Social Interaction with Shared Systems Report

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INTRODUCTION

In this semester we worked in the squad Social Interactions with Shared Systems. Shared systems are systems used by multiple people, where an interaction of one person affects other people as well. The system can be used at the same time or with turn taking. In your actions in a shared systems, you have to think about other people. This is why the designers of these shared systems have to take in account aspects like awareness, accountability and translucency.

We focussed on the context of Smart Home Assistants. This device is a computer in a home where it can be used by everyone and can control aspects that influence multiple people at once. However, they are not designed with awareness, accountability and translucency in mind. This makes it hard to use a Smart Home Assistant in a multi-user scenario. Since we believed that Smart Home Assistants will be improved in the future, we wanted to make a framework for designers of physical behaviour in Smart Home Assistants, to improve the multi-user interaction.

In this report we will describe our progress. First, we will explain our ideation of the research topic. Then we will explain our designs. After that the research and the data analysis will be described and the feedback we have gotten along the way. Finally, the reflections of the different team members can be found. The paper that is written in this course can be found in the appendix.

IDEATION

At the beginning of our project, we decided to do a group brainstorm, bringing at least 20 ideas that were relevant to the squad topic per person. In this way we have obtained more than 80 ideas that we have examined and evaluated together in order to find an interesting topic to carry out.

Thanks to these 80 ideas we found three topics/scenarios that seemed the most interesting to us to explore: Personal Sound System, Shared Menu in a restaurant, and Decision Making in shared systems. We decided to analyse these possible topics in more detail through four questions related to the concept of awareness in shared systems: 1. What do people need to be aware of? 2. What information is needed for this awareness? 3. How in the information gathered and presented? 4. How can people act based on this awareness?

During this process, discussing about an AI system useful to solve conflicts in a social shared situation, we started talking about voice assistants. The topic immediately seemed interesting and relevant to the context of our squad, since these devices still have obvious limitations in shared use. In this lack we have seen the possibility of a research that investigates how these devices can be developed to better adapt to a situation of sharing.

Figure 1. Ideating and discussing the four questions related to awareness.

The next step was to learn more about the state of the art of these devices and their role in human-computer interaction. This research was useful to focus more precisely on the path to follow and to define a possible research question: *"How does a Smart Home Assistant influence the behaviour of the human?"*. Subsequently, continuing the literature research and discussing with our coaches, we have redefined the question several times up to the final one: "*How do users interpret different physical behaviour, based on human body language, in a Smart Home Assistant in a multi-user scenario?*".

DESIGN

To find good designs which are useful to compare within our study, we went through an elaborate design process. We have made around 40 concepts and prototypes from scrap material to get a feel on what the Smart Home Assistant of the future may look like and explore the possibilities. We did this with a focus on the implementation of physical behaviour in such a Smart Home Assistant. From this exploration, we discovered certain aspects in which we could divide all the concepts, and certain human behaviour they mimicked. With these aspects and behaviours in mind, we made more complex sketches towards possible final prototypes. We turned some of the sketches in low and mid-fi prototypes to get a better experience of the interaction it would provide.

After all this exploration, we extracted the most viable and distinguishable concepts. We mapped out these concepts

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looking at the openness of the concept and the possibility of expression. To make our research as valuable as possible, we decided to pick the 4 designs which we believed to be at the ends of both spectrums, from now on called *Pointer*, *Ball*, *Pie* and *Beads*. Comparing the final results of the research with these designs would provide more specific results in our design framework.

We realised we could not make four voice controlled prototypes. That is why we decided early on to use the Wizard of Oz method for the interaction with the prototype and control the prototypes ourselves. For this we made Graphical User Interfaces for all the prototypes in Processing. Thanks to the Echo Dot that we could borrow from our coach, the interaction with the Smart Home Assistant prototypes could be imitated. Below the four final designs and their realizations will be discussed.

Pointer

The Pointer prototype is the biggest prototype in terms of height. The prototype is based on turning your body towards the person and using hand to express attention. The prototype was a high cylinder that could turn around its centre. The prototype had an arm that would move out when it was listening and talking to someone. By turning, it would point the arm to the person it was interacting with.

Graphical User Interface

The GUI for pointer was a centred circle with a line from the middle. The GUI could be controlled with the keyboard. The A- and D-key would turn the end of the line, the W- and S-key would change the length of the line to move it just in or out of the circle. All this information was sent to Arduino to be interpreted and control the servos.
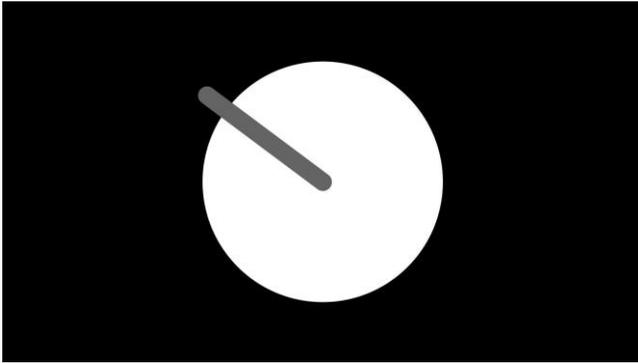

Figure 2. Graphical User Interface Pointer.

Physical prototype

The prototype was made of MDF. We first made a hexagon was made and using the sanding machine we made it circular. After this, a small part was cut out of the cylinder to make the arm. A separate base was made to allow the prototype to turn.

A continuous servo was placed at the bottom of the big cylinder with the blades attached to the base part. In this way we could turn the prototype. For the arm movement a 180 degree servo was used with a two part arm. The first

part was attached to the servo and would thus turn with the servo. The second part was attached to the end of the first and the back of the big arm of the prototype. If the servo turned, this arm would push or pull the big arm in the correct position.

Figure 3. Pointer prototype.

Ball

The Ball prototype was based on making eye contact and turning your head when you talk. It is more subtle than the Pointer prototype, but still based on a circular movement. The prototype was way lower than the Pointer Prototype. It looked like a low cylinder with a circular engraving. In the engraving was a metal ball that would roll towards the person that is talking.

Graphical User Interface

For this prototype the GUI had a simplified top view as well. The GUI had a big circle in the middle of the screen and the borders of a second, smaller circle on top. By using the keyboard a third circle would move over the border of the smaller circle. When the A-key was pressed the small circle would move counter-clockwise and when the D-key was pressed the small circle would move clockwise.
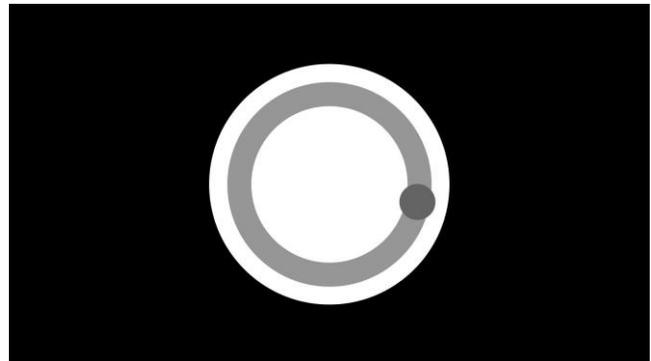

Figure 4. Graphical User Interface Ball.

Physical prototype

The body of the prototype was made by gluing multiple layers of MDF on top of each other. Using a drill a hole was made and enlarged with a fretsaw. A thin piece of MDF was placed on top and on the bottom to close the prototype. The engraving was made by adding yet an extra layer with a ring and a circle. The movement was made with a continuous servo with an arm attached to it. At the end of the arm a strong magnet was placed, which dragged the metal ball along the engraving.

Figure 5. Ball Prototype.

Pie

The Pie prototype is based on the movement of leaning towards someone with whom you are having a conversation. The prototype looks like a flat cylinder cut into 6 equal parts. When someone talks, a part in their direction will move out. For the prototype, only three parts were able to move, because we had too little space for the electronics of all six parts.

Figure 6. Graphical User Interface Pie.

Graphical User Interface

The GUI of the Pie prototype had six arcs placed in a circle making one big circle. The parts that could move out were made white and the parts that could not light grey. At the parts that could move out, small circles were placed outside the big circle. When the circles were clicked, the corresponding part would move out.

Physical prototype

After the two previous prototypes, we found making a circle of a hexagon better than layering MDF. That is why the cylinder was made with this method. After making the hexagon circular, a thin piece of MDF was placed on top and the prototype was cut in six parts. After this, a second level was made to create a rail so the movement would be straight. The movement was created by a servo and two arms. The arms would push out and pull back the part.

Figure 7. Pie Prototype.

Beads

The Beads prototype is a short cylinder with six sticks sticking out in a circle. This is based on the human behaviour where someone will raise their eyebrows when listening to someone. The sticks of the prototype move up towards the side where someone calls the Smart Home Assistant. When a second person calls the assistant the sticks on their side will move up, without the other sticks moving down faster.

Graphical User Interface

The GUI of this prototype is a big circle. When you click on the screen six smaller circles appear. The size of these six circles is based on the distance from the location of the click. The circles slowly decrease in size until they are size 0. When there is another click, the biggest option for the circle (current size vs. size depended on distance of the click) will be chosen.
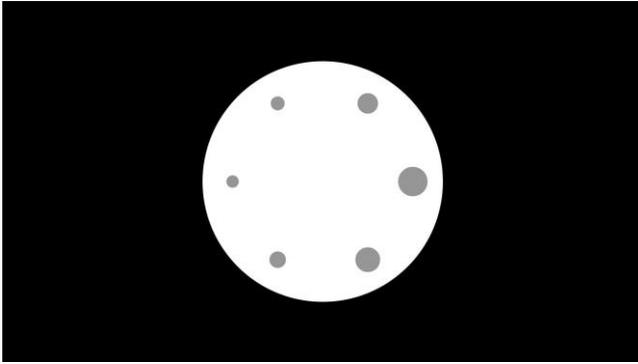
Figure 8. Graphical User Interface Beads.

Physical prototype

The physical part is made with the hexagon method. However, with this method the electronics did not fit. A hand band sending machine was used to make the hole bigger. In the top, six holes were drilled. The sticks were made with a 3D-printer to make sure it was the correct size and to add an extra part that was necessary for the upwards movement (see figure 9, 10). The movement was created with servos pushing up the sticks. The slot in the sticks caused the movement to be only upwards and not circular.
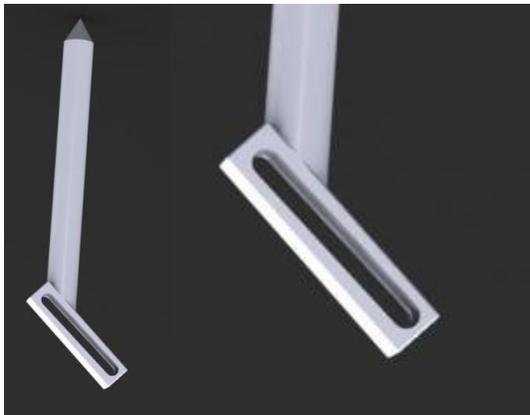

Figure 9. Beads prototype.

Figure 10. Render of Beads' pin and close up of the slot.

RESEARCH

Before the final research, we did a pilot study. The study setup for our pilot study was:

Amount of people at a time: three
Amount of groups Pilot: one (of three participants)
Location: Breakout Room, Laplace building

1) Explain the study, sign the forms
2) Show all four prototypes, through an interactive demo
   a) Using Amazon Alexa without any extras to familiarize the participants with the technology [three minutes]
   b) Test with the prototypes, every round of participants in a different order (see table ##) [two minutes per prototype]
   They are given a task: plan an international trip in as great detail as possible. Both participants have to agree upon the plans. Think for example: country, cities, activities, hotels, weather and flights.
   c) Participants have to create their own "Scale" on which they are going to rank the prototypes, individually. Each participant with one project research member.
3) Participants will rank the different prototypes using set scales, provided by the researchers, individually. Again with one project research member.
   a) Rank on Privacy
   b) Rank on Translucency
   c) Rank on Involvement
   d) Rank on Clarity
   e) Rank on Human Likeness
   f) Rank on How natural it feels
4) Ask participants which body language feature is portrayed in every prototype
5) Ask participants about their personal preference, in a group discussion (7 minutes)

After the pilot study, we changed the following things about in study setup:

- More guidance in the exercise (format of things they could work on or have to know)
- Alexa in a place where they cannot see her.
- Scale of 7 on the paper to avoid confusion.
- A clearer left and right side for the scales
- Let the people talk simultaneously in advance to get used to this phenomenon
- Explain in advance that it is for a future Smart Home Assistant

During the study we tested eight groups of three people. We controlled the prototypes with a laptop when the participants were experiencing them. Since we are a group of more people, the individual part of the repertory grid could go simultaneously for all the people in the same

group. We filmed the final discussion to get an insight in why the participants gave certain answers.

The order in which the groups experienced the prototypes changed every round. The orders can be found in table 1.

Round	1st	2nd	3rd	4th
1/5	Be	Ba	Po	Pi
2/6	Ba	Pi	Be	Po
3/7	Po	Be	Pi	Ba
4/8	Pi	Po	Ba	Be

Table 1. Prototypes' order during tests. Be: Beads, Ba: Ball, Po: Pointer, Pi: Pie

DATA ANALYSIS
From our research, we got a lot of both quantitative and qualitative data. To discover interesting results and find out why these results occurred, we tried to visualize and compare both our qualitative and quantitative data sets.

Using the repertory grid gave us a lot of different possibilities for analysing the data we got, and looking for correlations and interesting findings. We gathered our quantitative data from the repertory grid scales in one big spread sheet to try and get an overview of our findings. Using this data we calculated the average, standard deviation, median and mode for all the prototypes on the different scales. We then used this information to visualize our results in boxplots and provide ourselves with a clear visual overview of the data we got.

We also got a lot of qualitative data from the group discussions. We filmed the group discussions with the participants' consent and also took notes on striking occurrences. We made transcriptions and made an affinity diagram to extract interesting findings from this raw data. For each group we noted all interesting feedback on the prototypes from the group discussions and how the participants experienced the prototypes by making a transcription. We also made an affinity diagram, by looking at recurring comments that were made for each individual prototype and clustering them into appropriate groups with similar comments and experiences. To get a better understanding of the participants' perception of the prototypes, we analysed the scales they created on their own and clustered them in similar topics.

To extract our findings and conclusion we used the quantitative data to find interesting connections and phenomena between the scales, but also looked at specific experiences participants had with our prototypes. By looking at the qualitative data we tried to find reasons for connections between scales or divergent values in the repertory grid. We used these quotes to support our framework and put it in perspective so it is useful for future designers.

FEEDBACK
Throughout the project we received a good amount of feedback. We are still here to learn of course, so we took a lot of the feedback into account to improve our research. The feedback was most often given at milestones in the project, but in addition to that, also during small coach sessions.

During the midterm demo day we mainly received feedback about the research questions and direction. Our research question at the time was very long and too general. Because of that we were told that it is better to shape the research question more towards the mimicking of human behaviour. That was namely more of the aim in the set-up of our research. In addition, our research question contained "is it more suitable", which creates a yes-or-no question. To gain more important information, we changed that part to "which is more suitable" to easily compare our prototypes and findings. Our motivation was thought to be good, but we missed a future goal: where would our research be useful for? The solution to this became quite clear when we thought about how our framework would take its shape. Since we take a lot of different perspectives into account, we would create advices for the designers of future Smart Home Assistant. Another useful tip from the coaches was to use Repertory grid, since we did not make a plan on how to test our research question so far. This research technique could be very useful for the type or research that we were doing. Repertory grid was unfamiliar to all of us before that, but we decided upon using it: with great success.

After the "quick and dirty" prototyping session we performed a test-pilot user experiment. Although the prototypes were not the way we wanted them to be, they had the types of focus we had in mind. It however, became quickly apparent that our ideas did not work. We received feedback from the participants that all the movements were too vague and small. The prototypes also did not have their attention, making it very clear that our prototypes would have to be radically different. Movements would have to be bigger, more exciting and more responsive. Also, Alexa herself should be placed out of sight to keep the participants from being distracted by her. Adding to that was the feedback from Yaliang Chuang about the fact that the users had trouble using Alexa because of lack of experience. This made it very clear that we had to implement a learning period for every experiment group in the future and in overall add assignments to what the participants should do during the test.

After our real pilot experiment we also received some feedback from the participants. We had small discussion with them and found that the scales on which we rank our prototypes should be explained more clearly. The scale "involvement", which is about how the Smart Home

Assistant involves others, was confused with how involved the Smart Home Assistant itself was. Also, the whole aim of the research about a shared user scenario did not become visible. This meant that we had to add a scenario on how multiple people would use Alexa to the assignments.

The coach sessions in between provided us with valuable feedback for our focus on the research. We were told to look at more related research and look on terms and techniques that they have used to come to their conclusions. The coach sessions also helped us to keep track of what we were doing and have small reflective sessions each week.

The final demo day was, of course, one of the last possibilities for feedback. We received some feedback from different coaches about possible different interpretations in our research. The scales for example should be better explained, in addition to the meaning of "physical behaviour". Another valuable note was from Harm van Essen about the fact that we cannot use the averages of the data to draw conclusions. They are not reliable enough, so we should be focusing more on the boxplots. This is something we changed in the paper after that. We added excessive explanation to our interpretations of certain terms and highlighted data, only when we thought that it would be reliable. We also received some valuable feedback from other students about our framework. We namely had some trouble with defining how it should be set up. For the framework to make sense, we would have to go back to the beginning of our process and really define what we wanted to tell. Then, based upon the findings that relate to that, cluster the information with the right relations added to it.

Figure 11. Demo day.

REFLECTIONS

Reflection Bart Bolluijt (1004089)
The second semester's project of my second bachelor year was a Design research project. This time I was part of the Social Interaction with Shared Systems squad in a team of four together with: Joline Frens, Lars de Lange and Riccardo Gualzetti. I had the following learning goals for

this project: get woodworking and fabric prototyping skills, perform a large scale user experiment, use previously learned prototyping knowledge in my project and create a valuable research for future designers.

A pressure cooker marked the beginning of the project semester, this was however with another group. The assignment surrounding this group made me learn about shared systems, which was a new concept for me before this semester. After this pressure cooker the 'real' project groups were formed. We started off very strongly with a lot of ideas and but we learned to quickly narrowed it down to a few. Narrowing down the direction of our research, however, took a bit longer. But slightly adjusting it made me learn about what a real and realistic research should look like. I learned through extra background research to make new connections and improve the research questions.

To prepare the experiment for the research we made physical prototypes. I helped a lot with designing though more low- and mid-fi prototyping that I had learned in previous courses. This resulted in great ideas that could be further developed. This marks one of my learning goals as achieved. The next step was to make the prototypes in a higher fidelity. We spend a long time in the workplace to create them. I used wood and learned new techniques on how to make curtain shapes, make circles more round and create mechanisms for moving parts inside the prototypes. In addition, to make the mechanisms less visible from the outside, one prototype required some fabric. I followed a workshop in the wearable senses lab to gain the skills of working with sewing machines and the locking machines. After the training I made the fabric parts for the prototype, which fitted well into its designed place. The prototypes turned out very nicely, after which I can say that that learning goal can be marked as achieved as well.

After the prototypes were made we had to do the experiment. We aimed to perform one on a relatively big scale: 8 groups of three. It was quite hard to develop the experiment to create the type of findings that we needed. We ended up with a mixed method research where I learned to develop a new way of gathering information: repertory grid. This made the difference between a small and a bigger test group very apparent. I learned that the way I ask the questions could influence the answers of the participant very quickly. So I changed the way I explain the interview very early on. In addition, the pilot test showed that people have trouble performing a test when there is a learning curve. This made us change the experiment setup to create a better guidance for the participants. Although I did not clarify the amount of users I wanted to test in my learning goal, I feel like 24 was great enough. This became quite visible in the data analysis. Since we had generated so much qualitative and qualitative data we had some trouble to make sense of it. I eventually learned to cluster the data through repertory grid. To complete the research I had to make the related work. I normally would only use internet

links, but this time I also linked books that I read to it. Through this I learned to make the research more complete and stronger built.

The project made learn about the research project in a more concrete way than in a previous research course (Design <> Research). I learned how to better scope a research, develop prototypes with different materials as low-, mid- and high-fidelity, performed a user experiment with a large user group and executed an extensive data analysis with interesting results. I would say the research could certainly add value to future designers and was a success, marking my last learning goal as achieved. In the future I would like to learn more about the psychology behind the processes and develop prototypes in a more detailed level.

I enjoyed this project very much, especially since it broadened my interest in the psychological side of design. I would like to thank my team for the great work that we did, it couldn't have gone better. In addition, I would like to thank our coach Yaling Chuang, all the other coaches and participants of our test, everyone really helped us to make this project possible.

Reflection Joline Frens (0996504)
In this semester, I have learnt a lot. As a team we did a lot of our progress together, instead of splitting up the work. This meant that I had the opportunity to learn from my team members and we could develop our skills together.

Before this project, I had not done long term research projects like this before. It was valuable during the ideation phase to think about what knowledge was needed for future design instead of what were needs that need to be fulfilled. At the beginning of the semester, one of my goals was to really invest in the ideation period. Before, I would often not go into depth in this part and end up choosing an idea to continue the process. This project, we started by finding 20 Shared Systems per person. This forced me to think creatively and helped me with this goal. After that, we really went into depth with our ideas. I would use the techniques we used in future projects and they will help me as a designer.

Furthermore, a goal was to make a proper prototype by hand. In previous projects, I would use 3D techniques to model and make basic models by hand. In the project we made four prototypes. Riccardo already had more experience in this, but we all worked on it. We started working in the exam weeks, when Riccardo was absent. I took charge in these weeks and made different plans for the bodies of the prototypes. This gave me a lot of confidence for future prototyping. After Riccardo returned, he showed us what would be good techniques to finish the prototypes.

While we were making the prototypes, I decided to take the job of programing. I have become quite good at programming while working on previous projects, so I did not expect it to be too difficult for me. Something I had not done yet was work with control of Processing over an Arduino with servos. This project helped me to understand how to do this, but was only a small learning process for me at this time.

I presented at both the midterm demo day and the final demo day. This was because I am most comfortable presenting in English. I also train this regularly in my student team. It was good to practise presenting something in which I was less prepared, since I pitched my student team a million times. Presenting during this project, taught me how to improvise more during a presentation. I have also learnt how to pitch a research instead of a design. I started focussing less on the design aspects and more on the results of our research. This has made me more versatile as a presenter.

The largest takeaway from this project is how to conduct proper research. Since we had to start from scratch, we really had to understand the entire process. I had done small researches in smaller courses before. Since this was a longer course, we could really go in depth trying to analyse the data to create our framework. Doing this analysis will be valuable for future research I will conduct, but also for analysing user tests, which are important for me as a designer.

During this project, I have achieved learning goals I had set at the start of the semester. I have grown in ideation and in prototyping and learnt a lot about doing a research project of larger proportions. I also did some things I had already expertise in, but it is always important to practise skills earlier learnt.

Reflection Riccardo Gualzetti (1309331)
This course was the first research project of my university career and I found it really interesting. At the beginning I was a bit confused about what we had to do and how a research should be conducted properly. However, thanks to the lectures and the help of my group mates, I'm satisfied about what I have learnt and what we have done as a group.

The entire project could be divide in three big parts according to my experience: 1. Get the squad topic and defining a research question; 2. Design and make the prototypes; 3. Tests, results and writing the paper.

The first part was something pretty new for me because in my University in Milan we are not used to work in squads. It was stimulating and valuable at the same time, considering that before this course Shared Systems was a topic I wasn't familiar with. Now, I feel that I have learnt much more about it and that would be really useful for future projects. The second part of the course was a sort of comfort zone for me. I'm used to make prototypes and I like it. For these reasons, I found it really interesting and less difficult to carry out. I believe that in this part I gave my best contribution to the group, compared to the other two parts where I learned more but probably my contribution was less efficient. In particular in the last part of the project, I learned a lot about how to analyse and

evaluate the results of a research test. Despite some lack in my previous knowledge about research project, I feel I have worked properly within my group. This was possible thanks to the really good situation that there was in our group. All the members put the right effort and had the desire of reaching a good result.

About our paper, I think we achieved a good results. We conducted deep tests and collected a lot of interesting data to answer to the research question in a proper way. We struggled a bit to find the right way to analyse all these data but at the end we managed it.

To conclude, I'm satisfied with the entire course: both how it was organized and how we dealt with it. Now I feel more confident to work in a design research project both in theoretical and practical aspects.

Reflection Lars de Langen (1013802)
This semester I got to do a Design Research in the squad Social Interactions with Shared Systems. Although at first I found it hard to get a good overview of the definition of the squad, I think we found an interesting and currently relevant topic to conduct our research on. We had a motivated and ambitious group, and I am very happy with the outcome of our collaboration during the semester. The fact we had a diverse group provided me with a lot of learning opportunities.

Before we were divided in our final project groups and started working, we did a pressure cooker within our squad. I think this was a good way to introduce what the squad is about, which before I only had a very general idea of. Presenting the ideas to the others in the squad already provided me with some examples of scenarios we could conduct our research with.

After this we got divided into groups, and were able to start ideating on our research question. In this phase I learned a lot about the topic of Social Interactions with Shared Systems, due to background research we did and lectures we got within our squad. I discovered that I'm really interested in the sociopsychological aspect of shared systems. Within our group we discussed our own interests and started looking at shared systems which provided opportunity to cover all of our interests, which I really liked. This also was an easy way to give direction to our project, and I want to keep this structured and directed way of ideating. I feel like it also gave everyone motivation, since we were all interested in the topic. Having a guided ideation process was also a goal for me since during my project 2 a lot of time was lost in the ideation phase, which was a pity.

Because we came up with a pretty ambitious idea for the prototypes in our research setup, we had to spend a lot of time on realising the prototypes. Unfortunately, I wasn't always able to join my group at Vertigo because I had a very busy semester for which I had to attend other meetings as well. Although this was a pity, the situation provided me with the opportunity to learn a lot about structured planning and dividing work efficiently. Learning this was really valuable for me, because after some time I was able to efficiently plan my meetings and work that had to be done while at the same time I had never been busier. I really enjoyed the time I got to work on realising our prototypes. I really wanted to improve on woodworking and the mechanical part of prototyping, since these were not very applicable in my other projects. I also didn't expect to learn about it in my Design Research project but was glad I was able to.

After the prototypes were finished we could conduct our pilot study, improve our research setup and conduct our final study. At the beginning of the project I thought I would struggle with the research part of the project, since I didn't pass the Design Research course. This wasn't the case and I was able to quickly catch up with all the theory and background research. I think this partly was because of my interest in our research context and the squad topic, so I didn't mind spending time learning about it. I learned a lot about the research process, and passing the course next year won't be a problem at all. I learned a lot about different ways of gathering your data, mainly about the repertory grid technique. I also learned about ways to analysing your data and extracting useful information out of this.

Overall, I think I really learned a lot during this project and besides was able to grow and improve on things I learned in previous projects. I was very happy with my group and feel like everyone was motivated to bring the project to a good end and produce a valuable research paper. I learned what I wanted to and I am very satisfied with what I achieved with my group this semester.