentives were necessary to get participants to join us. We believed that most participants would volunteer without them, simply enjoying the opportunity to converse with new people and have their opinions heard, a notion which proved to be correct.

Our recruitment of participants was very casual, simply approaching people at St. Hanshaugen's elderly center and asking if they wished to help us with our project by answering a few questions. Right off the bat, people were eager to talk to us, though that did not mean everyone wanted to talk about robots. Before beginning any interview, however, we gave them a consent form to sign and made sure to explain what our project was and that they were free not answer or leave any time they desired, as per our ethical obligation (Zimmerman and Forlizzi 2014; Lazar, Feng, and Hochheiser 2010).

We asked questions about their living situations, their daily tasks, problems they faced, technology they used and more. We tried to encourage them to speak their minds on all subjects, wanting them to not only answer our questions, but add in points that they felt were relevant. Some things were relevant, and others were, as we expected of our user group and set time aside for it, more anecdotal experiences from their past with little to do with technology. Afterwards, having recorded everyone's responses, we compared the responses and did our best to find patterns.

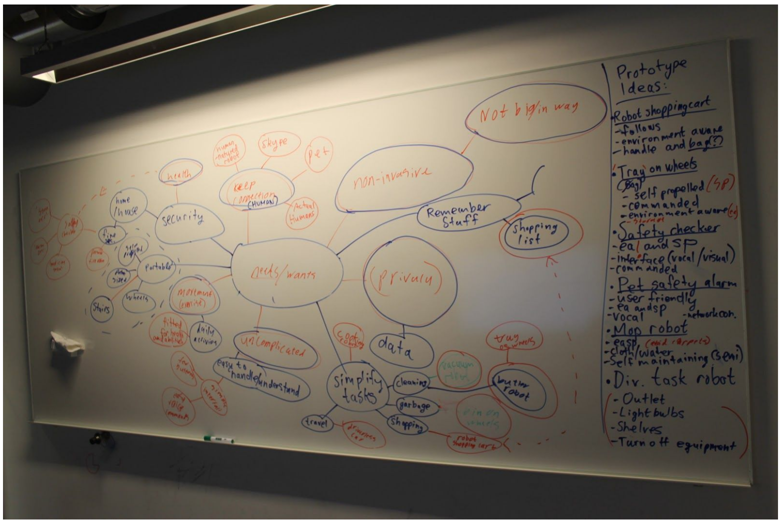
Some felt that using robots took away the interaction with other people, that any job given to a robot could also be done by a human, which would be more comforting and easier to interact with. Others felt that a robot, while not necessary in their lives, would be useful in certain circumstances. Scenarios such as reaching objects on high shelves or unplugging something from underneath a table, tasks which younger people can do without thinking, can be difficult and even frightening to the elderly, and having a robot to help them avoid the burden and the risk would be a great boon in their day to day lives.

Access to alarms and means of communicating with others was a common thread and desire during our interviews. Most had some device or tool which allowed them to alert others in emergencies, such as phones and emergency pull strings, but they are not always ideal. Pull strings, for example, are not everywhere, even in one's own home, and being able to communicate in an emergency, no matter where they are, is an important criteria for the elderly. There were also mentions of safety alarms that could be carried around, either around their necks or on their wrists. However many felt that it was too much trouble to have it on all the time.

One person even casually mentioned that, while they did not necessarily want a robot in their home, they would not hate it, assuming it was more ‘sociable’ than a simple machine.

3.2. Brainstorming

After having completed a round of interviews, it was time to analyze the data and use it to come up with potential ideas for our robot. First, we went through the recordings of the interviews individually. This allowed us to interpret the information without being influenced by one another. Whilst going through them, we all did our best to avoid bias and not cherry-pick our data. Having done that, we all met back at school and our brainstorming began.



The mind map/concept map made under the brainstorming session (“Mind Map - Wikipedia” 2016)

For our brainstorming, we used the principles known as the Osborn method (“Brainstorming - Wikipedia” 2016): no criticism, wild ideas are encouraged, quantity over quality, combining and refining of ideas. So we just started putting up data on the board, creating a mind map. Initially, we were not even coming up with ideas, just data. We put up common activities and tasks the elderly have to deal with, issues they want solved, solutions they would not use, and any other information we could formulate into categories.

After that, it became a matter of connecting all these points and using them to create a coherent idea. Instead of struggling to come up with ideas, we struggled to narrow them down. We came up with the robot shopping cart, the safety checker, the pet safety alarm, the mop robot, a robot which completed miscellaneous tasks (change light bulbs, plugged/unplug devices, etc) and the tray on wheels.

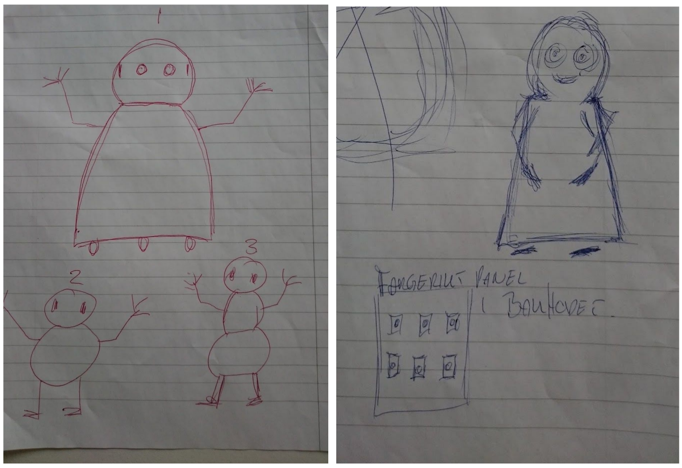
After coming up with all these ideas, we discussed amongst ourselves the pros and cons of each prototype. Towards the end, we were caught between two very similar ideas, the tray on wheels and the robot shopping cart. Both transported things for the user (though one went with you to and from the store while the other stayed in the home) which was an issue which we felt was prevalent for our user group. However, after much deliberation, we decided that the tray on wheels suited our needs more, since it would be used in the home, as opposed to outside of the home, which is more in sync with the project description.

3.3. Group interview

Having come up with an idea for what we wanted to research and ultimately create, we needed to return to our user group and discuss the concept with them. We needed their input to make our own idea more concrete, and establish what their wants and needs for such a robot would be. In addition, we wanted to know how useful they thought such a robot device would be to them.

This time, however, instead of one-on-one interviews we decided to have group interviews. This had two advantages for us. Firstly, it allowed us to collect more information much more quickly. With multiple people in a room several ideas could be expressed and within a short time span. And secondly, with several members of our user group in the same room, they felt much more secure and did not feel as pressured or as outnumbered as they would feel when interviewed individually (Aubel and International Labour Office 1994).

Our group interviews consisted of three people at a time, enough that ideas could be shared, but not so many that they overwhelmed one another. When they were brought together, we gave them a short introduction about what we were there to do, in relation to robots and how they might be used by the elderly. During the interview, we asked them several questions which they all answered eagerly and expressed many thoughts and ideas they had around the concept. At first, they seemed a little reluctant to want robots, worried it might make things too sterile, but as we encouraged them to think of applications and functionalities of robots, they became more open to the idea. Their image of a robot was more humanoid than we were expecting, giving it a full bipedal body with gripping hands and such. One even mentioned adding hair. And while they saw many uses for robots, one thing they were adamantly against was using a robot for physical companionship. It should be used as an aid, not as a replacement for human companionship.



A few examples of their pictures, one of which includes a 'colorful' panel of buttons

On their own, they came up with the concept of a robot that would carry things around for them and to them and were very pleased with the idea. The only way in which their idea did not match with our prototype idea was that this robot would be more self-sufficient, able to pick things up on its own, as opposed to simply carrying them. And when asked to draw how they imagined this robot, they drew machines which were more mechanomorphized (giving human characteristics to machines) instead of simple functionality.

Probably the most significant piece of information we gathered from these interviews was how many of the users automatically assumed that the robot would respond to voice commands. It is understandable, as voice communication is the easiest way to express one's desires. However, expressing a desire is not the same as interpreting one, which is something the robot would have to do. So despite their primary suggestion, we would ultimately decide on communication through buttons, something which we go into more detail below.

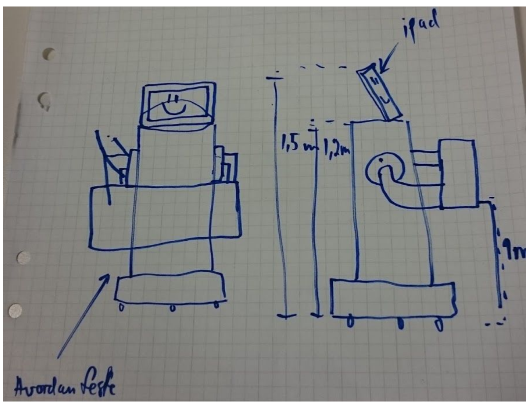
«Jeg lurer om jeg kunne tenkt meg en sånn robot…»

3.4. Prototyping

Using the information we gathered from the group interviews, based on our own individual interpretation of the facts, we drew our own concept sketches for a research prototype and then compared them. This helped solidify what we each considered the important points from the interviews.

Our prototype concepts were far more advanced than any practical prototype that we could have made. This did not stop us however, since our main focus was on the research itself, and as such, our concepts served us better than more down to Earth ideas.

Arms for the robot were a major point of discussion for us. On one hand, the idea of having a robot that could pick things up for you was a very appealing. However, a robotic arm is a research topic broad enough all on its own. The technical aspects alone are months of research. So for simplicities sake, we decided not to use it in our prototype. There was a later point where we considered adding on arms to serve as a more decorative function, something that may have been useful in a more advanced prototype, but we did not want to distract the users with miscellaneous details. Under the same token, we did not give the robot a face because it could have potentially made the users less critical of any flaws.



One of our drawings for the tray on wheels

Next, we had to decide how the user would communicate with the robot. We had several potential options for this. A voice sensor was one we really liked as well, which several in our test groups suggested. However, creating a program in which a robot reacted in a specific manner to a certain sound is a highly technical and time consuming endeavour, similar to the robot arm. Also, a common affliction with the elderly is the habit of mumbling and speaking unclearly. So in the end, we decided that a tangible button interface was more appropriate and efficient because a button has less room for misinterpretation and is already a familiar concept to our user group. More benefits of a button is described in the theory chapter.

After that, we discussed how we would create a moving prototype. Our two main ideas were either mounting a shell on a Roomba or mounting a shell on a remote control car. The Roomba had the advantage of being an actual robot with built in sensors and programing, but was never meant to move between two points as we wanted it to. The RC had the advantage of being far more versatile and was better at receiving signals. However, it was not an actual robot and redesigning one so it operated as a robot seemed a bit roundabout.

It was at this point that the midterm presentation was approaching, so we decided to take a slight break from prototyping and focus more on our presentation and then regroup and workshop our idea with fresh eyes.

3.5. Workshop

We held a workshop within the group to gather our ideas and discuss how we should build our prototype. The purpose of the workshop was to figure out what our next move should be, in regards to how we wanted to build our prototype. We divided the session into two parts; idea and criticism. In the idea-phase we started with an individual brainstorming, followed by a collective brainstorming where we could build on each others ideas. In the criticism-phase the purpose was to reflect on the ideas and eliminate until we could make a decision on what kind of prototype we wanted to build.

Some of the ideas we discussed were building a prototype with lego, make a virtual representation of the robot in the form of a 3D environment and building a robot using an Arduino. The idea we initially wanted to go with was a virtual representation, seeing that it would be a cost-effective prototype and an easy platform to show different scenarios.

Following a discussion with Alma we were told that the prototype had to be something tangible. After researching the components needed for a lego-prototype, we decided that an Arduino would be the best option, as we already had two Arduino-kits at our disposal.

3.6. Building

Now we were at the *dissemination* part of the project, where we wanted to create a product which could be demonstrated. Before building the actual robot we decided to create a video prototype first. With this video, we demonstrated the desired functionality of our final prototype. However, since we had no function prototype to demonstrate as of yet, during the filming, we used the Wizard-of-Oz method (Lazar, Feng, and Hochheiser 2010), creating a model of a robot and buttons which created the illusion of functionality.

Using Janlert's ideas for buttons we chose to focus on two different mechanisms for physical buttons. They both used two states, one for the robot to move to you and one for the robot to go back to its station to charge. One of the prototypes had one button, while the other had two buttons. For the one button solution the button had two states. Like a ball point pen the button could be pressed down or extended up. For the two -button solution you press one button to get the robot to come to you, and the other for the robot to return to its station. In our video prototype we used a flipping button for this solution as can be seen in the picture below. Both of our solutions give the user visual feedback, but this is a more inherent trait with the one-button solution since the two states are also used to decide which action is available. With a two- button solution you always have the two actions available.

The two-button solution

The one-button solution

The process of building the actual robot was a bit more intricate than we first thought, as none of us were particularly skilled with using Arduino. We started shopping for components which we hoped would prove useful, such as an infrared receiver with a corresponding remote controller and different buttons. The remaining components required to build the prototype we already had at our disposal. We did some research online and found a guide that we used as a base, and with some tinkering we made a simple, yet functional, Arduino-robot.

After a meeting with our contact teacher he introduced us to Mikael, who is a skilled programmer and an expert on electrical components. With his help we further developed our robot to become a sophisticated prototype. We used radio-signals for communication, which extends the range of the controller, and added extra batteries to support the engine. At this point we used a controller which was programmed to communicate with the robot using two out of its eight buttons, with the intent of redesigning it to a minimalistic appearance. We did not have enough time to redesign the buttons before the usability test, as we already had an appointment at St. Hanshaugen elderly center and had to deal with some minor technical difficulties with the Arduino-robot. However, we did make a new design for a button in the aftermath of our usability test, seen in the result section, that would be a potential next step for the project.

3.7. Testing

Once the prototype was functional, we made a detailed plan for how we wanted to conduct the usability test, while keeping in mind that we would probably have to improvise quite a bit. We used the guidelines stated by Rubin and Chisnell(Lazar, Feng, & Hochheiser 2010) as a template, which follows eight steps, covering everything from developing the test plan to report findings. We reckoned that St. Hanshaugen elderly center would be the best environment for the test as we already had established a good connection with the targeted user-group at their facilities, and recruitment would be easy. Our aim was to carry out three rounds with three participants in a each group, spending about forty five minutes per test. Given the size of this project, we felt that most of the usability problems would be uncovered by this sample-size. Considering that the intent was to collect qualitative data, we recorded with audio and supplemented with a camera, to analyze the data later on with informal analysis method, as described in chapter 2. This test would fit into the category of formative testing, as the goal was not so much to validate the prototypes, but use them as springboards for further discussion.

We started by describing how the robot is supposed to work, and then went on to complement the explanation by showing a video-prototype. The idea was to give a proposal of how Tray on Wheels would behave in a real scenario. With this in mind we went on to give them a case where the intention was to create discussion about the button. It was a fairly simple scenario where someone with inhibited motoric skills had left a book on their Tray on Wheels, and wanted it brought to them in the livingroom. Even though most of the participants had great motoric skills, the scenario is still realistic as many elderly are inhibited in one way or another. We then handed them the controller with two buttons, without any instructions other than what we described in the scenario, to make a formative assessment on the ease of use. After this we presented some pictures of buttons to spark discussion on how we could design a more appropriate button then the controller we used. Ideally, given more time, we would have created these buttons and put them into practice, allowing our user group to experience the practical sensation and feedback of these buttons, as opposed to simply imagining them.

3.8. Results of testing

We analysed the data using an informal analysis method where we made a categorial overview for our data collection. In the process of making the categories we used emergent coding as a way of analysing the data after the usability test was conducted. For the test we analysed the recordings by taking notes of significant occurrences of topics that would fit into the categories, and provide insight for further research. The participants expressed that they understood the concept presented in the video-prototype, while having some difficulties understanding which of the two buttons to press while using the physical prototype. After some trial and error they soon mastered the Tray on Wheels, though they seemed a bit confused as to how this would be useful for them.

There were a lot of comments on their daily lives and a general notion of negativity towards technology as a whole. As in previous visits, they expressed concerns about technology replacing humans, and that they could do without. By analysing the data we found that there was great distinction between positive and negative comments on technology in general, with a higher occurrence of the latter. But the occurrences seemed to even out a bit when talking about our prototype, which could be a result of observer-expectancy bias.

Some of the comments from the participants in regards to usability and ideas were:

- There had to be someone to place the objects on the tray.
- The button has to be designed in a way so that elderly with dementia and the visually impaired could use it
- The button should hang on the body, in the same way a safety alarm is designed
- The button has to be big
- A button would be easier to use than voice commands, as a lot of elderly has difficulties with articulation

- Could use a normal rolling table instead of a robot
- The button works just like a remote control for the television, same button for on and off.

As a result of the usability test and analysation we came up with a new design for a button that could have been a potential next step for this project.

Button designed based on feedback from the usability test

4. Discussion

This chapter will point to what went well in our project as well as challenges and difficulties we faced during our design process. This chapter will also focus on how our design has been analysed according to our research question (*How can interaction with a robot through a button best be designed for elderly users?)*, the referenced theory and what future improvements and development that is possible.

One thing that has been of great benefit for us is the fact that our methodology and our approach has allowed us to change and adapt our problem area. This has been particularly important for our learning process as well as the design process as it has allowed us to make mistakes and learn from them. This is an element of every research through design process, but proved especially valuable to us as we struggled early on in our project with narrowing down our research questions.

A challenge for us in our field work and our work with potential users throughout our project has been the nature of our user group. As described by (Lazar, Feng, and Hochheiser 2010) working with humans can be challenging and especially working with seniors. One aspect that we found especially challenging was getting the seniors to understand the scenario described by us. The scenario was clearly stated in our plan for the usability testing. Focusing on the importance of clarity when explaining the scenario proved important, which we missed on our first testing group and led to more time being spent on explaining and legitimating the prototype. Collecting qualitative data was our goal for the usability testing, but the data still has to be structured. Reviewing and categorizing the data took a long time and we realised that we may have had too little structure for this to be done efficiently. Working with senior participants can prove difficult in this aspect. Our experience is that seniors easily get off topic, and keeping a good tone with them is important, creating a nice atmosphere. Balancing this with the structure of the data collecting is something we found to be a challenge, and requires experience as an interviewer and tester.

Looking to our categories for analysis we found that there were a lot of negativity towards both technology in general and towards our solution. This can be seen as seen as a bad evaluation of our prototypes reliability and robustness. But the feedback was more balanced towards our prototype compared to towards technology in general. This can be because of an observer-expectancy bias, the seniors getting aware of the fact that we created the prototype, not wanting to hurt our feelings. This did not get in the way of our goal for the prototype and for the testing session. We wanted to create a good environment for discussion and exploring. This meant accepting both negative and positive responses.

Finding fitting categories for the results of our usability testing worked out pretty well for us and the categories of (Fink et al. 2013) proved easy to adapt to our data. While Fink's categories have been made for a long term research project we still found them helpful and applicable in making our own categories.

When conducting the usability test we would have wished to present several types of functioning buttons. Not being able to develop the physical buttons on time we were forced to think of other solutions. In addition to bringing one functioning version of the button controls, we also brought pictures of other buttons we thought could be relevant for our solution. This approach allowed us to discuss preferences with the elderly. The discussion could however possibly have been better with several different physical buttons for the elderly to actually test. This is what we think would be a good idea to focus on for future work on this project. Further developing the button me made towards the end of our project and finding the best solution is a very interesting topic for research, but something we unfortunately didn't have time to realize in this project.

5. Conclusion

To answer our research question (*How can interaction with a robot through a button best be designed for elderly users?*) is not easy. While we were able to look into a few variations of buttons and how they can be used this can only be seen as the beginning of looking into what kind of button can be best suited for handling interaction between robots and the elderly. We still managed to look into some button designs and through our data collection are able to point to some factors important for interaction. The seniors stated that the usability of the button is dependent on the button being of the right *size, shape and colour.* A button is *familiar* to the seniors, most of our participants seemed to have no preference regarding a one button or a two button -solution. This leads us to believe that there are other factors that are more important, factors such as button feedback and reliability along with familiarity. And these are topics that could have been included in this project as a next step.

Another goal we had set ourselves for this project was to contribute in some way towards the MECS project. While the physical prototype suited our needs at the time, the video prototype we made is better suited to explain the concept. It has been shared through our supervisor at the MECS meetings and can play the role of inspiration and eye opener for researchers looking for interesting areas of research. The future work of our project is therefore an interesting topic and would have the next *repeat* phase of research through design. If we would have continued on this project we would have had the opportunity to investigate button design further. This is something that our robot allows us to do already. Improvements can be made to the driving pattern and abilities of the robot to expand the horizon for possible scenarios to investigate. We, however, think that the most interesting path forward would be to design more buttons with the usability factors we pinpointed through this project.

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