Development of a prototype-centred co-design process with autistic people to support semi-independent living

Keywords: co-design, embodied empowerment, Research-through-Design, Creative Technology Design Process

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Abstract

As of March, 2018, the first hi-fi prototype of MyDayLight was realized: an interactive light system designed to support people with Autism Spectrum Disorder (ASD) with attention and organization for semi-independent living. Taking an iterative co-design approach, the motivation of this research was to investigate how users decided to appropriate MyDayLight in practice and what further redesigned interaction with the system should be possible to facilitate such appropriation. Furthermore, it was wondered how MyDayLight was appreciated for its purpose in the first place and what conclusions could be drawn on the co-design approach adhered to throughout this research.

To answer these questions, MyDayLight has been subject to a co-design procedure with three young adults with autism, advisors and supervisors, encompassing changing phases of prototype deployment, reflection and prototyping. As a result, it has been identified that MyDayLight has mainly been used as a notification system to combat personal challenges caused by autism. Regarding redesign interactions, it has become aware that MyDayLight lacked noticeability and subsequent design explorations have seen the successful inclusion of a personalizable sound system in response. Regarding the appreciation, it can be concluded that MyDayLight has been perceived positively overall. Lastly, the co-design procedure itself has proven to be effective and fruitful, but problems with communication and planning caused by autism have prompted the researcher to be pragmatic and flexible, and to take the role as a supervisor as well aside solely functioning as a researcher and a designer. Throughout this procedure, the input of supervisors and advisors has been indispensable and it is highly-recommended for future research in this area.

Preface

As a token of appreciation, I would like to take this opportunity to thank a number of people that have been of paramount importance to me for conducting this research. The first person on this list is my graduation project supervisor Jelle van Dijk. I would like to thank Mr Van Dijk for guiding me throughout this graduation semester in the incredibly pleasant way he has done this. Furthermore, Mr Van Dijk has provided me with numerous interesting papers, talks and brainstorm session to make me academically-prepared for the assignment given.

Secondly, I wish to thank Shireen van Rosmalen from Karakter, centre of psychiatry for children and young adults. Mrs. Van Rosmalen has definitely been of equal importance to me. Firstly, Mrs. Van Rosmalen has provided me during numerous times with valuable insights during interviews and conversations, but she has also accompanied me with meeting one of the users. Next to this, Mrs Van Rosmalen has worked beyond the extent of expectation to facilitate the right network that I needed in order to get this research rolling. However, maybe most importantly for myself, Mrs Van Rosmalen has been of personal support throughout this research, something that I truly appreciate.

Thirdly, I wish to give thanks to Wendy Oude Nijeweme – d'Hollosy, the critical observer of this research. Ms Oude Nijeweme – d'Hollosy has volunteered with great enthusiasm to be a part of this project. I cannot be more thankful for this, as the road to finding a critical observer had been quite problematic before the participation of Ms Oude Nijeweme – d'Hollosy.

Naturally, I would like to give many thanks as well to all the participants: Toby, Adam and Gerd. Without them, I truly would not even have a research to conduct. During several intensive weeks, they have proven to be determined and willing to generate interesting results out of the prototype deployment-, reflection- and prototyping phases.

Lastly, I would like to thank my family and my friends as well for supporting me throughout this graduation semester.

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1. Introduction

In 2015, economists succeeded for the first in mapping the American societal costs for treatments for Autism Spectrum Disorder (ASD), which was followed up by a simple yet ominous conclusion: already astronomical costs will continue to rise unless things change. The economists estimated that for medical-, non-medical- and productivity losses associated with the disorder, autism will cost 461 billion dollars for 2025. However, the researchers said these projections are conservative and if the prevalence of autism continues to increase at the current rates, the costs could reach 1 trillion in the next decade (Welch, 2015). Due to such high treatment costs, it is often decided to invest money in newly-diagnosed children and their parents, causing loneliness, depression and other mental health problem to be common for adults with autism (Vaillancourt, 2016). A negative consequence of this is that adults with autism are often forced to live without support, causing a lower life expectancy compared to adults without autism. The demand for a solution for high treatment costs is especially high since the number of (Dutch) children diagnosed with autism, which is currently representing 3% of the population, has seen an increase of at least 16 times since the 70's. This increase can largely be explained by the broadening of the diagnostic criteria and the inclusion of Asperger and PDD-NOS in the autism spectrum, as well as better recognition- and awareness of autism (Nederlands Jeugdinstituut, n.d.).

To combat high treatments costs for people with autism, a Manchester-based semi-independent residency for people with autism successfully designed a living environment to help resident live fuller, more independent lives with the help of technological integration (Turner, 2015). Due to the reduction of caretakers, the total costs of two individual's annual care- and support packages in the residency was cut from almost 500,000 British pounds to 240,000 British pounds. Thus, the usage of semi-independent living conditions for adults that are diagnosed with autism might be an appropriate solution for reducing rising treatment costs and potentially improving the mental well-being of adults with autism thereafter.

Contributing to the development of semi-independent living conditions for autistic adults is the *MyDayLight* project that was initiated in 2015, where MyDayLight had been introduced as a product that not wishes to build upon the cruel premise that autism is not *normal* and curable, but rather to find a way to deal with it in a unique way: MyDayLight is an interactive light system that is designed to support high-functioning, semi-independent living for people with autism in their own lives and in their own home, as it is described by co-developer Jelle van Dijk (n.d.). One symptom that MyDayLight aims to address is having difficulties with organization and attention. Many of the tasks of the *executive function* are notably disordered in autism. Executive function skills are instrumental for proper

coordination of cognitive resources: planning and organization, flexible and abstract thinking, short-term- and working memory, initiating appropriate actions and inhibiting inappropriate actions (Autism Speaks Inc. (a), 2012). MyDayLight, being a prototype that has been finalized very recently, is an agile design that so far has been co-designed by people with autism. The next stage in the project is to test the finalized prototype with users that have autism. That is, people with autism that are willing to evaluate if the system would support them with semi-independent living, with the main objective being to find out how these users appropriate MyDayLight in their daily lives ("Graduation Project Proposal", 2017). To achieve this objective, there is a number of sub-questions that need to be answered as well.

This thesis starts with a description of the state-of-the-art on the MyDayLight project as it is now and on similar applications that serve the same purpose as MyDayLight and/or make use of similar-like technology. Subsequently, a literature review is given that provides in-depth information on co-design and embodied being-in-the-world, two integral aspects of this research. Furthermore, the research methodology is discussed, followed by an iterated process description involving co-design. This thesis concludes with a discussion, a conclusion and recommendations for future research.

Research Questions

1. Main question: how do people with autism appropriate MyDayLight to support them in attention and organization for semi-independent living?
2. What further design explorations with the system should be possible to facilitate such appropriation?
3. What co-design approaches should be used to evaluate MyDayLight with people that have autism?
4. Is MyDayLight appreciated for its purpose?

Collaboration with Karakter

This research is a collaboration between the University of Twente and Karakter, centre of psychiatry for children and young adults. The collaboration is, in particular, with Shireen van Rosmalen, manager of innovation at Karakter. Mrs Van Rosmalen has had a facilitating and advising role in this research. Through Karakter, two of the three participants have come forward as willing to participate in this research.

2. State-of-the-Art

In this chapter, a state-of-the-art review is given on the current state of the MyDayLight project. It will be elaborated upon what the system currently looks like and what functionalities it offers. On top of this, similar applications are discussed that serve the same purpose as MyDayLight and/or use the same technology. Inspiration is taken from these applications, but moreover, it is tried to identify what is different from MyDayLight and should be avoided when designing further interaction with MyDayLight.

2.1. Autism Spectrum Disorder

Before discussing MyDayLight in detail, it is important to understand the need for a light system such as MyDayLight and what existing problem prompted the creation of this light system. At the roots of this problem, one can find the challenges that come along with *Autism Spectrum Disorder* - more known as autism. Autism Spectrum Disorder is a range of conditions that are classified as neurodevelopmental disorders (American Psychiatric Association, n.d.). Individuals that are diagnosed with autism present with two types of symptoms: problems in social communication and social interaction, and restricted, repetitive patterns of behaviour, interests or activities. As stated in the introduction, one symptom that MyDayLight aims to address is having difficulties with organization and attention, for many of the tasks of *executive function* are notably disordered in autism. In practice, this can result in an autistic person not executing a task that they is supposed to do. On top of this, this person is even aware of the fact that they is supposed to do this, however, due to being on the autism spectrum, something goes wrong between *knowing* what task to do and actually *executing* this task.

Since the MyDayLight system is designed to support high-functioning, semi-independent living with people with autism in their own lives and their own home, it is useful to assess the different types of relationships that exist between caretakers and people with autism. The primary persons affected by people with autism are their parents (Sarris, 2017). Most parents experience stress from raising their children that have autism: they need to keep their child from running away, manage meltdowns, wrangle with teachers about special education, avoid sights or sounds that overload their senses and drive to therapists and doctors. Often, they do all this while being sleep-deprived. Furthermore, young adults with autism are more likely to live with their parents and least likely to live independently after leaving high school as compared to those with other types of disabilities (Heasley, 2013). Only about 17% of young adults on the spectrum ages between 21 and 25 have ever lived

completely on their own. By comparison, nearly 66% of their peers with an intellectual disability have ever lived completely on their own.

Secondly, the biggest group involved aside the parents are the therapists and doctors (Autism Speaks (b), n.d.). There is a number of conventional interventions that are currently used to treat people with autism – specifically children, such as the *Pivotal Response Treatment* and the *Early Start Denver Model.* All are based on *Applied Behavioural Analysis* (ABA), which is a treatment to teach children with autism communication, play, social-, academic-, self-care-, work- and community living skills. It must be mentioned though, that ABA is morally questionable, largely because of a fiercely articulate and vocal community of adults with autism that says that the therapy is harmful (Devita-Raeburn, 2016). This community contends that ABA is based on a cruel premise: of trying to make people with autism *normal*, a goal articulated in the 1960s. As stated in *Chapter 1: Introduction*, this has been one of the reasons that had prompted the start of the MyDayLight project in the first place.

Fortunately, there already exist a number of alternative intervention options for people with autism that are focused on enabling semi-independent living, rather than trying to cure autism. A total of 8 different semi-independent options can be distinguished that are included as Appendix A. However, the three users in this research are primarily all living according to the description of *Supervised Living*. Supervised living offers direct and intensive structure supports available. Functional life skills, such as banking and shopping, are taught and supported by staff.

2.2. MyDayLight Design

In this section, the current design of MyDayLight is discussed. Past research involving MyDayLight has been conducted by – among others - Melina Kopke (2015-2016), Loes van Uffelen (2016), Laura Gabriela Sánchez Guzmán (2017) and Laura Beunk (2017-2018). As of March 2017, already 24 bachelor students and 3 master students helped to design MyDayLight for- and with a user with autism (Van Dijk & Hummels, 2017).

As of 2018, MyDayLight has seen several prototypes:

Figure 1: Three First Prototypes of MyDayLight (Van Dijk, n.d.)

Figure 2: Current MyDayLight Prototype

Figure 1 shows the first three MyDayLight prototypes in subsequent order. Figure 2 shows one of the MyDayLight lights as it is now. In total, there are seven lights, connected to a user interface over a wireless local area network (LAN). As of today, the system's design offers the users two functionalities: *task management* and *mood setting*. Through a special interface, the user can plan an activity at a certain time for one for the seven lights. When it is time, the light will turn on using the colours of the rainbow. It will do this for a couple of

seconds after which it will return to the pre-set default colour. Compatible with the default colour is the brightness and, naturally, the colour that is being used.

Regarding the mood setting, the user can spin the plastic case of the light and change the colour while doing this. If the spinning is paused long enough, the colour that is shown at that moment will be saved in a database and shown in the interface. The colour represents the mood of the user at the moment of doing a specific activity. Together with someone else, for example, a supervisor or family member, the user can reflect back upon that activity using the colours as a guideline. The interface, in which activities can be planned, settings can be changed and colours for feedback are depicted, is shown in Figure 3.

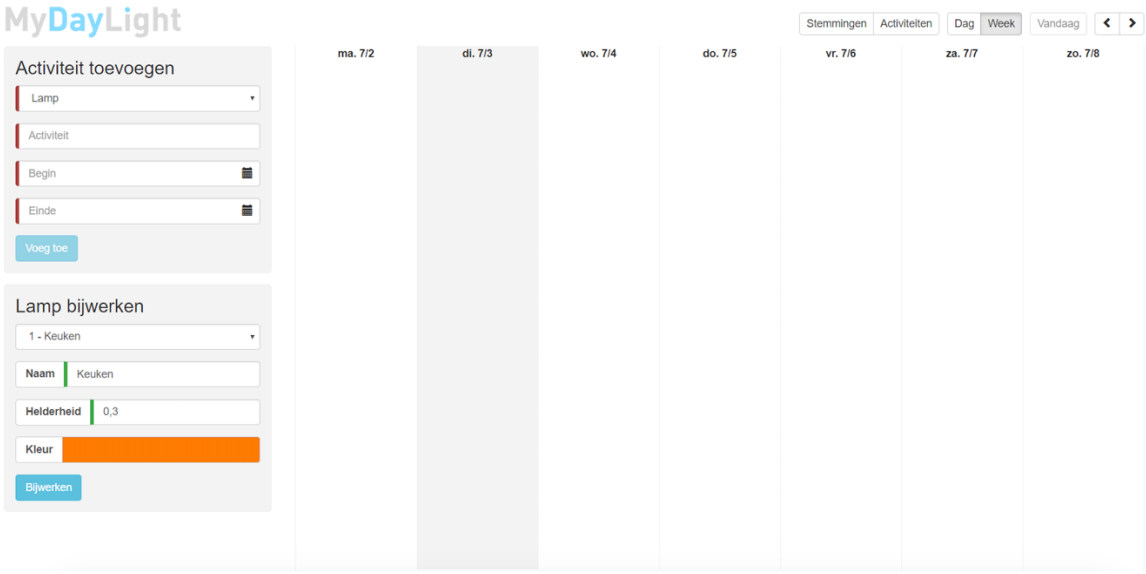


Figure 3: MyDayLight Planning Interface

2.3. Similar Applications

In this section, five similar applications will be discussed that support the same objective as MyDayLight: to support a person with autism in attention and organization. Special attention will be given to the two functionalities that are currently offered by MyDayLight: task management and mood setting. For each similar application, it is described what it offers, what exactly is similar to the MyDayLight system and what MyDayLight can offer that this application can not. The applications are arbitrarily ordered.

Cosmo by Filisia

The first application is *Cosmo* by Felisia, which is a light system that changes the way in which early-year learners and young people with special educational needs train their physical, cognitive and communication skills (Figure 4) (Fisilia, n.d.). If the button on a light is pressed, the colour of the light will change.

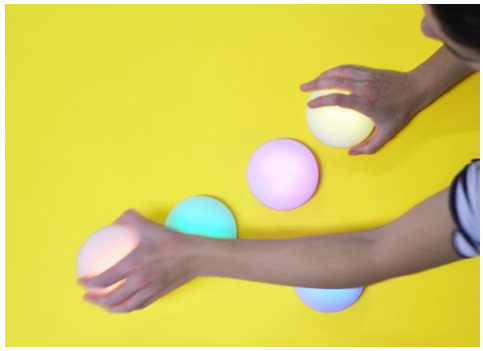


Figure 4: Cosmo

Although Cosmo does not per se support the same objective as MyDayLight – nor the same target group - its aesthetics are quite resembling. As well as MyDayLight does Cosmo work with a light system in which the colours of the lights can be adjusted. The buttons are smart and dynamic, connected to fun games on a tablet that are based on the child's curriculum. Furthermore, the system allows interaction with the entire classroom. If Cosmo could be relevant for MyDayLight, it would be through its design and its aesthetics. However, the application does not offer the needed functionalities to the needing users and is therefore incomparable to MyDayLight when it comes to high-functioning people with autism in semi-independent living.

First Then Visual Schedule HD by Good Karma Applications

The second application is a mobile application called *First Then Visual Schedule* by Good Karma Applications, which is a mobile support tool that helps people with autism to conduct their daily tasks (Figure 5) (Good Karma Applications, n.d.).
Naturally, this application supports the same objective as MyDayLight: it supports a user with autism in attention and organization. It offers a checklist, choice boards and video models.

Figure 5: First Then Visual Schedule HD

The biggest difference with MyDayLight is the absence of hardware. Where MyDayLight is a combination of a web interface and seven physical lights, this application is solely software. Nevertheless, this application offers an interesting user interface where icons are used to represent the daily activity. Moreover, this application offers choice boards and video models as well but fails to enable any form of feedback opportunities. In short, the application is not as assistive as MyDayLight and offers no feedback.

My Daily Tasks by Ablevox

The first application that offers the user opportunities for feedback is *My Daily Tasks* by Ablevox, which is a mobile application that visualises a daily schedule and a reward system, as well as video- and audio models (Figure 6) (Ablevox, n.d.). However, most interesting is the notes system for the teachers and caregivers in which they can provide feedback on the execution of a certain task.

Figure 6: My Daily Tasks

As well as MyDayLight, this application offers the user to reflect back upon his executed daily task to discuss the execution with his teacher or caretaker. However, despite this valuable functionality, there is no hardware to assist and push the user to actually execute the planned tasks.

AutiPlan

AutiPlan is a mobile application that can help people with autism with planning daily activities with the use of pictograms (Figure 7) (AutiPlan, n.d.). The planning can be printed or used directly on a computer, tablet or mobile phone. The application states to be unique by offering structure, its easy- and intuitive use and by saving a significant amount of time. The application also offers an assistive side: the application can read out loud which activity the user is supposed to be doing. By doing this, the user can keep its attention on the allocated activity. Thus, this application offers assistance in keeping attention and organization in the daily life of the user. On top of this, the interface provided on the computer screen is particularly similar to that of MyDayLight. However, the application is noticeably made *for* the users, instead of *with* the users; although the daily activities that can be chosen in the interface are changeable for each user, the application is not open to feedback by the user that might wish to appropriate the system in a totally different way. Lastly, the application fails to offer opportunities for feedback and uses no assistive hardware other than the device on which the application is shown.

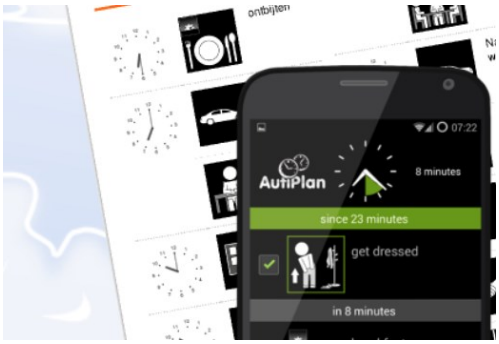


Figure 7: AutiPlan

Social CheckIn

Social CheckIn is an application that supports the user with getting off the sofa and execute more daily (outside) activities (Figure 8) (Autismeplein, n.d.). Social CheckIn is part of the *Wonen Autisme Toolkit*, a project in which Dr. Leo Kannerhuis, Pluryn and software developer NoXqs work on the development of E-health products that support young adults with autism in independent living.

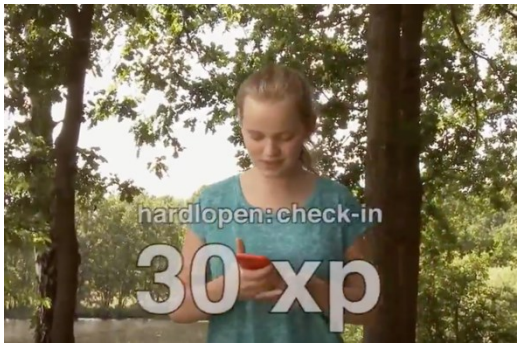


Figure 8: Social CheckIn

With Social Checkin, the user can map their own goals and prove themself that they can truly execute that particular activity. If the user has executed a particular task, they receives points for this. Furthermore, the user can ask friends and family to support the activity by receiving *likes* on Facebook.

The Social CheckIn application, which is available on the Google Play Store, offers an interface in which activities can be planned. The use of explicit gamification is an interesting technique that it uses to push the user to become active. Naturally, the users of MyDayLight can use the system as a game for themselves as well, but there is no explicit game element implemented in the system as it is now. For this particular application, it is the question whether or not it will work: there is no explicit assistive technology pushing the users to execute the daily tasks aside from the game effect and the application also does not offer the user opportunities for feedback.

3. Literature Review

At this moment, MyDayLight has been presented along with some similar applications. In this literature review, special attention is paid to two elements of MyDayLight that are of value for MyDayLight's development and design: co-design and embodied being-in-the-world. Those terms will remain to be important throughout this research. Firstly, whereas co-design has proven to be valuable in developing MyDayLight prior to its finished prototype, it is worth continuing with this methodology as it might prove to be useful and even result in new insights in using co-design in user studies, rather than solely in design development trajectories. Therefore, in this chapter, the concept of co-design will be explored to fully understand it.

Secondly, a design perspective specifically adhered to while designing the already existing interaction with the system is that of embodied being-in-the-world. Throughout this research, prototyping phases will be introduced to explore the further interaction opportunities and, while doing this, designing for embodied being-in-the-world need to be reconsidered as well. Therefore, this literature review will explore design for embodied being-in-the-world in depth to fully understand it. When the feedback is given by the users during this research, it is the responsibility of the researcher to connect the proposed design opportunities with this design perspective.

3.1. Co-design

In this section, the concept of co-design is elaborated upon. As it has become apparent in *Chapter 1: Introduction,* co-design has been the leading design methodology towards the creation of MyDayLight as it is now and will be re-used in this research. To start with, co-design is deconstructed into two concepts that it encompasses: participatory design and co-evaluation. Secondly, it is discussed why co-design with people with autism has mostly been avoided, and why some researchers find this a missed opportunity.

To start with, participatory design started from the simple standpoint that those affected by a design should have a say in the process as well (Ehn, 2008), and it falls in the category of human-centred design (Sanders & Stappers, 2008). Another design technique that falls within this category is the well-consolidated user-centred design, which remains to be widely-used in the industrial practise and education. User-centred design, in which design is practised from an expert perspective, is the opposite of participatory design. In user-centered design, trained researchers observe and/or interview largely passive users without given influence and room for initiative in roles for users where they provide expertise and participate in the informing, ideating and conceptualizing activities in the early design phases.

The concept of participatory design is not defined by one clear definition. Sanders (2006, p. 5) refers to participatory design as “design in which the researchers or designers invite users who will benefit from the design as partners in the process”. Ehn (2008) broadens this definition by saying that any person involved can function as co-designer in the design process. Trischer et al. (2018, p. 5) seem to put emphasis on the interaction between the user and many parties involved from the expert side, as they describe participatory design as ‘’design in which participants are invited to cooperate with designers, researchers and developers during an innovation process’’. Noticeably, in all three definitions, it is clearly defined that the user takes an active role in the design process. In short, it appears that the biggest difference between participatory design and classical design is the fact that in the latter the user has only a passive role in the design process, but receives an active role in the design process in participatory design. The difference between classical design and co-design/participatory design is visualized in Figure 9.

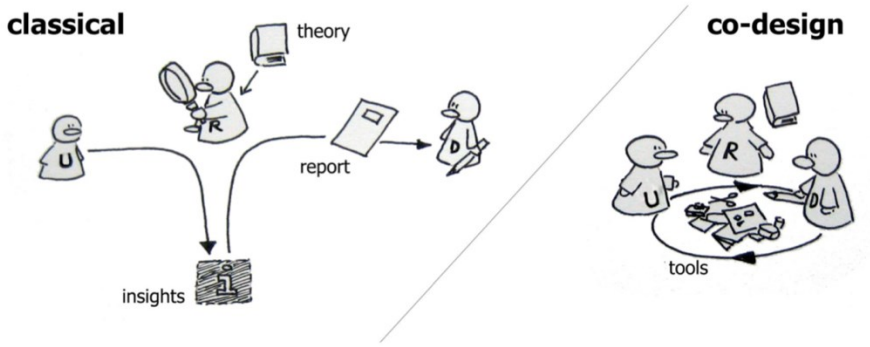


Figure 9: Classical Design versus Co-design
(Sanders & Stappers, 2008)

Interconnected with participatory design is co-evaluation. A definition of co-evaluation is given by Spiel, Malinervi, Good and Frauenberger (2017, p. 3). They name it, however, participatory evaluation: “a way in which researchers will be able to include autistic children in dedicated evaluation phases of participatory design through the co-definition of goals and methods, joint processes of data gathering and the co-interpretation of results”. It must be noted that this definition addresses co-evaluation with children with autism, but in this research, this definition will address young adults with autism.

Noticeably, in participatory design, the researcher and the designer may be the same person and is therefore undeniably leading a process in which design and evaluation are interconnected as *co-design*. Given the interconnected nature of this process, co-design approaches involve both designing and evaluating. Techniques for co-design, therefore, cannot clearly be divided between a design part and an evaluation part, but must be

addressed holistically where valuable insights are gained precisely by the combination of designing and evaluating. For example, in regard to MyDayLight, it could be the case that a user would like to see the rainbow light going the other way around for a specific reason – at this moment, the rainbow light is turning clockwise while brightening up. The only way to find out if this works for him is by actually implementing this design opportunity and evaluating it once more afterwards, asking the question if this has helped.

So far, co-design has primarily served product development trajectories that, on contrary with this research, started from ground zero with a development goal in mind. This research, however, starts with a fully developed prototype and co-design is used in the context of a user study – aside developing new interactions. Having said this, already developed co-design approaches should be kept in mind as they can be useful nonetheless. For example, Van Rijn en Stappers (2008) present with an idea that stimulation of psychological ownership can act a factor for motivation, an argument built upon research conducted by Beggan (1992) which states that a user is more willing to participate if they feels respected or trusts the intentions of the designers. Sleeswijk Visser et al. (2005) and Sanders and Stappers (2005), on the contrary, emphasize the practical aspects of a successful co-design approach, rather than on a psychological aspect. They suggest that contextmapping techniques can be useful for information and inspiration about the context of product use. Sanders and Stappers (2014) present probes, toolkits and prototypes as prominent approaches in the practice of participatory design. Most interestingly is their trust in prototypes. According to them, prototypes can play a number of roles in the participatory design process: to evoke a forced discussion in a team, to test a hypothesis and to confront theories. Iterative prototyping can be viewed as growing early conceptual designs through prototypes into mature products.

Prominent co-design approaches have also been constructed by Benton et al. and Merter and Harırcı. However, in comparison with the approaches discussed in the previous two paragraphs, they chose to focus on a specific target group: children. Benton et al. (2012) constructed IDEAS, an approach for actively involving children with autism in the design process, consisting of six design sessions: team building, context setting, idea generation, design development, design refinement and evaluation and reflection. Supposedly, Merter and Harırcı (2016) would criticize this approach, though, as the involvement of parents and caretakers in the participatory design approach is clearly missing. In their approach, they emphasize on the importance of involving parents and caretakers in the participatory design process, because this allows comparison of the information collected, and thus have a more comprehensive understanding of the child as well as their needs.

3.2. Co-design Exclusion

The characteristics of autism often cause people with autism to be excluded from the design process, where a deficit in social communication is one of the core features of autism that can cause such exclusion. Individuals that have autism with additional learning disabilities are often excluded as well (Lowe, Gaudion, McGinley & Knew, 2014; Grawemeyer et al, 2012).

It can be argued that such an exclusion is unjust. A first protest is presented in the proposal by *Powertools* (2015), a collective of institutions that works on participatory design methods for people with cognitive disabilities. In the proposal, it is stated that the majority of current assistive technologies are solely covering the technology's perspective, rather than the perspective of the users and caretakers. However, forced and imposed technologies requires the learning of a new behaviour, something that is specifically difficult for people that have a cognitive disability. By involving both the caretakers as the users in the design process through participatory design methods, the chance of long-term success increases. Merter and Harırcı (2016) share the same positive opinion on co-design with people with autism. In their opinion, co-design, as a democratic and empowering approach, provides the opportunity to learn more about special user groups and design for them. The involvement of individuals with autism in design does not only increase their well-being and quality of life, but also draws attention to their presence in the society, their potentials and capabilities.

In conclusion, it is widely acknowledged that participatory approaches to designing technology are particularly valuable in an autism context, not only in terms of creating meaningful technology, but also for the enriching and empowering experiences of the participants in the design process (Keay-Bright, 2007) (Rijn, Sleeswijk Visser & Stappers, 2009) (Benton & Johnson, 2014) (Parsons, Yuill, Brosnan & Good, 2015).

3.3. Embodied Being-in-the-world and Embodied Empowerment

Aside co-design, embodied being-in-the-world has been another important element throughout the development of MyDayLight and will yet be important throughout this research. As a matter of clarity, the distinction between embodied being-in-the-world must be clearly explained before diving into the theory. Firstly, embodied empowerment is *a goal towards is worked* in the design of MyDayLight. Embodied being-in-the-world, on the other hand, is the phenomenological viewpoint of how a human lives in this world, and, thereby, forms the fundament for designing for embodied empowerment.

This section starts with explaining embodiment from a phenomenological viewpoint. It continues with an exploration of how embodiment is gaining ground in human-computer interaction. Subsequently, the design theory for embodied being-in-the-world that is relevant

for MyDayLight is discussed and it is explained how this theory is brought into practice for MyDayLight. In the latter, the concept of embodied empowerment is discussed.

3.3.1. Embodiment and Interaction Design

Embodiment does not immediately has to refer to a complex and philosophical concept, as it can also simply refer to something that it is attached to the body or measuring bodily signals (Van Dijk, 2018). In Merleau-Ponty's vision, however, embodiment is a concept that finds itself in the disciplinary field of philosophy that is called phenomenology. To define phenomenology: "phenomenology is the study of the development of human consciousness and self-awareness as a preface to- or a part of philosophy" (Merriam-Webster, n.d.). In other words, phenomenology is concerned with the way we experience things and how we are aware of this experience. To understand embodiment in a phenomenological viewing point, it is helpful to explain the underlying anthropological assumptions that Merleau-Ponty takes as the truth. Merleau-Ponty, namely, wishes to reject any clear distinction between the physical body on one hand, and the non-physical mind on the other hand, a Cartesian distinction that is taken as truth quite commonly (Van Dijk, 2018). Therefore, Merleau-Ponty (1962) introduces the term *lived body* to appoint what he believes a human really is: a unification of the body and mind as one; and it through this lived body that a human experiences the world.

The lived body, a unification that is contrary to Cartesian dualism, took some time for philosophers and cognitive scientists to be acknowledged (Hermans, 2002). According to Gallagher (1995), the Cartesian dualism is still not that easy to escape. Even at this point, there are many cognitive scientists that reduce mental events to brain processes, a view in which the body is reduced to a mental process. Gallagher recalls the image of the brain in the vat as a good example of such disembodiment: a disembodied brain, sustained in a chemical bath, seems perfectly capable of experience and cognition as long as the correct information inputs are provided. Merleau-Ponty, supported by Gallagher, supports the claim that cognition depends on experience that is informed with various perceptual and motor capacities. In other words, Merleau-Ponty emphasises that we need both a body and a mind in order to experience things. The body and the mind do not solely interact with each other, where one of the two could be replaced by an equivalent element, but they are unified. Both are necessary elements that form one whole in order to experience things. In the lived body, it would be impossible to replace the body for a virtual body in a virtual world – as is done in, for example, the movie *The Matrix*: cognition depends on the body and cannot go without.

Historically, human-computer interaction developed in parallel with cognitivism (Van Dijk, 2018). Over the past years, however, there has been an exploration of the value of embodiment for interaction design, with embodied cognition, ecological psychology,

phenomenology, situated cognition and pragmatism as main sources, respecting the unification of the body and mind as a lived body as it has been described by Merleau-Ponty (Dijk & Hummels, 2017). Van Dijk even explains that designing for embodied theories promises to open up a theoretically informed, largely unexplored design space, which can help designers to utilize the full power of [interactive] technologies (Van Dijk, 2018).

Most recently, Van Dijk (2018) critically analysed the concept of embodiment in the design of interactive products in which he gives a criterion for- and exemplifies when he believes an interactive product has successfully been designed for embodiment. Van Dijk argues that a product has successfully been designed for embodiment when it has become part of the lived body; when it exists next to the mind and the body in unity. A simple example he gives is a blind man's cane. The cane has become an extension of the body and he does not consciously think about it while using it. It is just *there*, being part of the lived body.

In conclusion, Van Dijk shows that embodiment can function as a mere goal towards one can work whilst designing an interactive product; ensuring that a design is a part of the lived body. The latter is an essential notion in this article. It is one of the effects strived after in the design of MyDayLight.

3.3.2. Designing for Sensorimotor Couplings

To ensure that an interactive product succeeds in design for embodied being-in-the-world, adhering to the criterion provided by Van Dijk (2018), there are three design theories that can help in doing this. The first one is called *designing distributed representations*, the second one is called *designing for social situatedness* and the third one is called *designing for sensorimotor couplings*. The design theory that has been relevant for MyDayLight has primarily been the last one, which will be explained and exemplified.

To start with, an explanation on what a sensorimotor coupling is would make this theory more understandable: a sensorimotor coupling describes the way by which the lived body continuously self-organizes into coordinating patterns in response to perturbations, where the coordination is established between the formation of couplings between *perception* (the activity of our senses) and *action* (the activity of our 'motor'-system). Subsequently, these sensorimotor couplings lead to behavioural patterns that fit the given situation (Beer, 2008). To elaborate on that: the development of a sensorimotor coupling produces a *grip* on the world that is continuously re-established in response to changes in the relation between the lived body and the world. Therefore, the development of a sensorimotor coupling can be seen as the development of a *skill*, as it is a successful way of doing things that is stable enough to pop up when needed.

To exemplify such a complex development of a sensorimotor coupling, a baseball outfielder that needs to catch a ball can be considered. What the outfielder could do first is

calculating the goal position and running speed to catch the ball. However, the outfielder simply starts running instead while making sure that the ball maintains a straight horizontal line in his visual field. This is a sensorimotor coupling. Firstly, the outfielder *perceives* that they needs to catch a ball. Secondly, the outfielder responds to that perception with an *action*: they starts running. After catching the ball multiple times, the outfielder has come to the understanding that to simply start running after knowing that they needs to catch a ball is the most successful pattern in this situation; it results in catching the ball the most times. By now, the outfielder has developed the skill of catching the ball and each time they needs to re-do this, the outfielder will almost *intuitively* start running.

It could be argued that, when a product is part of such an intuitive sensorimotor coupling, it has become part of one's lived body. A product that would have been successfully designed for embodiment – once again according to the criterion given by Van Dijk – is the concept study of F.E.E.L. (Bergamaschi, Rampino & Dijk, 2017). The design goal of this concept was to reduce shower time and save water thereafter. Instead of simply reminding the users of a shower to save water or shutting off the water supply, the developers of F.E.E.L. decided to "intervene in the sensorimotor couplings that underlie the gradual build-up towards that familiar moment one just feels one is finished and quits voluntarily" (Van Dijk, 2018, p. 11). Therefore, the F.E.E.L. concept proposes an interactive floor that physically stimulates the feet in a certain massage, with the temporal structure of the massage always being the same for each shower session. The system first measures the average shower time of the user, adapts the massage rhythm to it, and at the end of a specific period of time, the user is accustomed to the rhythm and thereby will implicitly associate the temporal structure of the massage with the normal shower routine. After several days, the pattern will gradually reduce its length over a period of weeks, while retaining the same overall massage choreography. Clearly, the idea is that, along with this reduction, the user will unconsciously adjust their embodied routine with the effect that one feels one is done showering arrives sooner. As Van Dijk puts it (2018, p. 11), "the user will save water, while not being forced, and not having to decide consciously: he will just feel like it".

3.3.3. Embodiment and MyDayLight

The exploration of Merleau-Ponty's vision of embodiment, where the unification of body and mind is respected, has opened up a new design space in Interaction Design. MyDayLight has also been developed for embodiment and the logical questions raised are: how is MyDayLight related to embodiment? Why is MyDayLight designed for embodiment? How has embodiment as a goal guided the design of MyDayLight? What design theory has

been adhered to? And has its design for embodiment been successful according to the criterion given by Van Dijk?

However, before diving into those questions, another term must be introduced: *the lifeworld*. Simply put, the lifeworld is the world in which the lived body lives (Van Dijk, 2018). Phenomenologically speaking, though, the lifeworld is the world how it shows up for us, how the spatial settings, the people and the social settings show up; it is the world in which our lived body operates. Therefore, one could say that the someone's lifeworld is a phenomenological description of their world (Van Dijk, 2018). MyDayLight, being a system designed for embodiment, is especially focused on adding to a person's lifeworld.

As stated at the start of this article, MyDayLight is an interactive light system that would be designed to support high-functioning, semi-independent living for people with autism that experience problems with attention and organization in their own lives and in their own home. Speaking of design for embodiment, designing for sensorimotor couplings have been the red line in MyDayLight's design, as the system aims to help to create the right sorts of sensorimotor couplings: those that hold the user's attention at activities that they wishes to conduct. For example, a young, semi-independent man with autism called Simon could have troubles with cleaning the dirty dishes because nothing is triggering him to do so. Persuasive supervisors and intrusive mobile applications have appeared not to have any effect on his behaviour. Subsequently, Simon receives MyDayLight as a potential solution to his problem. As MyDayLight's design allows, it is not pre-set how the system should be used as it is designed in such a way the user can discover his own unique way of dealing with his challenges in organization and attention. Simon finds out that he succeeds in doing the dirty dishes when he puts the light on top of the extractor brightening up just before 6 o'clock, where he is not being disturbed by intrusive supervisors and annoying buzzers coming from his phone. After following this pattern for a couple of weeks, the man almost *instinctively* starts to do the dirty dishes when the light brightens up.

At least, the latter is the desired outcome. The light becomes a part of the user's lived body as it functions as an essential reminder to do something. Being part of the lived body, it can be stated that the system has succeeded in being designed for embodiment. The reason why embodiment has been such a prominent element in MyDayLight's design has to do with the effect that it can bring about. By making it embodied, the system can gradually transform the user's lifeworld. The set of lights create a supporting structure for gradually developing new routines in dealing with the world (Van Dijk, 2018). To elaborate on this, MyDayLight invites the user to reorganize their daily environment around the lights such that the world has an increasingly better fit into the user's routine. In the user's own unique way and mediated by MyDayLight, the user's lifeworld and its daily routines can co-evolve in a desired grip on the challenges caused by autism. And this is where the concept of embodied

empowerment finally steps into the scene. If a user is finding their own unique way of dealing with his challenges, they is not only combatting these challenges whilst building upon the premise that autism is a curable illness, it also allows the user to become fully who they is as they does not need to change who they is whilst combatting the challenges caused by autism. This effect is what is called embodied empowerment.

3.4. Summary

This literature review has discussed elaborate descriptions of co-design and embodied being-in-the-world, with both of them becoming yet prominent concepts in this research. Firstly, to recall the novelty of this research, this will be the first time that MyDayLight is being tested with actual users *after* the completion of a hi-fi prototype. Therefore, it is of importance that the idea behind co-design is well-understood. Furthermore, it is important that the dynamics between the user and the researcher are clear, as well as the role that the researcher should adopt. The role of embodied being-in-the-world will, foremost, be relevant for the co-design phase where design opportunities are discussed and realized, as MyDayLight's interaction with the user must be designed for embodied empowerment. The future interactions must comply as much as possible to this concept, and should definitely not oppose it – by, for example, making the system too persuasive.

Lastly, it should be noted that the inclusion of co-design and embodied being-in-the-world in this research are not solely included to facilitate an effective and efficient research. Gathering insights about their inclusion in a user study after the completion of MyDayLight is also part of this research. For example, how effective is co-design in a user study? And what roles must the researcher adopt in the user study? Or, in regard to embodied empowerment, are there any design opportunities mentioned by the users that are not complying with the idea behind embodied empowerment? And how must the researcher make sure to implement the user's feedback while respecting the fact that MyDayLight is designed for embodied being-in-the-world?

4. Research Methodology

In this chapter, the research methodology is presented. Firstly, the concrete co-design process is presented elaborately. Secondly, Research-through-Design as the underlying research methodology is discussed. Thirdly, the Creative Technology Design Process*s* is introduced, which forms the fundament of the Bachelor Program of Creative Technology. It also forms the fundament of the co-design process for this research.

In order to retrieve approval for this research methodology from the Ethical Committee, a number of documents had been sent to a representative of the committee. This consisted of a formal approval request, an informed consent form, an information brochure explaining the research, a data management plan (included as Appendix B), an ethics checklist, and an example interview. This research was given the green light after it was considered standard research in a fast-track procedure. In the database of the ethical committee, the research approval is referenced to as file number *RP 2018-14*.

4.1. Co-design Procedure

Firstly, the co-design procedure is elaborated upon, which is not a linear process. It is divided into four distinct phases of which the last three will be iterated. The reason for opting to include design iterations with smaller phases has to do with the underlying research methodology of Research-through-Design, that will be discussed later in this chapter. In Figure 10 on the next page, the co-design process is visualized.

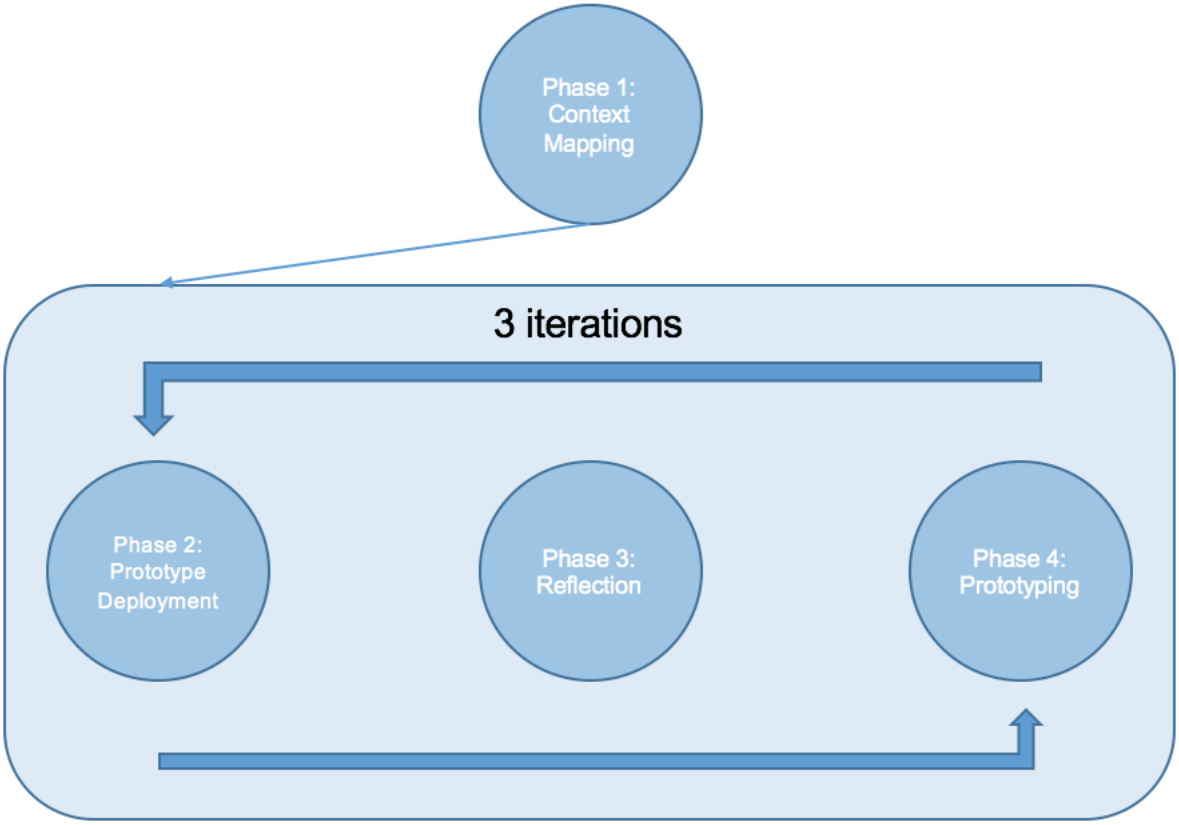


Figure 10: The Co-design Procedure

	1	2	3	4	5	6	7	8	9	10	11	12
Initiation												
Prototype												
Deployment												
Reflection												
Prototyping												

Table 1: Week Overview

Week:	Starting Date:	Ending Date:
1	26-03-2018	01-04-2018
2	02-04-2018	08-04-2018
3	09-04-2018	15-04-2018
4	16-04-2018	22-04-2018
5	23-04-2018	29-04-2018
6	30-04-2018	06-05-2018
7	07-05-2018	13-05-2018
8	14-05-2018	20-05-2018
9	21-05-2018	27-05-2018
10	28-05-2018	03-06-2018
11	04-06-2018	10-06-2018
12	11-06-2018	17-06-2018

Table 2: Weeks and Dates

The entire co-design process consists of 12 weeks, as can be seen in Table 1. Clearly, some of the phases overlap each other due to time- and organizational constraints. In Table 2, the accompanying dates are presented. The first phase, which is the *Context Mapping* phase, consists of several tasks: meeting the users, establishing contact with the advisors and supervisors, agreeing on communication- and time schedule preferences and initiating the ethical procedure. Meeting the potential users is the primary and most important task, as it is the goal of the researcher to understand the user's challenges caused by autism and their context in advance to know what he needs to pay special attention at whilst collecting data and gaining insights. Topics to be discussed are not only related to autism and the user's context, but also about the user's hobbies and aspirations. Since the researcher and the user are going to work together closely, good chemistry between them is

of paramount importance; also for the sake of academic outcomes, as bad chemistry could prevent the user to give full disclosure. Once the researcher has established contact with all the (potential) users and has collected data thereafter, the researcher will conduct PACT-analyses to make descriptions of the users. A PACT (People, Activities, Contexts and Technologies) analysis means that identifications of the different activities that people conduct in different contexts using different technologies are made (Reinius, 2011).

Noticeably, MyDayLight has not yet been installed at the user's places in the context mapping phase, but it has been merely introduced. However, in the *Prototype Deployment* phase, MyDayLight is going to be tested. Throughout testing the system, a phase that will be crossed three times in total, it is the goal to identify usage appropriation and redesign opportunities thereafter. The testing method depends on the user: it could be that a user wishes to test the system completely on his own, but it could also be that user expresses the presence of the researcher as a condition. Both methods have advantages and disadvantages. An advantage of having the user test MyDayLight individually is that the user will test the system in their natural context; the influence of the researcher on the system's usage can be excluded. A disadvantage is a probability that the user will use the system less intensively, as they might be more scared to use it in case of calamities. Furthermore, if the user has a preliminary feeling that the system might not be of value to them, there will be no researcher present to push the user into finding potential value nevertheless. An advantage of testing MyDayLight together with the user is the fact that such a push factor actually is present. On top of this, the user will feel less scared and less careful to use the system. Furthermore, if the researcher is present during the testing of the system, he will be able to capture a lot more insights, such as facial expressions and usage of the system that the user would otherwise forget to mention to the researcher.

After the prototype deployment phase, the researcher sits down with the user and the advisors and supervisors – collaboratively or apart from each other – and reflects on MyDayLight for the *Reflection* phase. It will be discussed how the user has been appropriating MyDayLight and if they has appreciated it. Regarding MyDayLight's appropriation, it is tried to identify for what *means* the user has been using MyDayLight, at which *locations* the user has put the lights and how the user has been *framing* the system *mentally*. The latter means as *what* the user has perceived MyDayLight. This could be notification system, an alarm clock, a game, a reward system, etc. Moreover, it is discussed what design opportunities have been discovered and how these can be transformed into concrete requirements for the following prototype. The focus of this phase is not yet primarily on designing prototypes, but reflecting upon desired changes, missing functionalities or newly-identified usage opportunities through a number of semi-structured interviews. This

phase is a phase of reframing, which means that the usage of the system as it might have been anticipated beforehand, changes to new uses, both mentally as physically.

If the third phase has proceeded successfully, the last phase of the iteration is initiated: the *Prototyping* phase. At the end of the reflection phase, the ideas on design opportunities have been well-documented and transformed into concrete requirements for a prototype. Together with the user, the researcher will now start realizing the prototype – of course, to the extent of which this is possible. Anticipating what design opportunities could be mentioned by the users allows the researcher to already prepare the prototyping sessions to a certain extent. What will not be done at all is shoving MyDayLight completely away if one of the user's expresses to not find it effective in supporting them in attention and organization. Instead, if such a situation occurs, it is the responsibility of the researcher to find out why the user is saying this and collaboratively exploring usage opportunities in making MyDayLight effective nevertheless.

4.2. Data Collection and -Analysis

As has been presented in *Chapter 3: Co-design,* a number of co-design approaches have already been developed that aim to collect data and gain insights through a number of techniques. However, since this research has the nature of a user study and it is conducted together with young adults, the primary collection method is an interview. At the start, the sessions will be guided with the help of a semi-structured interview, but it is expected that the interviews can become unstructured as the co-design process proceeds. In the latter, the interviews are simply steered by the researcher's notes, rather than by pre-set questions. The interviews will be conducted in the context mapping phase, as well as the reflection phase. During the prototype deployment phase, the researcher and the user share data over WhatsApp if MyDayLight is being tested at the user's house with the researcher being absent.

Throughout this entire research, the researcher will also write down his insights in a confidential logbook, as not all insights are gained from the mere interviews. Facial expressions, interesting observations and side-note reflections are all captured in the logbook and contribute to richer outcomes. Lastly, to organize the collecting of design opportunities in the reflection phase, a How-Wow-Now-matrix (HWNM) is used for each iteration, which is a four-quadrant matrix that can help the user in organizing their ideas into ideas that are impossible, easy to implement, normal and original (Innovation Games, n.d.). The HWNM was preferred over the MoSCoW Methodology as it was more visual and thus, more presentable. This eases the conversation about the input of another during reflection interviews.

The data analysis follows a pattern throughout this research. First of all, after the interviews have been recorded, the researcher goes over every recording and writes down in a document how the conversation proceeded, what topics were discussed and what has been said. In the same document, the researcher also writes down interesting points - if needed - that reflect on insights previously gained. From these interview analyses, the researcher tries to find statements made by interviewees that are representative of the story that had been told. Subsequently, the interesting points and statements are included in the logbook and/or in the HWNMs if they concern design opportunities. Subsequently, the HWNMs are subject of discussion in the follow-up reflection interviews.

4.3. Research-through-Design

Research-through-Design is one of the research methodologies leading this research, which is a concept that describes a research approach where the design process in itself becomes a way to acquire new knowledge (“What is Research”, n.d.). By taking this approach, Research-through-Design distinguishes itself from *Research-and-Design*, where design activities create tools or stimuli on specifications (Stappers & Giaccardi, n.d.). Naturally, the Research-through-Design methodology in this research will be generating information that can be used in answering the research questions that were introduced in *Chapter 1: Introduction*. The fact that Research-through-Design is the leading research methodology is also the primary reason why there is no clear hypothesis about what the answers to the research questions could be; as unclear as it is which insights will be identified throughout this research, as unclear it is what the outcomes will be.

To exemplify Research-through-Design one more time, the situation described in *Chapter 3: Co-design* is recalled. It *could* be that the user wishes to have the rainbow light turn the other way around. The underlying thought behind this is that by changing the rotation of the rainbow, the user believes the system is working more effectively for themselves. By applying this feedback, realizing it and re-testing it in a next iteration, it can either be confirmed or rejected that this is indeed working more effectively for them.

4.4. Creative Technology Design Process

As stated at the start of this chapter, the Creative Technology Design Process (CTDP) forms the fundament of the co-design process for this research. In the CTDP, four phases can be clearly distinguished: ideation, specification, realisation and evaluation (Mader & Eggink, 2014), as can be seen in Figure 11. From a theoretical level, the CTDP works in the following way: within the ideation phase, the design problem is defined, relevant information is collected through literature reviews, interviews and observations and ideas are generated through mind maps, mood boards and brainstorm sessions. The specification

phase starts when a design concept is decided upon. At the end of the specification phase, certain usability and user- experience requirements for the design concept are set that are realized in the subsequent realisation phase. The last phase is the evaluation phase, in which functional prototype deployment is included, as well as a test to determine whether or not all the original requirements from the specification phase are met in the service or product.

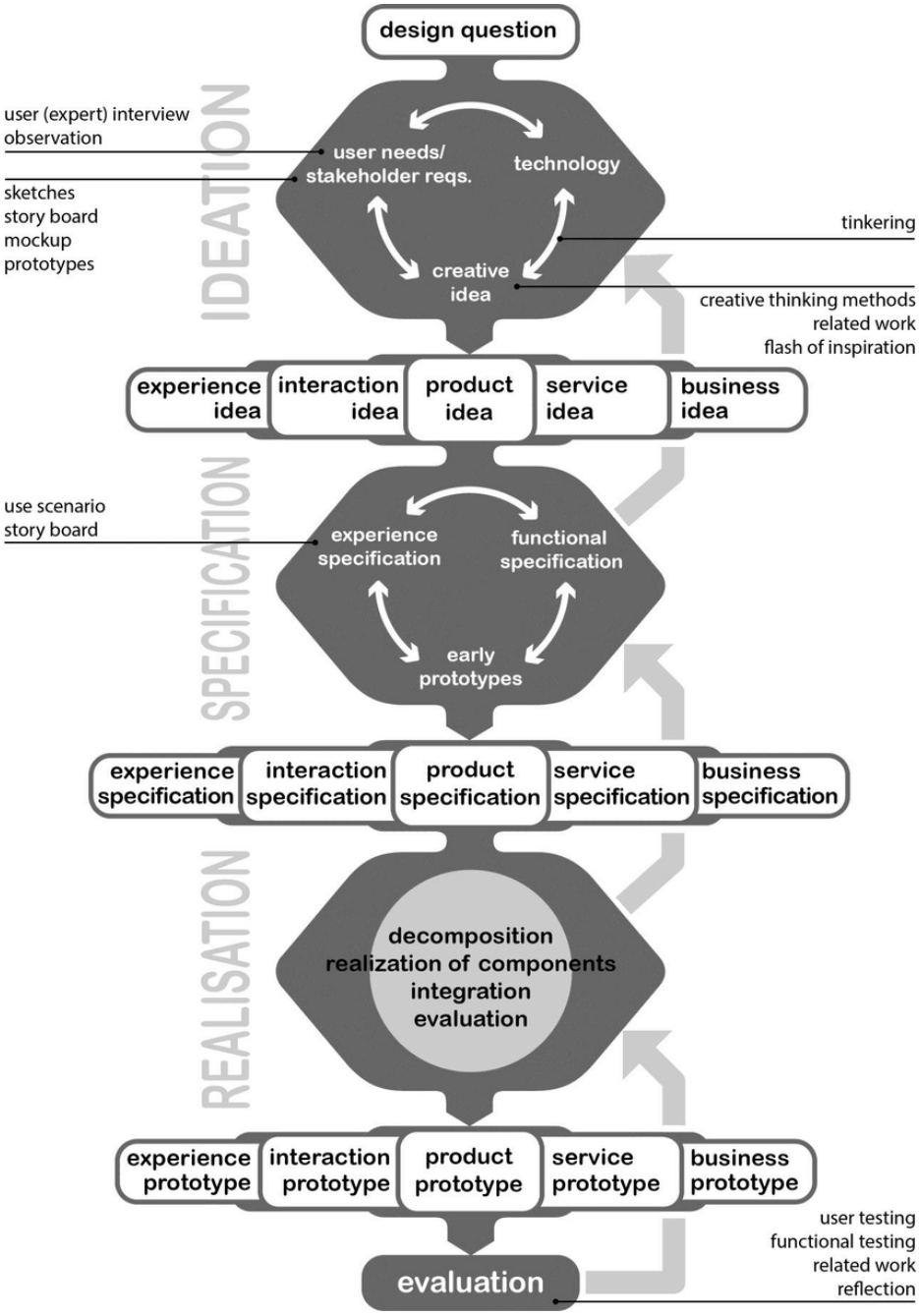


Figure 11: The Creative Technology Design Process
(Mader & Eggink, 2014)

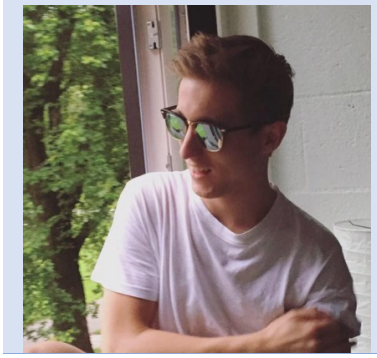
The CTDP shows parallels with the co-design process described at the start of this chapter. There are differences, though, with the most striking difference being the fact that the context mapping phase of this research is not the same as the ideation phase in the CTDP. Whereas the ideation phase of the CTDP aims to generate a significant amount of product and/or system ideas, this research already has a fully-functioning hi-fi prototype. Furthermore, the CTDP already introduces prototypes in the reflection phase, whereas in this research prototyping does not start before the prototyping phase due to time constraints. Overall, it could be mentioned that this entire co-design is one big iteration from the CTDP as well, as the usage of prototyping in the CTDP's reflection phase shows parallels with the design methodology of Research-through-Design.

5. Context Mapping Results

In this chapter, the context mapping outcomes are presented. The context mapping phase has consisted primarily of PACT analyses in order to make precise descriptions of the users. These descriptions can help to place data provided by the user in their context, as well as presuming with arguments how MyDayLight could be appropriated by this user – if not appreciated.

5.1. Parties Involved

The most prominent participants in this research are the users and they will be presented elaborately in the next section. However, since this research is following a co-design trajectory, advisors and supervisors are equally important to this research. In Table 3, all parties involved are presented, including the researcher who will from now on present the findings in the first-person perspective. It must be noted that the advisors and supervisors are labeled either as advisor or supervisor for matters of simplicity. Of course, their contribution has gone beyond the level of giving mere advice, as almost all parties have been asked to be actively involved in brainstorming about design opportunities as well.

	Profession and role:
Johannes Cornelis van Huizen 	**Profession**: Student Creative Technology **Role:** Researcher and Designer who is conducting this research. Johannes Cornelis will actively be involved in discussing appropriation and design opportunities, as he has a deepened understanding of design requirements and technical possibilities. **Label:** Researcher
Shireen van Rosmalen 	**Profession:** Manager of innovation at Karakter, centre of psychiatry for children and young adults **Role:** Advisor, facilitator and sparring partner in brainstorm sessions regarding appropriation and design opportunities **Label:** Advisor

Arjan Dogger 	**Profession:** Student Business Economics at the Applied University **Role:** Experience Expert, as he finds himself on the autism spectrum himself. Arjan can provide insights and give feedback on appropriation and design opportunities. **Label:** Advisor
Erna Dogger 	**Profession:** Autism coach for the Dutch Association for Autism (NVA) **Role:** Expert advisor and sparring partner in brainstorm sessions regarding appropriation and design opportunities **Label:** Advisor
Corné Stolzenbach 	**Profession:** Supervisor at the Regional Institute for Sheltered Accommodation in Nijmegen (RIBW) **Role:** Supervisor of Gerd regarding semi-independent living in a sheltered facility. Corné can help to put the findings into Gerd's personal context. **Label:** Supervisor
Wouter Boenen 	**Profession:** Supervisor at Ten Kate Activity Centre **Role:** Supervisor of Gerd at the activity centre (Dutch: Dagbesteding) that he needs to attend to receive living allowance. In the activity centre it is the goal to develop the personal skills of the clients and to potentially (re)integrate them in society. Wouter can help to put the findings in Gerd's personal context. **Label:** Supervisor

Table 3: Parties Involved

5.2. PACT Analyses

As stated in the previous chapter, PACT analyses are used to construct descriptions of the users. By constructing them in a similar format, it is possible to compare the participants holistically and better understand the outcomes of this research. The first description describes Gerd, the principal and most participating user. The second one describes Adam and the third one describes Toby. Naturally, all three names are pseudonyms. Toby, unfortunately, has not been a great part of this project due to personal circumstances. However, he has been part of this Context Mapping Procedure extensively in which he has shared details about autism and the personal challenges brought along that could be interesting to reflect on potential usage of MyDayLight for his context. It must be noted that not all information given in the following sections was collected solely in the context mapping phase. This co-design process is a continuous process of gaining new insights about the users, their activities and their contexts. Having said this, the context mapping interviews did provide most parts of the following three sections, of which analyses are included as Appendices C.1-4.

Gerd

The first user is Gerd, who is 24-year old young adults with autism that can be described as kind, soft, and helpful. Gerd also appears to show some negative character traits that may or may not have to do with autism, as experienced by myself as well, but also by Gerd's supervisors Corné and Wouter. First of all, Gerd is not always honouring existing commitments. Specifically, it appears that Gerd has problems with showing up at appointments in the morning. This is due to the fact that Gerd has troubles with sleeping before 3 or 4 o' clock in the morning due to personal reasons, after which he needs an incredibly persuasive alarm clock to wake him up in the morning. The dishonouring of existing commitments does not stop at showing up at appointments, but it also obstructs him from adhering to agreements made and prioritizing, which appears to be a recurring deficit in Gerd's behaviour.

Gerd's daily activities follow a recurring pattern: he wakes up around 11 or 12 o' clock in the morning and he stays at the activity centre from around 1 o 'clock in the afternoon until around 5 o' clock where Gerd occupies himself in a developmental way until he returns homewards. At this moment, Gerd is looking for an apprenticeship that can help him to develop skills that can eventually lead to a profession, which is one of his aspirations. After attending the activity centre, he does groceries and he makes dinner, alone or with a friend. During the weekend, it is assumed that Gerd frequently visits his parents. In regard to Gerd's living conditions, he stays at a sheltered accommodation that is part of the RIBW, where supervisors are present as well. Gerd needs to share the bathroom, kitchen and washing

machine with the other residents, but he has his own bedroom, living room and sink. It is Gerd's personal aspiration to live completely independent one day.

From all users, referring to Gerd, Adam and Toby, Gerd is the only one living in a facility for a sheltered accommodation and seems to be the only user that is limited by autism in his life choices. To elaborate on this: Toby has a profession and Adam is able to study, regardless of having autism. Gerd, on the contrary, is clearly not able to catch up with Toby and Adam on this level of professional development. Gerd also seems to be struggling with cognitive deficiencies in a way that Toby and Adam are clearly not. Lastly, in comparison to Toby and Adam, who only experience challenges in attention and organization, Gerd also seems to show challenges in social interaction. That is, Gerd showed at the start of the context mapping phase that he failed to grasp the appropriateness of the social context, as one of the first things he shared with me – accompanied by advisor Shireen – that he felt bad about not being able to flirt with girls and not having lost his virginity yet, which is not something one would normally share during a first meeting.

Adam

The second user is Adam, who is a young adult at the start of his twenties. Adam could be described as kind, helpful and intelligent and he shows no signs of challenges in social interaction. Regarding autism, Adam explains that the most affecting challenge caused by autism is the fact that he keeps on planning activities until there is no more leisure time and his daily schedule is entirely occupied, where a great number of activities planned are related to his study program at the applied university and his job where he does not hold back in dotting the I's. The second challenge is the fact that he can be immersed in an activity to the extent where he needs quite some persuasion to draw his attention, a phenomenon also referred to by Toby as hyperfocus, who experiences the same challenge. In regard to Adam's living condition, he does not yet live independently, but he lives with his parents. It is clear that, in comparison to Gerd, Adam's living conditions are not limited by autism. Adam has never been in need of supervised living and it is clear that he will also never need such supervision. Moreover, Adam is also not in need of apprenticeships or a developmental program at an activity centre. The only supervision that Adam receives is from his parents, that focusses slightly on him having autism. For example, Adam expressed that it is often his mother that confronts him with his overly-occupied schedule and advises him, subsequently, to plan more time for relaxation amidst the other activities.

Compared to Gerd and Toby, it appears that Adam is cognitively the most competent user among them. This also allows him to reflect critically on himself and on other people with autism on an unparalleled level. Furthermore, Adam is also able to express himself in a

detailed, reflective and critical way on an intellectual level; there are no apparent challenges in communication and social interaction.

Toby

Lastly, the third user is Toby. For his description, information is taken from the logbook and from the interviews, but permission has been given as well that I was allowed to look into a confidential interview conducted on 13-07-2017 by Shireen van Rosmalen and Jelle van Dijk. Toby is a young adult at the start of his twenties who can be described as opinionated, assertive, reflective, smart, critical, ambitious and sincere. Toby also has *Attention Deficit Hyperactivity Disorder* (ADHD) aside autism. Regarding autism, one primary challenge caused by autism is the fact that Toby cannot neglect to do an activity he has already started, as he will not pick it up again. This can go as far as an escalation. To exemplify this challenge, Toby told me that he had already collected eight trash bags on his balcony, as he had forgotten to throw the first one away. After this, it becomes virtually impossible for Toby to re-continue with throwing away the trash bags and he simply lets them pile up. In the past, doing the dishes has escalated in a similar way, which ended up in him piling up all the dirty plates until he was out of clean plates and wanted to buy a completely new set of tableware. This process can also be seen as a negative spiral: the longer he would neglect an activity, the more the situation escalates and the higher the threshold becomes to restart with the activity. The challenge described above was also causing Toby to have difficulties with reading letters: he does not like to open envelopes, and as the letters pile up in his mailbox, the threshold for opening the letters is only getting higher. Another challenge caused by autism, as explained by Toby, is the fact that he can be overly immersed in an activity, such as working on the computer at night, which has frequently led to Toby not getting a proper amount of sleep or even not getting enough nutrition. In regard to Toby's living conditions, he does not live at a sheltered accommodation, but he does receive support from a personal, ambulatory supervisor. The supervisor helps toby with finances, setting the day format and going through the mail. The supervisor does not come automatically, though. In a self-reliance form, Toby has declared to adhere to his responsibilities independently, but he can contact the supervisor when he feels this is needed. Toby and his supervisor meet once a week, but he sees her as well at the *buurtcirkel*, which is an initiative that connects people who are living alone in the same neighbourhood.

In comparison to Gerd, Toby only receives ambulatory supervision, while Gerd stays at a sheltered accommodation. In the past, Toby has also lived at a sheltered accommodation under the supervision of the RIBW. However, this has not been a joyous experience for him. Regarding intellectual competencies, Toby finds himself more on the

same level as Adam. However, whereas Adam is steadily following the same educational program, Toby shows a history of starting and quitting a number of educational programs thereafter. A job has also appeared to be a problematic aspect of his life, as it is too exhausting for him. Currently, Toby works - with great pleasure - at an ice skating rink, though. Lastly, it should also be stated that Toby does not experience autism as a deficit. In his opinion, it is only an enriching aspect of his life as it helps him to organize excellently. He also expresses that autism is not something that defines him, but merely something that he has. He is perfectly able to live with it, as it does not affect the aspirations he has, nor the ambition he shows.

5.3. Current Usage of Technology

Regarding current technology, none of the users is currently using applications specifically made to help people with autism with attention and organization. Gerd solely uses the calendar application on his phone, but he often forgets to open this application. Adam also uses the calendar application on his phone and it appears to work for him. Regarding Toby, WhatsApp appears to be an important channel for him to get in touch with his supervisors. Therefore, his mobile phone is an essential element for his supervision.

6. Iteration 1 Results

In this chapter, the results of the first co-design iteration are presented that started on the 23rd of April, after the context mapping phase had ended the week before. In total, 3 iterations have been realized, all consisting of phases of prototype deployment, reflecting and prototyping. In this and in the following two chapters, it will be presented how the prototype deployment phases have proceeded, what insights were gained from the reflection phases and how this has affected the prototyping choices. Throughout these chapters, information and insights are collected from the interview analyses and the logbook. It must be noted that the contents of these chapters are recapitulatory of nature. To get a holistic understanding, it is strongly recommended to have a look at the interview analyses.

Prototype Deployment

The first iteration was conducted with Gerd at his apartment in a facility from the RIBW for sheltered accommodation, where MyDayLight was being tested in its original state. The system was installed on the 24th of April and was de-installed on the 30th of April, 6 days later. Throughout these days, Gerd and I have had contact through WhatsApp. Noticeably, Gerd had only been using the system twice after the I had left the apartment on the 24th of April. This suggested that a more intensive prototype deployment session together with me could be more effective for the next prototype deployment phase, which was also confirmed by supervisor Corné. After all, most of the usage insights were collected in my presence, even though this was not the most natural context for Gerd.

Reflection

The reflection phase started on Thursday the 26th of April with an interview with advisor Shireen, of which an analysis is included as Appendix C.5. In this interview, the initial feedback already provided by Gerd in the previous two days was discussed, as Gerd had already expressed some concerns and desires. Moreover, an interview was conducted on the 8th of May with advisor Arjan, of which the analysis is included as Appendix C.6. In this interview, the focus was put on reflecting on the way Gerd had been appropriating MyDayLight. Furthermore, based on Gerd's feedback, Arjan suggested design opportunities that would be more elaborately used in the second prototyping iteration.

Noticeably, however, there has never been a reflection conversation with Gerd himself until the 25th of May, even though this was scheduled on the 30th of April. Furthermore, the meeting was also never officially cancelled, but Gerd simply did not show up at the appointment, after which communication had completely stopped. It took until

Sunday the 13th of May until contact was re-established after I reached out to him once again. In the meantime, however, the second co-design iteration had already started with the second user, Adam.

Means	Location	Mental Framing
Leaving the house on time	At the location of the to be conducted activity	Notification system
Doing dirty dishes on time	On top of the pile of dirty laundry	
Alarm clock	Within the field of view	

Table 4: Appropriation Iteration 1

The way Gerd had been using MyDayLight in physically had already been revealed in my presence in the first prototype deployment week, which is summarized in Table 3. Regarding the *means* for which Gerd was using MyDayLight, it appeared mostly that he had been using the system for activities that were related to the personal challenges caused by autism, referring to the problems with showing up on time, adhering to agreements made and prioritizing activities. During the meeting on the 25th of May, Gerd also seemed to be willing to have MyDayLight function as an alarm clock, as he was explicitly comparing the system to the alarm clock on his phone. Regarding the *locations* of the lights, he seemed to be placing the lights at the location where the activity was set to happen. The most interesting scene was where he put one of the lights on the big pile of dirty laundry. He put it on there and made the light *part* of that pile. However, when he noticed that he was not able to spot the rainbow light brightening up when it was out of his field of view, he decided to place the light in front of him on the salon table. Another question to answer regarding the appropriation of MyDayLight, is how Gerd had been using MyDayLight mentally. That is, had he been using it solely as a notification system, or was he perceiving it as a reward system, etc. However, during the conversation on the 25th of May, Gerd emphasised that MyDayLight had been functioning solely as a notification system, for which he used at most three lights only. The last question to answer regarding the appropriation of MyDayLight is Gerd's *appreciation* of the system. However, as there had not been an official reflection conversation with Gerd in this first iteration, there was not yet an answer to this question for now.

Figure 12: Gerd put one of the lights on top of the pile of dirty laundry. This photograph is staged though, as Gerd preferred not to have any pictures taken at his apartment.

Figure 13: The activities for which Gerd used MyDayLight that were out of his field of view prompted him to put the light in front of him on the salon table.

As stated, the design opportunities from this reflection phase are captured and visualized with the help of how-wow-now-matrices. The HWNMs for this iteration are included as Appendix D.1. and summarized in Table 5, encompassing design opportunities brought forward by Gerd, myself and advisors Shireen and Arjan, consecutively.

Input by:	**Gerd**	**Researcher**	**Shireen**	**Arjan**
Now	Make the rainbow light brightening up for a longer period of time	Mend the broken lights		
Wow!	Have sound played along the rainbow light brightening up during a notification			Ensure that the sound is not too intrusive, as they must not be scared up by the sound while doing a certain activity The sound must come from the light itself. It is preferred to make the sound work wirelessly.
How?	Make the battery last longer	Implement on/off button Add a sound interface for embodied empowerment	Make MyDayLight portable Send live updates of the user's schedule to the supervisor	
(Impossible)			Enable the user to communicate with the system	

Table 5: Design Opportunities Iteration 1

The first design opportunities expressed by Gerd were to make the system more noticeable and more persuasive for him. Therefore, he suggested making the rainbow light would simply brighten up longer and to make a simple sound go off at a notification. The last design opportunity that was mentioned by Gerd was to replace the current battery with a battery that would last longer. The second HWNM captured my feedback on the suggested design opportunities provided by Gerd. A practical matter I thought of was to add an on/off button on the lights, as there is not any at the moment, which causes the battery to drain quite rapidly. However, it could also be decided to use a magnetic battery that can easily be detached from the lights and save battery thereafter. Regarding the inclusion of sound, I suggested implementing a sound interface to the current software that would enable the user

to personalize the tune that would be played when an activity is set to happen. This interface would also include a recording button that would enable the user to record something for each of the seven lights independently. Finding the balance between intrusion and embodiment, the idea behind this recording button would be that the user can record the voice of a supervisor that would tell him to do the planned activity when this activity is set to happen. This voice would come as close as possible to the user's natural context, or, in phenomenological terms, the lifeworld, and would activate the user without using an intrusive tune.

The next HWNM captured the design opportunities brought forward by advisor Shireen, in which the interface was discussed as well. Shireen brought forward mostly creative out-of-the-box design opportunities that could be interesting for future design plans with MyDayLight, such as MyDayLight becoming a portable system. By having a fixed location, Shireen explained that this limits the activities for which MyDayLight can be used to the home situation, even though most users also leave their home. Furthermore, Shireen saw a greater role for the supervisor in the system's design: by having live updates of the user's schedule being sent to an interface on the supervisor's side, the supervisor can step in if it becomes apparent that the user is neglecting the schedule. Lastly, Shireen suggested that the inclusion of artificial intelligence could be a promising addition in the form of a robot with whom the user can speak and reflect on the activities.

The last HWNM made in this reflection phase was based on the feedback provided by advisor Arjan. Arjan critically stated that the inclusion of sound had solely be considered to please Gerd's feedback, but could have an unsettling effect for others on the autism spectrum where it could be perceived so gravely annoying that they would not like to use MyDayLight (anymore). Arjan was also sceptical about the possibility to record the voice of a supervisor, as he believed some people with autism wish to hide their challenges. A voice telling the user what to do would be confrontational and especially unsettling if the user has visitors over. Having said this, Arjan was not completely negative about the inclusion of sound, as he understood that MyDayLight in its current state might not be noticeable enough to have any effect. However, he did point out the following necessities. Firstly, the tune must not be intrusive. Secondly, the sound must be coming from the light(s) and the sound interface must be understandable and simple. The latter would become difficult if there was the possibility to have a different tune for each and every light. Therefore, Arjan suggested to only make it possible to have one tune for all lights.

Prototyping

From the design opportunities brought forward in Table 4, the following opportunities were realized: the broken lights had been mended, sound had been added to a notification using a newly-introduced programming language called *Processing* – which means that the user hears a doorbell tune every time the rainbow light brightens up – and the duration of the rainbow light had been increased. In Figure 14, the new prototype working in practice is captured. A limitation of the prototype is the need for a physical connection between the light's Arduino and the laptop on which Processing is running due to its serial communication – which also limits the number of lights that can be tested with sound. For testing purposes, this physical connection has not been a problem, though. The (adapted) Arduino Code for this prototype is included as Appendix E.1. and the Processing code is included as Appendix E.2. In the next iteration, it is the goal to investigate what effect the inclusion of sound could have on the way Gerd perceives the system and to what extent he appreciates this addition.

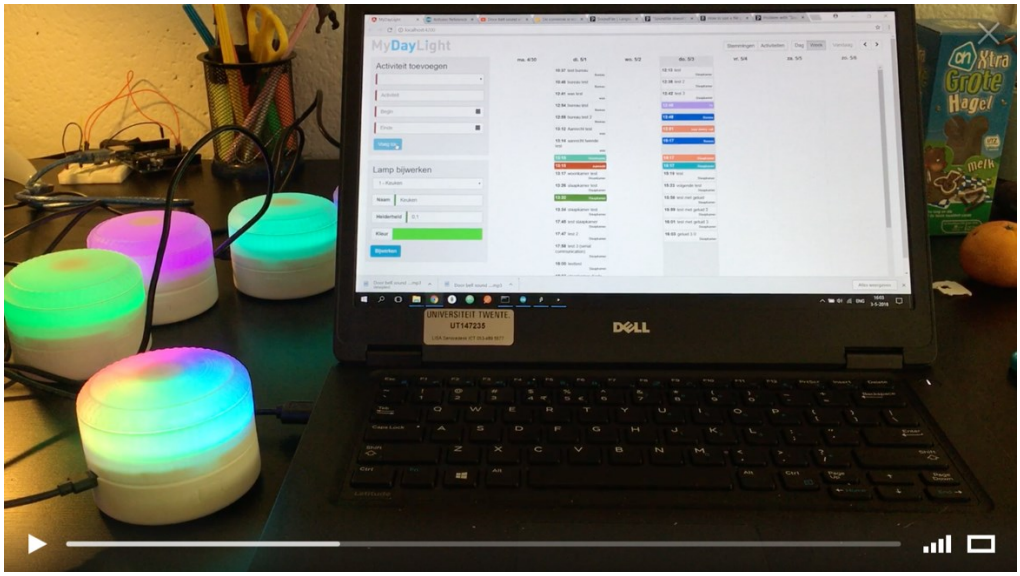


Figure 14: A still from the video explaining the first prototype

7. Iteration 2 Results

Prototype Deployment

Although Gerd was supposed to be part of this iteration, problems with communication made his participation impossible. Therefore, Adam participated instead, testing the first prototype at home during an intensive afternoon test session on the 10th of May. The test session consisted of two parts: a part with the original version of MyDayLight and a part with the prototype; he could compare the versions and bring forward valuable design opportunities thereafter. It should be noted that the means for which MyDayLight have been used in this iteration are staged, as this was part of the test session. However, to have the means come as close as possible to the natural context, the staged activities are related to the personal challenges as they had been pointed out by Adam on the 18th of April, referring to overly planned days and undesired immersion. Therefore, the first act saw one of the lights being placed next to him as he was occupying himself with something on his computer at the kitchen table. The second act saw one of the lights being placed on the kitchen top. Subsequently, at the dinner table, I was having a conversation with Adam in which a topic was discussed that grasped Adam's full attention. The main difference between the two acts is the fact that the light was inside Adam's field of view in the first setting and outside his field of view in the second setting. Both acts were executed twice: one time with the original version of MyDayLight and one time with the new prototype.

Reflection

The reflection phase started right after Adam had tested out the original version of MyDayLight and the first prototype. These test sessions were followed by two consecutive reflection interviews of which analyses are included as Appendices C.7 and C.8. The second contribution to the reflection phase of this iteration was provided by advisor Shireen on the 14th of May (Appendix C.9.), with feedback mostly related to the system's appropriation.

Means	Location	Mental Framing
Grasp attention out of an immersed conversation	At the location of the to be conducted activity	Notification system
Grasping attention while being immersed in something on the computer	In the field of view without a sound being played during a notification	Big stick
Leave the house on time	Sound allows the system to be placed out of the field of view	

Table 6: Appropriation Iteration 2

After the first reflection interview, I asked Adam for what purposes he would have used MyDayLight if this was not a collaborative test session. Adam explained that he would have used it to have him notified to leave his house in time for an appointment. Regarding the *locations* of the lights after the original version of MyDayLight had been tested, Adam explained that he would prefer to put the lights at the location of where the activity was set to happen but decided to put the light next to him as he was afraid he would miss the notification. Regarding the locations of the lights after the first prototype had been tested, the inclusion of sound would at least allow him to place it out of the field of view at an activity that would be in the same room as him, using three lights maximum at the same time. In regard to the *mental framing* of the system, Adam explained that he would not only use MyDayLight as a notification system and as a big stick that would ensure him not to neglect the upcoming activities. Adam also expressed that he can see other users wanting to use MyDayLight to teach them how to improve planning and keeping attention over time, which would make MyDayLight educational of nature. Regarding the system's *appreciation*, Adam explained that he appreciated the system triggering the user in a different way than for example a mobile phone application does – or simply the mobile phone alarm clock. In his experience, he would simply start doing different things on the phone rather than setting an alarm clock for an upcoming activity. MyDayLight does not allow such distraction.

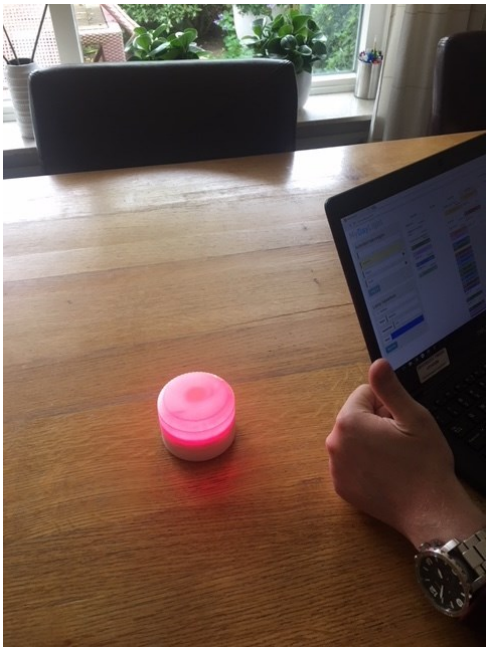


Figure 15: The first activity conducted with Adam saw the light placed in his field of view.

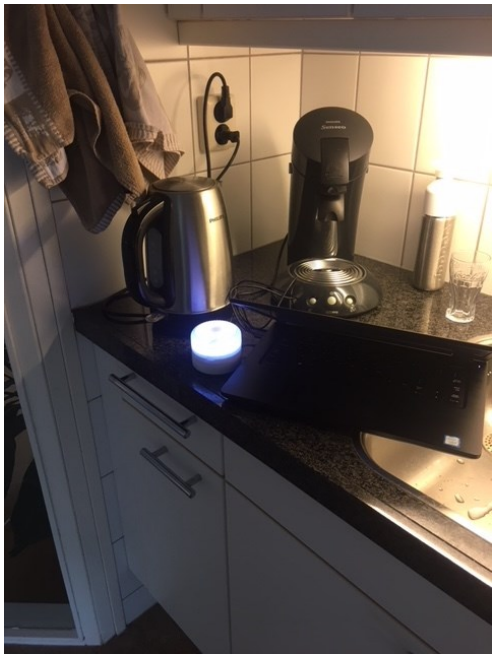


Figure 16: The second activity conducted with Adam saw the light

In this iteration's reflection phase, the following questions can be answered: what was the effect of the enlarged duration time of the rainbow brightening up, and what was the overall effect of the inclusion of sound on the user? To start with the duration of the rainbow light, Adam explained that he believed that the enlarged duration time was adding value to the system as it would allow the user to process the notification more calmly. The sound, however, evoked mixed reactions, as he believed that the sound can scare him when badly-timed. On the other hand, he also believed it is needed to grasp his attention. The default sound, a doorbell, was badly-chosen, though, as this would remind users of unexpected visitors and could evoke an unsettling feeling afterwards for some people on the autism spectrum. Both the appreciation as the scepticism revolving around sound naturally led to a discussion about design opportunities for the next prototype that are summarized in Table 7, with this iteration's HWNMs included as Appendix D.2. The first HWNM, therefore, captures the design opportunities brought forward by Adam himself.

Input by:	**Adam**	**Researcher**
Now	The rainbow lights need to be brightening up longer	2 of the lights broke down. The need to be mended
Wow!	There should always be the option to have or not have a sound play during a notification The default sound must be chosen carefully. It should be subtle and not too intrusive. For example, a doorbell can be associated with unexpected visitors and, because of this, can be perceived as very intrusive	Connect the sound system to a wireless Bluetooth speaker
How?	The user should have the option to decide how intrusive the system should be. Therefore, the sound interface should be personalizable The following variables should be personalizable: volume, duration and which tune The rainbow light must brighten up until feedback is given to the system that it has been noticed Have to interface on the mobile phone as well	The interface for sound must be user-friendly The recording button must be in the same interface as the other sound settings The recorded track must be one of the optional tunes
(Impossible)		

Table 7: Design Opportunities Iteration 2

First of all, Adam and I both agreed that the sound played should be balanced between noticeability and subtlety. If the sound is too noticeable, it can be perceived as intrusive. If the sound is too subtle, it might have no extra effect on notifying the user to do something. Intrusive sounds should not be automatically avoided though, as Adam believed

that some users on the spectrum would paradoxically appreciate an intrusive sound to remind them of important activities or appointments. This introduced the first variable that Adam believed should be personalizable for each and every user: the character of the sound. Depending on the importance of the planned activity, it should be possible by the user to change the character of the sound with intrusiveness as a variable. For example, a doorbell could be considered as the most intrusive tune, whereas a gong could be considered the least intrusive one. Adam also suggested the variables of volume and duration to change a sound's intrusive character. Lastly, Adam expressed that the possibility to record to something during a notification is a design opportunity that he would like to see explored.

Next to design opportunities regarding sound, Adam also suggested other design opportunities: enlarging the duration of the rainbow light even more. This would allow putting the lights out of the field of view without needing to use sound to make it noticeable. Adam even added to this that some sort of feedback to the system could be another alternative. For example, the user could press something on the light that would make the rainbow stop brightening up. Secondly, Adam explained that he would appreciate it if he could also add and change things to the interface through his mobile phone so he would not have to remind himself to do it later on the laptop when he comes back home.

Subsequently, I added and/or changed the design opportunities brought forward by Adam in more concrete design requirements in the next HWNM – mostly concerning the interface. First of all, the interface should be understandable and user-friendly. Secondly, the interface should contain sliders to adjust the three variables mentioned by Adam: audio character (options of tunes), volume and duration. Thirdly, the recording button should be present as well in this interface and the recorded track should be one of the options in the slider containing the options of tunes. The default tune for the sound system should definitely not be a doorbell, but a less intrusive tune that does not evoke an unintentional reaction.

Prototyping

The subsequent prototyping phase saw almost all design opportunities from Table 6 realized, of which the sound interface is displayed in Figure 17, including all the three variables. Furthermore, the recording button is realized and the recorded track can be selected as one of the tunes to play during a notification. The interface provides feedback to the user on whether it is recording or not and if the microphone is working properly. Next to the sound system, a Bluetooth speaker has been added to MyDayLight's hardware (JBL GO), that can mimic a light's built-in speaker. Lastly, the duration of the rainbow light brightening up has been enlarged one more time to one minute. For this iteration, the Arduino code, nor the Processing code is included. For the Arduino code, no grave changes had been made in relation to the previous prototype. Regarding the Processing code, the

code for the third iteration is smoother, more efficient, optimized and better commented. Therefore, only the code for the third iteration is included as Appendix E.4.

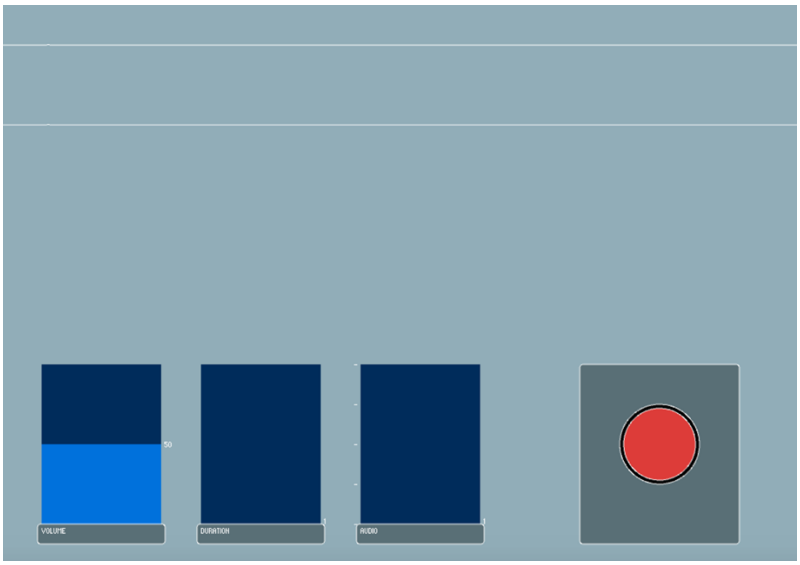


Figure 17: The sound interface of the second prototype

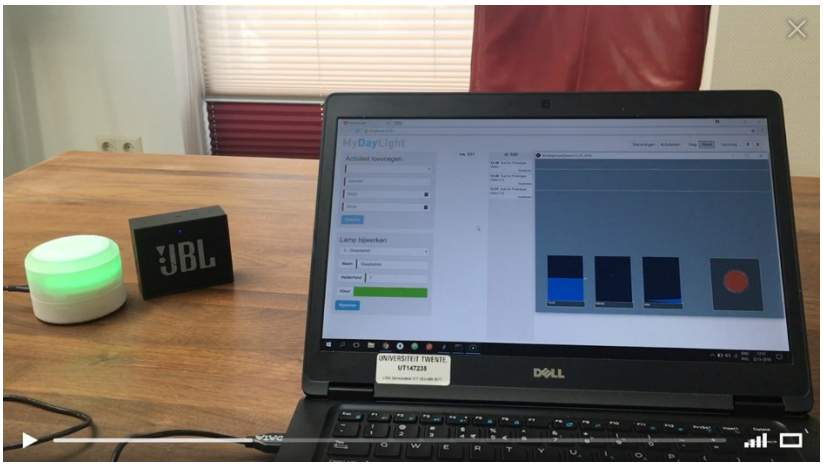


Figure 18: A still from the video explaining the second prototype

8. Iteration 3 Results

Prototype Deployment

The third iteration was conducted collaboratively with Gerd again at a new apartment in a facility from the RIBW for sheltered accommodation on the 25th of May and more elaborately at his activity centre (Dutch: Dagbesteding) on the 29th of May. Furthermore, the new prototype had been demonstrated to-, and discussed with advisor Erna, from the Dutch Association for Autism and advisor Arjan, the experience expert, on the 1st of June. The set-up of the test session at the activity centre was not that insightful: as Gerd had supervisors around him, there were no means for which Gerd could use MyDayLight with added value. Therefore, the system was put on the centre's bar and Gerd was sitting on the sofa a couple of metres further. The focus of the session was to find out how effective Gerd thought the new prototype was and if he personally appreciated it in this way.

Figure 19: MyDayLight being tested at Gerd's activity centre for the third iteration

Reflection

The reflection phase started along with the test sessions on the 25th and 29th of May, as each session would end with a reflection interview of which analyses are included as Appendices C.10 and C.11. The second contribution to the reflection phase was by advisors Erna and Arjan, which also marked the first time a focus group was organized: myself, Erna and Arjan collaboratively discussing the new prototype and Gerd's usage of the system. The

analysis of this interview is included as Appendix C.12. It appeared that a focus group can be of added value, as the parties involved can respond to each other immediately and gain new insights with each other throughout. Aside from these interviews, the interview with Gerd's sheltered facility supervisor Corné was also conducted in this phase, of which the analysis is included as Appendix C.13.

Means	Location	Mental Framing
Leaving the apartment on time	At the location of the to be conducted activity: good reminders	Notification system
NOT: as an alarm clock		

Table 8: Appropriation Iteration 3

Most of the insights on the way Gerd had been appropriating MyDayLight so far were identified during the interview on the 25th of May, summarized in Table 8, in which Gerd confirmed that he had been using MyDayLight during the first iteration to combat personal challenges. He expressed primarily that he believes MyDayLight could be used to support him in leaving his apartment on time for appointments - but not as an alarm clock. Regarding the *locations* on the lights, I recalled Gerd putting them in front of him and on the pile of dirty laundry. Gerd explained that he believed those were good reminders. He also confirmed that he had put the lights at the location of where the upcoming activities were set to happen. Regarding the *mental framing* of MyDayLight, Gerd emphasised that MyDayLight had been functioning solely as a notification system. Lastly, regarding the system *appreciation*, Gerd explained that he believes MyDayLight is a *funny* device, which can be considered a positive attribute.

Input by:	**Gerd (1)**	**Gerd (2)**	**Arjan & Erna**	**Researcher**
Now				
Wow!	Erase the recording button as it is too distractive	No longer erase the recording button, as it can be used to record personally-effective tunes, such as an alarm clock		
How?	Implement a feedback system where the user lets the system know it has seen the notification	Implement an elaborate choice menu for the tunes Implement a game that needs to be solved to stop the sound playing	Intrusiveness in the interface should be related to association and repetition frequency The elaborate choice menu needs categories The sound interface and the planning interface should become one integrated whole The full spectrum of the rainbow colours to chose as a mood should be restricted to 4 colours	Allow new recordings without manually needing to delete the previous one Make processing and Arduino work wirelessly Optimize code so that it is not only working effectively, but also efficiently
(Impossible)				

Table 9: Design Opportunities Iteration 3

Consecutively, HWNMs were constructed that are summarized in Table 9 and included as Appendix D.3., with the first one being based on Gerd's feedback given in the first reflection interview at his apartment on the 25th of May. Gerd had expressed that he preferred the recording option to be erased, as he found it to be too distractive. Furthermore, Gerd explained to see value in a feedback system and suggested the rainbow light to brighten up for five minutes in which the user is given time to let the system know they has become aware of the notification. Lastly, Gerd appreciated the choice menu in which he can chose a tune, but suggested that it would be nicer to have even more options. Gerd's feedback changed after he had been testing the prototype more elaborately at his activity centre on the 29th of May. Firstly, Gerd and I collaboratively found out that the recording button could be used in an effective way, contrary to earlier beliefs. On my initiative, I proposed to record the tune that always successfully woke Gerd up in the morning. I argued

that if this tune would be successful in waking Gerd up, it might also be successful as the perfect notification, something confirmed later on by Erna and Arjan as well. After execution, Gerd stated that he found this effective.

In the subsequent reflection interview with advisors Erna and Arjan, not only valuable insights were gained on the way MyDayLight has been used so far, but also a number of design opportunities were proposed. First of all, Erna and Arjan believed that the most important variables for determining the intrusiveness of a tune are the personal association the user has with that sound and the frequency of repetition. However, Erna suggested to not only add tunes that are supposed to be changing in intrusiveness, but a more elaborate choice menu with a number of sound categories, such as instruments, animal- and bird sounds. Secondly, Erna and Arjan believed that, for future designs, both the original interface as the sound interface should become one integrated whole. Thirdly, Erna and Arjan saw value in the feedback system as it had been proposed by Gerd, but argued that it should be tried to make MyDayLight work without the user needing to take such an active role. When the mood functionality was introduced, Erna emphasised that the user should not have the opportunity to select a colour out of the total rainbow spectrum to represent their mood, but they should only be able to choose between green, orange, red and blue, as it is currently taught to children with autism that they can express their mood using one of these four colours. By restricting the possibilities to these four colours, the mood functionality would become more meaningful and it would be easier for the supervisor to recognize patterns in the user's mood swings.

The last HWNM also includes the design opportunities brought forward by myself, primarily dealing with some practical issues: establishing a wireless connection between the sound system and the lights, optimizing the Processing code and replacing the current speaker with another speaker that fits better with MyDayLight's design.

Prototyping

This prototyping phase saw design opportunities realized that were proposed in the previous reflection phase. First of all, a more elaborate choice menu was introduced, enabling the user to choose a category of sounds, as can be seen in Figure 20. Furthermore, in this prototype, it has been made possible to record more tunes without the need to re-start the program. Feedback is given to the user when this maximum amount has been reached, as can be seen in Figure 22. Hand in hand with the possibility to allow multiple recordings is the newly-added reset button, which is the green button on top of the recording button. If pressed, the old recording is *deleted* and a new recording can be made. To provide feedback to the user that the old recording is deleted, the rectangles in the recording area will disappear. These rectangles, displayed in Figure 21, pop up when a recording is being made

and will not disappear until the reset button has been pressed. Lastly, the communication between the Processing sketch, which handles the sound interface, and the Arduino is now being conducted wirelessly using internet protocols. The Arduino code fragment for this prototype is included as Appendix E.3. and the Processing code is included as Appendix E.4.

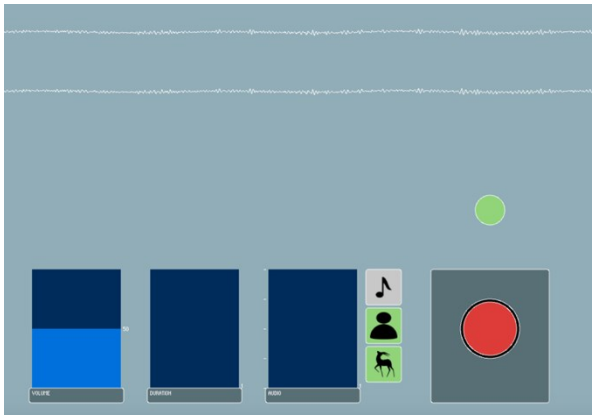


Figure 20: The third prototype contains an elaborate choice menu

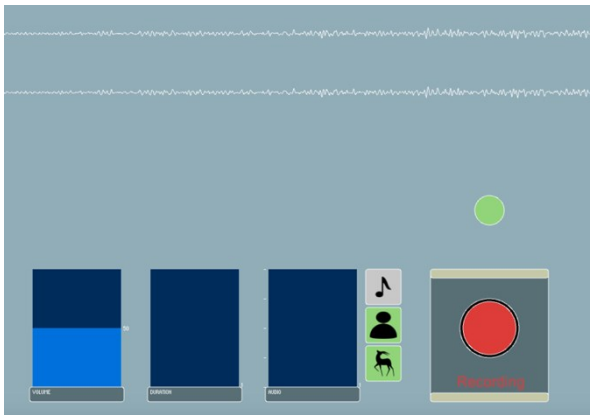


Figure 21: A recording in process

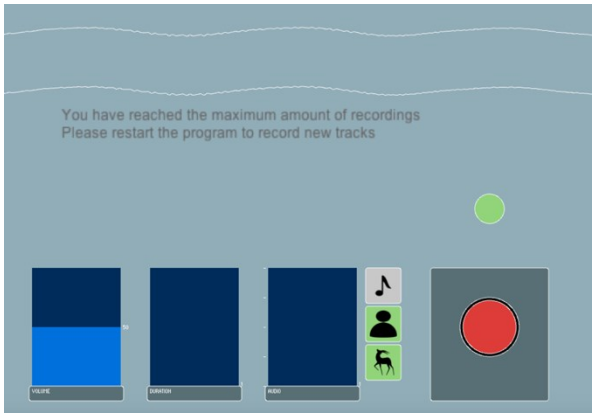


Figure 22: The maximum amount of recordings is reached

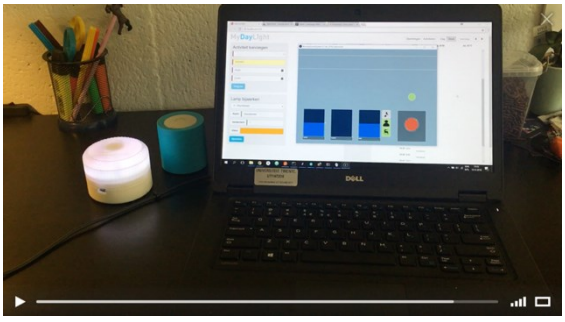


Figure 23: A still from the video showing the third prototype working wirelessly and with a new speaker

9. Discussion

In this chapter, a step is taken back from the findings and it is discussed critically to what extend closing answers can be given to the research questions as they were introduced in *Chapter 1: Introduction*. Special attention is paid as well to the concepts of co-design and embodied being-in-the-world, that so far have not been widely-discussed in the previous three chapters. Furthermore, it is reflected upon what the wider implications are that this research entails.

9.1. Findings

To recall the main question, it has been wondered how people with autism appropriate MyDayLight to support them in attention and organization for semi-independent living, with the focus being on means, locations and mental framing. In general, it can be stated that the means for which the users have been using MyDayLight try to combat the personal challenges caused by autism. Gerd's has been using MyDayLight as a persuasive agenda, notifying him on time to leave his apartment. During the testing session with Adam, he as well suggested to conduct test activities that were related to his challenges: starting a conversation in which he would be immersed and having him do something on his computer that would grasp his full attention. Regarding the *locations*, it has become apparent that both Gerd as Adam prefer to place the lights at the locations of the upcoming activities. However, as the system was initially not noticeable enough, Adam already decided at the start to put the lights in his field of view. Gerd did this later when he as well had gotten aware of the system's lacking noticeability. Regarding the *mental framing*, Gerd has manifested clearly that he would be only interested in using the system as a notification system. Adam confirmed as well that he has been using MyDayLight for this purpose – and as a big stick. However, he did understand that MyDayLight could serve different purposes for others on the autism spectrum, such as a learning trajectory to help users with autism improve planning and keeping attention over time. Advisor Erna adds to this that she also sees how MyDayLight can be used for support-, alarm-, and notification purposes. Regarding Toby, it must be speculated how he would appropriate MyDayLight. Given his challenges, the inability to re-continue with activities after negligence and hyperfocus, it would be logical if Toby would use MyDayLight to either remind him of the activities that should not be neglected and to grasp his attention when he is overly-immersed in an activity, such as being occupied with his computer. Presumably, he would as well place the lights at the locations of the activities, but he would also come across the same problems regarding noticeability as Gerd and Adam. Regarding mental framing, the obvious purpose that MyDayLight would

serve for Toby would be as a notification system. However, as Toby has expressed the desire to live completely independently, it would be advisable if he would approach MyDayLight as a didactic system to learn how to plan, organize and to keep his attention where it is needed.

The first subquestion deals with the needed interaction to facilitate the appropriation that has been identified. First of all, it must be recalled that it has been noted before the execution of the iterations that future interactions must comply as much as possible with the concept of embodied empowerment, with MyDayLight creating the right sensorimotor couplings: those that hold the user's attention at activities that they wishes to conduct. Phenomenologically speaking, MyDayLight must become a part of the user's lived body as it functions as an essential reminder to do something. A keyword in this concept has been *instinct*, as design for embodiment tries to activate the user to do something without them being fully aware of this. Naturally, this requires the design to not become too persuasive, as it makes the user aware of the fact that it is tried to activate them to do something. The challenge that has been emerging throughout this process, thus, is to respect the concept of embodied empowerment, but also to address the desire of the users to make the system more noticeable. Throughout this research, I have tried to achieve this balance with the inclusion of a personalizable sound system that can be tailored in the intrusiveness of the tune, the volume and the duration. Furthermore, I have included a recording button, with the idea behind it that the user can record the voice of the supervisor that would tell them to do the planned activity when this activity is set to happen. This voice would come as close as possible to the user's natural context, or, in phenomenological terms, the lifeworld, and would activate the user without using an intrusive tune. Advisor Erna specifically appreciated the recording button for this purpose. As she has an understanding of sensorimotor couplings, she believes that the recording button allows the user to use their own sensorimotor coupling to use MyDayLight in an effective and unique way. Its success is exemplified the best on the last testing day with Gerd, where his personal alarm clock was recorded. He expressed that this sound was the right trigger for him to get activated without the tune being inappropriately intrusive.

Overall, the exploration of sound has appeared to be a good direction taken to find the balance between embodied empowerment and addressing MyDayLight's lacking noticeability. What should also be mentioned is that the exploration of sound has identified how broad the spectrum of autism truly is with varying desires. Whereas Gerd wanted an intrusive buzzer, Adam explained that this would only scare him, which eventually led to the introduction of multiple personalizable variables for the sound system. Lastly, as the rainbow light was evidently not brightening up long enough, this duration has been enlarged with positive responses afterwards.

The second subquestion addresses the assessment of the co-design procedure. First of all, it must be noted that pragmatism and flexibility are of paramount importance to co-design with people with autism. Naturally, the users would not wish to participate in this research if they had not had any problems with attention and organization. The fact that the users had problems with attention and organization affected the research as well, as I have been standing in front of closed doors twice. However, my most important realization is the fact that I was slowly becoming a *supervisor*, aside from being solely a researcher and a designer, something that had already been expected by advisor Shireen. Throughout the research, I have inescapably had to hit the nail on the head at some occasions to evoke the needed reactions and gain insights afterwards. Such topics would deal with shame, losing one's virginity and being dependent on another. Overall, the research is confrontational in general, as the challenges of autism are continuously discussed. Future researchers should be aware of this and try to prepare in advance for such a research nature; especially when working with people with autism that are often excluded from co-design procedures due to the difficulties they bring along regarding communication and behaviour. This also suggests that the inclusion of an autism coach or another expert working side-by-side with the researcher could be of value, as this will ease the process of putting the participant's feedback in context. Regarding the collection of data within the co-design procedure, the input from the users, supervisor(s) and advisors has proven to be indispensable for placing the findings in the right context. Especially the last reflection interview with advisors Arjan and Erna appeared to be very fruitful. The parties involved could build upon each statements and collaboratively gain an understanding of the system's appropriation and proposed design opportunities.

The last subquestion addresses the appreciation of MyDayLight by the users. To answer this question, the users have been asked straightforwardly about their appreciation of the system. Gerd has described MyDayLight as a 'funny' device. This can be interpreted positively. Regarding Adam's appreciation of the system, Adam explained that he appreciated that the system triggers the user in a different way than for example a mobile phone application. In his experience, he would simply start doing different things on the phone rather than setting an alarm clock for an activity to happen. MyDayLight does not allow such distraction.

9.2. Limitations

Working with participants with autism results in limitations, which is why this group is often excluded from the design process, as described in *Chapter 3: Co-design Exclusion*. Primarily related to Gerd, communication problems might have disabled Gerd to give full disclosure and/or to express himself in well-chosen words. This can have resulted in faulty

interpretations of what message he has tried to convey. Furthermore, due to the fact that this research involved self-reported qualitative data, it can not be completely excluded that the findings are without bias. It could be that some findings have unintentionally been exaggerated and/or follow from a selective memory of events. Bias might also have been occurred in connecting findings to the diagnosis of autism, as I have not yet worked together with people with autism before. This might have resulted in me attributing findings to the challenges caused by autism, even though these findings might have been related to other character traits of the participants that have nothing to do with autism.

Lastly, it has been mentioned that the interactions explored throughout this research are aimed to fit with MyDayLight's design for embodiment. As this is a design perspective only recently discovered – as well as its design criteria, it cannot be tested if the interactions realized in this research are truly complying with design for embodiment and have the desired effect as described in *Chapter 3: Embodiment and MyDayLight*.

9.3. Wider Implications

As stated in *Chapter 1: Introduction* and *Chapter 2: Autism Spectrum* Disorder, autism has been introduced as a disorder with high treatment costs that causes money often to be invested in newly-diagnosed children and their parents, causing loneliness, depression and other mental health problem to be common for adults with autism. Furthermore, conventional treatments are morally-questionable because of a fiercely articulate and vocal community of adults with autism that says that the therapy is harmful. In this research, a prototype-centred co-design process has been developed together with three users with autism to support semi-independent living as a response to those conventional, yet controversial treatments.

In conclusion, it can be stated that this co-design process has been a successful response to treatments as it has allowed finding unique solutions for the users with autism to keep attention at- and organizing daily activities without them needing to change; MyDayLight does not build upon the premise that autism is a curable disease that needs healing. The co-design process itself has proven to be successful in facilitating a way to *find* the unique solutions for the users. Without their inclusion in the design process, there would be no iterative prototyping and the end prototype of MyDayLight could have become the opposite of what the users really would have wanted. Therefore, it is highly-recommendable for future researchers to include the participation of users with autism in the design process. By stating this, I agree with the conclusion given on the inclusion of users with autism as it has been presented by Merter and Harıcı in *Chapter 2: Co-design Exclusion*, that states that co-design, as a democratic and empowering approach, provides the opportunity to learn more about special user groups and design for them.

However, as discussed in the previous section, co-designing with people with autism comes along some limitations and it is therefore advisable to take advice from the conclusion on the co-design approach as it is discussed in *Chapter 9: Findings*. This includes the role as supervisor for the researcher, but also close contact with supervisors and advisors.

9.4. Summary

This research has seen MyDayLight, a light system supporting semi-independent living for people with autism, being subject to a prototype-centred co-design process to identify appropriation, design opportunities, appreciation and to assess the underlying co-design process. The findings have been subject to a discussion that can be summarized by the following points:

- MyDayLight has been used to combat personal challenges.
- The preferred locations of the lights are the locations of the activities to be conducted.
- MyDayLight has been used as a notification system and as a big stick.
- It has been the desire for the users to make MyDayLight more noticeable, something achieved by a sound system and the rainbow light brightening up for a longer period of time.
- The design challenge for MyDayLight is to respect its design for embodiment, but also address the desire of the users to make MyDayLight more persuasive.
- Co-designing together with people with autism requires a flexible and pragmatic approach.
- It is advisable for future researchers to take the role of supervisor aside from solely taking the role as a researcher and a designer.
- MyDayLight is appreciated for how it triggers the user to start doing the planned activity.
- Limitations of co-designing with people with autism are problems in communication and attributing findings to the challenges caused by autism, even though these findings might have been related to other character traits of the participants that have nothing to do with autism.
- MyDayLight is a successful response to current controversial treatments that build upon the premise that autism is a curable disease that needs healing.
- The co-design process itself has proven to be successful in facilitating a way to find the unique solutions for the users.

10. Conclusion

1. **Main question: how do people with autism appropriate MyDayLight to support them in attention and organization for semi-independent living?**

People with autism use MyDayLight to combat their personal challenges, with the preferred locations for MyDayLight's lights being the places where the planned activity is set to take place, as these are, epistemically, the best reminders. However, due to the system not being sufficiently noticeable, it is decided by the users to place it in their field of view. Regarding the mental framing, MyDayLight has been used solely as a notification system and as a big stick, but it is understood that it might also be used as learning trajectory to help people with autism improve planning and keeping attention over time, as well as for support-, alarm-, and notification purposes.

2. **What further design explorations with the system should be possible to facilitate such appropriation?**

It has clearly come forward that the notification had to be more noticeable, as the rainbow light was not outstanding enough. Therefore, the inclusion of a personalizable sound interface has been successfully introduced that finds the balance between intrusion and its design for embodiment. Lastly, enlarging the duration of the rainbow light has also proven to be effective.

3. **What co-design approaches should be used to evaluate MyDayLight with people that have autism?**

Due to communication- and planning problems, the researcher is prompted to be flexible and pragmatic. Furthermore, due to inescapably confronting the users with their challenges, it is advisable for future researchers to take the role of supervisor aside solely researcher and designer as well. Lastly, the inclusion of supervisors and advisors have proven to be indispensable for the outcomes and must not be neglected in future co-design researches that involve users with autism.

4. **Is MyDayLight appreciated for its purpose?**

MyDayLight is a welcomed system.

11. Future Research

Regarding future research, there are two focus points that could potentially lead to new and valuable insights. First of all, throughout this research, a significant amount of design opportunities have been identified that have fallen out of the scope for this research due to time- and technical constraints. However, they could provide opportunities to explore in future research**.** All the design opportunities from the three iterations are displayed in Table 10.

Iteration 1	Iteration 2	Iteration 3
Make the battery last longer	Have to interface on the mobile phone as well	The sound interface and the planning interface should become one integrated whole
Implement on/off button	The rainbow light must brighten up until feedback is given to the system that it has been noticed	The full spectrum of the rainbow colours to chose as a mood should be restricted to 4 colours
Make MyDayLight portable		
Send live updates of the user's schedule to the supervisor		
Enable the user to communicate with the system		

Table 10: Unexplored Design Opportunities

Secondly, it has become aware that MyDayLight might also be valued for its purpose by other target groups that have difficulties with keeping attention at- and organizing daily activities; specifically, those with another diagnosis than autism. This has been confirmed by members of Pluryn's Living Lab, which is a gathering place for all innovation where people with a handicap and supervisors test out the latest applications and devices in the field of telemedicine. During the visit in which MyDayLight was presented, it had been pointed out by the present members that they can also see MyDayLight working effectively for people in the first stages of dementia and for people that have acquired brain injury, sleep disorders, ADHD, borderline personality disorder, and for people that are blind, mildly- and moderately limited intellectually and limited intellectually and deaf at the same time. During the visit, it was generally acknowledged that MyDayLight can provide the most value for the people in this list that receive ambulatory supervision.

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13. Appendices

Contents:

Appendix A: Semi-Independent Living Options

Semi-Independent Living	**Description**	**Provision of Care**
Supported Living	Offers services to individuals with disabilities who are able to live independently in a home or an apartment.	The individual's needs are provided by caretakers working under the direction of the individual.
Supervised Living	Offers more direct and intensive structured supports available.	Functional life skills, such as banking and shopping, can be taught or supported by staff.
Group Home Living	The current traditional model for residential services for people with autism. In a group home, several unrelated people live together with staff that is constantly present.	The house is owned and operated by a provider agency that also employs and supervises the staff.
Teaching Family Model/Foster Home Living	Offers family-style living.	Constant support services are available by professional teaching parents
Farmstead Communities	Combine residential living arrangements with agricultural science and community-based employment.	Provide residential supports and services
Assisted Living Facilities/Intermediate Care Facilities	Provide assistance with personal care and activities of daily living.	Personal care provided by caretakers.
Development Centres	Are large residential facilities clustered on a campus setting.	Residents have intensive needs related to their developmental disabilities.

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Data Management Plan

Graduation Project Creative Technology

J.C. van Huizen

Supervisors

Jelle van Dijk

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Data Responsibility

J.C. van Huizen

18-04-2018

1. Data Description

In this graduation project, new qualitative data will be generated. The type of data that will be generated is text, audio- and video recordings from the data supplier interacting with the researcher. The data will be generated from interviews from which answers are either written down or recorded. On top of this, photographs will be taken that capture images that can provide important insights. Next to data coming directly from the data supplier, the researcher himself also keeps track of a log book in which he notes important and interesting findings. Lastly, important messages on WhatsApp are screenshot and saved in the database as well – anonymised of course.

2. Standards and Metadata

The data will be saved using certain standards and formats. Video recordings will be saved as *MP4*. Audio recordings will be saved in *m4a* format. Textual data will be saved in *doc* files. Photographs will be saved in *jpg* format. WhatsApp screenshots will be saved in *jpg* format as well.

In archiving the data, certain standards will be used to refer to the data:

Data Type	
Text	Text_Interview_*Date_ImportantStakeholder_TopicDiscussed* Text_Observation_*Date_ ImportantStakeholder_TopicDiscussed* Text_Other_*Date_ ImportantStakeholder_TopicDiscussed*
Log Book	LogBook_MyDayLight_JCvanHuizen
Video Recording	Video_Interview_*Date_ImportantStakeholder_TopicDiscussed* Video_Observation_*Date_ ImportantStakeholder_TopicDiscussed* Video_Other_*Date_ ImportantStakeholder_TopicDiscussed*
Audio Recording	Audio_Interview_*Date_ImportantStakeholder_TopicDiscussed* Audio_Observation_*Date_ ImportantStakeholder_TopicDiscussed* Audio_Other_*Date_ ImportantStakeholder_TopicDiscussed*
Photograph	Photo_Interview_*Date_ImportantStakeholder_TopicDiscussed* Photo_Observation_*Date_ ImportantStakeholder_TopicDiscussed* Photo_Other_*Date_ ImportantStakeholder_TopicDiscussed*
WhatApp	WhatsAppScr_Message_*Date_ImportantStakeholder_TopicDiscussed*

	WhatsAppScr_Audio_*Date_ImportantStakeholder_TopicDiscussed*

3. Ethics

The data supplier receives an informed consent form in which he/she gives permission that their responses to interviews and out-loud-thinking procedures are recorded with audio or video and/or are written down. The data will encompass the data supplier's daily life, behaviour, wishes and worries.

The data and personal details will be anonymised. Furthermore, the data collection methods are clearly described in the project's brochure and what kind of data will be gathered from these methods (recordings and text) are elaborated upon during a first meeting. If new data collections are introduced, the researcher will ask permission from the data supplier first before using this data collection method. If there is data from the data supplier that appears to be useless for the project, the data will be erased. The user can also only give permission for some of the data collection methods and can ask for further information regarding a data collection method is this is needed. The user can withdraw given permission at any time.

Furthermore, any use of video or photo, verbal or other forms of personal expression recorded during this experiment will only be used for communication purposes (such as presentation at conferences) after explicit informed consent by the persons in question.

After the project is completed, all data will be erased from camera's, computers and USBs. However, it must be saved for an additional of five years on a secured database at the university. The data supplier is informed about this. The data on the database will be anonymised and will only be accessible for the responsible researchers that were mentioned on the informed consent form. However, the data supplier can choose to give other employees of the university and third party Karakter access to the data as well. This is an option, though. During the project, data will be stored on the mobile phone of the responsible researcher, which is secured with a password. Data will also be stored on an online database called SURFdrive, which is secured with a password as well. Initially, only the researchers mentioned on the informed consent form have access to this database, unless the data supplier also gives access permission to university employees or Karakter as well. If one of the stakeholders that had access to this database decides to stop participating in the project, their access to the database is cancelled.

4. Storage and Archiving

As mentioned in the previous section, data during the project is stored in a secured database called SURFdrive, for which the expenses are covered by the responsible researchers. After the completion of the project, aimed to be on the 7th of July, 2018, used data is saved for five years on a secured database at the university.

Appendix C.1.: Interview Analysis Gerd – Initiation

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
User: Gerd
24-04-2018

In the database, this interview can be found as:
Audio_Interview_24-04-2018_Gerd_InitiationInterview

Description: In this initiation interview, the second contact was established between the researcher and the potential participant, in which primarily the challenges caused by autism were discussed. The interview approximately takes 15 minutes. As stated, the main topic discussed is the challenges that are caused by autism in the life of Gerd. However, collateral information is collected as well in order to place Gerd's future feedback in better context.

Conversation Course: In the interview, Gerd immediately start with discussing in what way autism causes him to experience challenges. Firstly, Gerd explains that it often obstructs him when he needs to leave his apartment. He often does not pay attention when he needs to leave his apartment and then problems occur.

Subsequently, some demographic data is given. Gerd's highest education degree obtained is VMBO-T, which is the highest Dutch level of vocational education. While discussing the demographic data, one of the rainbow lights turns on, that was planned by Gerd in the interface. Gerd immediately remarks that the rainbow light is not brightening up long enough. He points out that, in his vision, the duration of the rainbow light can even be doubled or lasts for 10 seconds more. He says: "Overkill is better than underkill". To continue with the interview, the researcher asks about the facility where Gerd is staying. In Dutch, it is called *Beschermd wonen*, which is literally translated to *Protected Living*. It basically means that Gerd is living semi-independently with a supervisor available if needed. When asked a possible profession, Gerd states that he currently without a job, as he stays at the *Dagbesteding*. Again, a Dutch term that refers to a daily occupation that people with cognitive disabilities often need to participate in in order to receive social securities. Gerd also explains that he is searching for a so-called *leerwegtraject*. This is some sort of an educational course.

Subsequently, the researcher asks about activities that have proven to be problematic for Gerd. The researcher was prompted to ask this, because during the first meeting on the 19th of April, Gerd failed to give full disclosure on this topic and responded to the question with: "we will find out". This time, Gerd gives some disclosure, though. He explains that he has difficulties with getting somewhere on time, prioritizing things and adhering to agreements in general, such as adhering to appointments made.

The researcher then asks if Gerd has already been using any prior application that can help him with overcoming these challenges. However, he has only been using the agenda on his mobile phone. This often does not work as he tends to forget to look up appointments that he put in his agenda. Afterwards, the researcher addresses a question that was previously asked by Gerd the Friday before: what will happen with the system after

completion of the project? Gerd then confirms that he hopes that the system is the small extra push that helps him to conduct the to be conducted activities.

The following topic discussed again discusses the living context of Gerd. It becomes apparent that Gerd is living there with multiple people with a shared kitchen and a shared bathroom. Subsequently, Gerd returns to a question asked earlier about prior applications that have helped him with attention and organization in the past. He explains that he has used an application that has helped him before with organizing his finances and then he shows an application that did not have anything to do with attention and organization, but what he rather just wished to show the researcher.

The next question is then raised by the researcher. It is asked what a typical day of Gerd looks like. Gerd explains that he stays at the Dagbesteding from 11:00 to 16:00. Afterwards, he does his daily groceries. In the evening, he often catches up with friends where they switch cooking chores. Subsequently, the supervision of Gerd is discussed. He has his own personal supervisor that he meets once a week for one hour. Aside his personal supervisor, he receives support from his parents that help him with organization and attention. Subsequently, the researcher receives permission from Gerd to get in contact with his supervisor. He does not, however, gets permission to get in contact with his parents.

Interesting Points: In the interview, it is clearly clarified that Gerd is limited because of the autism. The biggest challenges experienced by him are problems with being somewhere on time, prioritizing and adhering to agreements made. The latter would be demonstrated by Gerd himself as he failed to show up on a meeting planned the next Monday. He told the researcher that he had no recollection of a planned meeting, even though the meeting had most definitely been planned and was even mentioned a couple of times in the days prior to the meeting.

The challenges caused by autism also influence the social behaviour of Gerd, which can make the co-design process quite problematic. It has already become quite clear that pragmatism and flexibility are two terms that need to be considered whilst co-creating with Gerd. The problems with social interaction has already become clear during the first interaction the Friday before, a meeting that was accompanied by Shireen. In that meeting, Gerd expressed his discontent with the fact that he had troubles with flirting with girls and he felt bad for still being a virgin, expressions that would not have been made if Gerd had understood the inappropriateness of it in this social context.

Appendix C.2.: Interview Analysis Adam – Initiation

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
User: Adam
18-04-2018

Description: The interview, that took approximately 30 minutes, was not recorded. Therefore, it cannot be found in the database. The reason why it was not recorded was because it was the first meeting in which the researcher decided to present himself in an informal way, instead of already start with presenting as an academic. Notes were made though, as well as an elaborate description in the logbook. In this interview, the focus is mostly on Adam's personal experiences with autism, but some initial thoughts on MyDayLight are shared as well. The objective of the interview was to find out if Adam could be useful as a user in the project.

Course Conversation: The conversation starts with demographic information about Adam. He is 20 years old and is currently following a study program at the applied university. He lives with his parents and is single.

According to Adam, his is not experiencing too much challenges because of autism. It is most certainly not limiting him in conducting his daily activities, not even in attention and organization. If the spectrum of autism would be divided by the extremes of *no challenges* and *a lot of challenges*, Adam would definitely be at the start of the spectrum. If there are any challenges, Adam mostly describes them as an abnormally-high immersion in an activity. Furthermore, he often forgets to plan time to relax as well, as he plans his days until they are completely filled.

Adam is not using any application to support him with getting out of his immersion – or hyper focus if you will – or telling him to keep spaces open in his days for relaxation. He is also not supervised by a professional supervisor, nor does he have professional interventions in which he discusses the experienced challenges. The most important person to discuss the effects of autism with someone is his mother. His mother, for example, occasionally confronts him with his overly planned days. If there is an application that he uses to plan his activities, it is only the calendar application on his mobile phone.

When asked about activities, Adam stays quite abstract, but he exemplifies it by saying that he might have made an appointment with friends even though he is already busy. The researcher then asks whether or not he also experiences difficulties when such an appointment is cancelled, as this is one of the more commonly-known challenges caused by autism. Surprisingly, this is not something that Adam experiences. He explains that he can reason why someone would have cancelled an appointment.

After discussing autism and the personal challenges of Adam, the initial thoughts on MyDayLight are given. Firstly, it is explained and introduced by the researcher. The first remark that Adam makes is that he already senses that it might not work for him, as having solely a rainbow light brightening up might not notify him strongly enough to conduct a planned activity. He does seem to be very interesting in the product and also shows enthusiasm in working with the researcher. He explains that he had a negative experience prior to this one in working with another student on another application aimed to support people with autism. The girl he worked with was not talkative at all and left him in the dark during multiple occasions.

Naturally, the goal of the interview was to discuss to what extend Adam might prove to be useful in the project. Even though both Adam as the researcher can think of creative means for which Adam might want to use MyDayLight, he does emphasize that he cannot see himself becoming the main user – for now. Therefore, the researcher and Adam agree on giving him an advising role, rather than giving him the role of a user.

Appendix C.3.: Interview Analysis Toby – Initiation 1 (1)

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
User: Toby
30-03-2018

In the database, this interview can be found as:
Audio_Interview_30-03-2018_Toby_FirstMeeting

Description: This conversation, that takes approximately 50 minutes, was not steered by a semi-structured interview per se. However, during the interview, the researcher did try to cover some relevant topics related to the project and related to Toby as a person. In the end, the majority of the time, the LGBT community and policies revolving around this community were discussed. This was clearly a common interest and was therefore used a discussion material to make sure the potential user and the researcher got closer.

Unfortunately, Toby, being a transgender young man, was undergoing his transition surgery one month later and had to cancel his participation due to this reason after this interview was conducted. Nevertheless, the conversation with Toby, as it was recorded, is analysed nonetheless to provide additional information to his case study.

Conversation Course: The conversation kicks off with the researcher giving an explanation on MyDayLight, what is is, what goal it serves and what it consists of. Furthermore, the researcher explains what his research objective is. While doing this, he explains his research questions to the user.

Subsequently, Toby discusses his role as experience expert and explains his interest in LGBT policies. The researcher, subsequently, discusses his own experience in LGBT policies, as he had been conducting a research into the stereotypes revolving around members of the trans collective. This then enrols in a discussion of the hobbies of Toby: singing, ice skating and costume events.

The next topic is discussed is the common experience for working for the McDonalds, where both the researcher and Toby have worked. They discuss the work atmosphere, career development and ethics regarding working for McDonalds. Regarding professional work, Toby also shares his negative experiences regarding working in a call centre, where he experienced difficulties in needing to be manipulative in order to increase sales.

After discussing work ethics, the conversation returns to LGBT issues, but this time Toby discusses his own LGBT history. It appears that he first identified as a lesbian woman, then as a pansexual woman and he then realized that he never felt like he was gay or pan, but always believed he was straight. He then presented himself to the world as a transgender man. Subsequently, he connects his own gender to sexual education in high schools. The researcher and Toby seemed to agree on a lot of issues regarding different treatments of gay and transgender people by some people. Toby also shares an intriguing story about his boyfriend, Jonathan, who is also a transgender boy. Toby explains how some people thought he contaminated his former girlfriend in becoming a transgender boy as well. Toby continued

with experiencing negative and stereotypical comments that he encountered following coming out as a transgender boy. He did this with a sense of humour, though.

The following topic discussed, again in relation to LGBT issues, was the discussion whether a gay man or a lesbian woman has the most privileges among all members of the LGBT collective. Both agree that gay men still experience the most violent behaviours, but women still face sexism, despite their sexual orientation or gender. Toby can especially share insightful experiences regarding this topic, as his transition went from a girl to a boy. Regarding the transition, Toby criticizes the commotion he witnesses in an online vocal sharing platform where people who are transgender – and have not yet changed their voices – and non-binary feel discriminated because their voice does not fit in the box of the gender they identify as. Furthermore, the controversial comment of football critic Renee van der Gijp regarding the outing of Belgian news reporter Beau van Spilbeeck as a transgender woman. It is discussed how far satire can go; what are the boundaries? Lastly, the relationship between transgenderism and gender neutrality are discussed.

Interesting Points: It is apparent that this conversation was not focussing on Toby as a being on the autism spectrum. However, reading the course of the conversation, it becomes quite quickly apparent what kind of character traits Toby has: he is opinionated yet nuanced, assertive, quasi-nonchalant and a clear sense of cynicism can be identified in the way Toby speaks of things. He is also reflective, smart, critical and he explores the sense of justice. He could also be described as realistic and sincere.

At this moment, Toby is undergoing some drastic changes in his life. This might have to do with the autism spectrum, as people on the autism spectrum have a larger percentage of LGBT-members among them as people not on the autism spectrum. Apparently, it is more common for someone with autism to have a less common gender or sexual identity.

Regarding Toby's possible participation in this research, it becomes more apparent in the analysis of the next interview if he would be the right user to test it with - if he experiences significant challenges in attention and organization. However, a practical matter excluding him from the research could be the fact that his current transition is becoming too distractive or even obstructive. However, there is still some time to figure this out. Good communication between Toby and the researcher is important for this matter.

Appendix C.4.: Interview Analysis Toby – Initiation 1 (2)

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
User: Toby
30-03-2018

In the database, this interview can be found as:
Audio_Interview_30-03-2018_Toby_DiscussingautismandAttentionAndOrganization

Description: The previous interview conducted with Toby was not steered by interview question. This was due to the fact that this meeting was not supposed to be very formal of nature, but rather to get to know each other a little bit better. Nonetheless, in this interview, the focus is a little bit more on his experiences as a person with autism. During this meeting, Toby has been asked to explain and exemplify what challenges he experiences because of autism. The conversation, that takes approximately 35 minutes is recorded and provides insightful information that adds to his case study as one of the potential participants.

Unfortunately, Toby, being a transgender young man, was undergoing his transition surgery one month later and had to cancel his participation due to this reason after this interview was conducted. Nevertheless, the conversation with Toby, as it was recorded, is analysed nonetheless to provide additional information to his case study.

Conversation Course: When asked about the challenges with autism that Toby experiences, he automatically emphasises that having autism does not occupy him. He explains that is is simply a part of him, just as his gender identity. He explains that he introduces himself to people as Toby that *has* autism and not Toby that *is* autistic. In his opinion, autism is not what defines him as a person. He also explains that he is not that far on the autism spectrum.

Subsequently, Toby starts with explaining how he notices that autism is influencing him. Firstly, he explains that he notices autism in social contexts; he often gets irritated, he is very much interested in patterns of the social behaviours of others and he tells that he is often interested in what people *mean* when they say something; what do they imply with what they are saying? Furthermore, Toby explains that he has become quite good at understanding who someone is based on their social behaviour; he explains that he even understands this before the actual person himself understands it. He explains that this can be problematic: he has the feeling that other people also have this same capability and automatically can understand him as well. He exemplifies this by saying that he assumes it is understandable when he randomly gets up out his chair to go to the toilet. However, this randomness is often misunderstood by the people with whom he is. Some things that are logical for him and he believes he should not have to explain these things, even though they are not as logical as for others.

At this moment, Toby's boyfriend enters the room. Toby explains that his boyfriend, named Jonathan, can maybe add valuable information as Toby might fail to include information that he believes is not so strongly characterized by autism – even though it is. The first thing that Jonathan mentions as something he believes is characteristic about

autism and influences Toby is *hyperfocus.* Toby explains an important aspect of his challenges: when he starts with something, he cannot stop with conducting this activity until it is finalized. If he quits with it midway, he will never continue with it again. Therefore, this activity will be neglected if conducted this way. However, Jonathan adds that, when Toby is conducting an activity without interruptions, he tends to forget basic things such as to eat and to sleep.

Subsequently, Jonathan takes the word to describe a personal issue she experienced with Toby's autism. He recalls when she wanted to make it implicitly clear that he needed some time for his own, stating that he was going home to make a sandwich. Toby did not understand this, because the sandwich could easily be made at home. Jonathan then stated that he did not have time for it that morning, to which Toby responded that Jonathan could have made the sandwich the night before. Clearly, he wasn't hearing what Jonathan tried to tell him. He could only hear the literal meaning of what Jonathan was telling him; he failed to read between the lines as he failed to understand the social interaction between them at that moment. Toby compared Jonathan's statements to what he believed was logical, not to what the social desires of Jonathan could have been at that moment – to be alone for a second.

Toby then describes that having a strict routine is not one of the challenges that he experiences because of autism, which is slightly surprising as autism is often accounted for causing this. Toby, on the contrary, does not have such a strict routine. Furthermore, Toby explains that he is not limited by having autism, as he knows other people with autism that are not functioning because of it anymore.

At this moment in the conversation, the researcher takes the word and asks if Toby wants to share something that explicitly involves attention and organization. Toby then basically repeats what he stated before: if he quits with something midway, he fails to pick it up again after a period of time and he starts to neglect that activity. He exemplifies this with the dirty laundry: if he doesn't address the dirty laundry instantly, it all just piles up until it is one big mess. And while the pile is getting bigger and bigger, the threshold of picking it up again only becomes higher and higher. He also explains that the dishwasher is a god's gift for him, as he used to just pile up all the dirty plates until it was one big pillar that he would not start cleaning again.

The following topic was the fact that Jonathan had continued with an episode on Netflix that they had started with together. Toby, on the contrary, thought that they were going to watch the episode together. It was very logical for Toby that Jonathan would have told him that he was going to watch it independently, even though, in the eyes of Jonathan, this was not logical at all.

At the end of the conversation, the researcher tries to summarize the challenges that Toby is experiencing: he always acts in the most effective way possible – even though the social context requires a different way of acting – and as soon as he neglects an activity, he does not pick it up again anymore. Toby gives another example: one time, he had 8 trash bags on his balcony because he neglected to bring away the first bag. At this moment, he needs someone to push him to do something or he needs someone that suggests to do something together.

Interesting Points: Toby confirms what Jelle had already made clear: that people with autism do not consider themselves to *be* autistic, but rather to *have* autism. Probably, this has something to do with the fact that people with autism can feel ashamed about having it. They do not want people to think that it defines them, nor that it determines what they do.

Regarding Toby's challenges with autism, it can be summarized that he wishes to do everything in the most effective way and that he cannot re-start with something when he decided to neglect an activity. The fact that he wants to do things in the most effective way also influences social interactions. He cannot understand that someone else wishes to do something in a way that is not the most logical and effective way of doing it, neglecting the fact that this person simply wants to do something in a way that might not be the most effective, but is the most desired one at that moment. Furthermore, Jonathan mentions that Toby is sometimes negatively affected by being overly focused on something. He needs

quite persuasion to get out of this focus. This has already caused him to stay up all nights in participating in music platforms. Two weeks later than this interview, it would also become clear that Toby was not able to receive me at his place, as he had not slept for 38 hours in a row due to this hyperfocus.

A third interesting point is the fact that he cannot neglect activities, as he will not pick those activities up again until it has escalated. Shireen once told me he didn't clean his dirty plates up to the moment where he had to throw it all away and went to a store to buy new plates. This is, naturally, a serious and costly issue.

To already presume how MyDayLight could and would work for Toby, it becomes clear that it would have to work in such a way that it takes him out of his focus – it should grasp his attention – and it needs to notify him when to do certain activities in order to make sure he doesn't neglect this activity.

Appendix C.5.: Interview Analysis Shireen – Iteration 1

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
Advisor: Shireen
26-04-2018

In the database, this interview can be found as:
Audio_Interview_26-04-2018_Shireen_CommentsOnMyDayLight

Description: In this interview, that takes approximately 30 minutes, the researcher discusses the preliminary feedback provided by Gerd after the first two days of testing MyDayLight. Furthermore, Shireen is asked from her expertise to reflect on concerns regarding the effectiveness of the system, the co-design trajectory and preliminary means for which MyDayLight might prove to be useful. autism and its challenges are central topics throughout this interview.

Conversation Course: The conversation starts with the researcher asking Shireen what her job is at Karakter, centre for child- and youth psychiatry. Shireen replies by saying she is project leader for innovation. Subsequently, it asked what the connection is with Gerd. Shireen replies that she does not yet have a connection with him as he is not a client of Karakter. However, when the previous potential user in the project had to withdraw his participation, she asked a young man with autism if he new anyone that could possibly be interested in participating in this research. Via him, it had gotten to her attention that Gerd would be someone that was willing to participate. The first time she saw Gerd was together with the researcher at the appointment the Friday before. When asked about Shireen's role in this project, she states that she considers herself to be an advisor and a facilitator. Furthermore, she aims to support the researcher in finding his way in the world of autism and in analysing qualitative data. She calls herself a sparring partner.

The researcher then asks Shireen if, to her knowledge, there would already be something where the usage of MyDayLight would be useful. Shireen replies negatively: autism is a spectrum and it cannot be more personal for what means users would want to use MyDayLight. Some people on the spectrum would need MyDayLight to keep their attention in place, whereas other would need it for the opposite. They need to have their attention taken away from something. Some people need to bring structure to their life and some need to deconstruct it. Some people also might to use it for trying new things. She exemplifies this with the disability to stop gaming. She concludes that she cannot already think of means for which MyDayLight could be used. She also expresses that this is what she likes about the project: ideally, at the end of the project, those means are better identified. Thus, as it clear as the challenges are already recognizable, it is not yet clear how MyDayLight can provide them with a clear and unique way to overcome these challenges. Shireen also expresses that talking to multiple users would enrich this research. The researcher subsequently shares a personal story on why he believes user-centred research

in the area of telemedicine is of paramount importance. Shireen also expresses how she, as psychiatrist, used to be *afraid* of technology, but she now sees that it is nothing to be scared of and it is also something that everyone has to deal with, whether they like it or not.

Another question that is posed by the researcher is whether or not the researcher already has concerns about the system not being able to become effective. Shireen replies positively. She things it is a pity that it is not portable. It is attached to the home situation. Furthermore, she believes that is would be better if there was a live connection between the interface and someone monitoring him. She believes the strength of connecting people can be very important. Shireen also starts thinking out of the box and mentions an intelligent functionality where the user can interact with the system. If the user then fails to conduct an activity, they can share with MyDayLight why he is failing to do so. A conversation should be possible. Subsequently, quite off-topic though, Shireen explains that she found it moving to see the interaction between the researcher and Gerd. The researcher, being of similar age, was clearly working hard towards an ambitious future, whereas Gerd was clearly limited by having autism.

The researcher then asks Shireen what he needs to consider whilst co-creating with users with autism. It can be advice. Shireen then explains that the researcher also has to consider the effect that the research can have on Gerd. In this way, the researcher is also functioning as a supervisor as he is having interventions with Gerd. The latter should also be clearly-described in the thesis. Lastly, Shireen explains that it is important that the researcher must not address unrealisable design opportunities proposed by the user with a negative approach, but rather a nuancing approach. Shireen then recalls Gerd expressing during the first meeting that he really wants to flirt with girls and have sex. Instead of instantly saying that the lights would not be appropriate to help him with achieving this, it should be wondered if the lights *really* would not be able to help him with flirting. Shireen then states that it could be, for example, planned in the interface that everyday at a certain hour he needs to go onto the streets to find a girl and flirt with her. The researcher than implies that this is something to steer the user towards, but also mentions that such steering would really become an intervention. Shireen explains that it depends per user how much the user needs to be steered into a certain testing behaviour. The researcher then mentions that, through an intervention, it should also be clearly considered how much of the changed behaviour in organization and attention at the user's side is due to MyDayLight and how much is due to the intervention-characterized conversations held with the researcher. This is a piece of qualitative research that should be clarified in the thesis. Shireen, however, advises a steering and slightly-subjective role for the user in the research.

The subsequent topic that arises is the communication between the researcher and the user. Shireen and the researcher anticipate what effect the communication could have on Gerd. Naturally, it could be the first time that Gerd will have contact with someone at least every day. Will he like it or will he not? He did seem enthusiastic during the first meeting, though, both Shireen and the researcher agree on this. The researcher supports this claim that he started with using the system instantly once it got installed in his apartment.

The next topic that arises is a personal idea by the researcher: instead of having an intrusive tune installed as the extra notification, the user should have the freedom to simply record whatever they wants. This could be the voice of a supervisor; it would be very natural in the user's context and add the MyDayLight as being designed for embodied empowerment. The researcher also shows a first interface of his design idea. Shireen seems to be very enthusiastic: it is very personal! The researcher, by the way, justified the idea of adding sound to the interface by having a previous conversation with Jelle in which it was discussed. Arjan, Toby and Gerd had all already mentioned that sound would be added value to the system. This is something that has to be analysed, though.

Interesting Points: An interesting topic cut into during this interview was the question whether or not MyDayLight could be an appropriate system for activating Gerd into flirting and meeting girls. Such an activity perfectly resembles the necessity of this research: it is completely open for what means MyDayLight could be used and an activity such as flirting

could definitely not have been though about before hearing it from Gerd himself. On top of this, is it also not yet clear if MyDayLight could, in fact, be an effective system to support Gerd with this activity. During the interview of the 25th of May, when a reflection conversation is finally conducted, this topic is cut into. To lift the corner of the veil: Gerd does not at all seem willing to use the system for such means.

Appendix C.6.: Interview Analysis Arjan – Iteration 1

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
Advisor: Arjan
08-05-2018

In the database, this interview can be found as:
Audio_Interview_08-05-2018_Arjan_ReflectionsOnGerdsFeedback

Description: Arjan, as advisor, was asked to reflect on the feedback that was provided by Gerd on the first prototype. In this interview, that takes approximately 30 minutes,

Conversation Course: The interview kicks off with Arjan explaining why it was quite difficult to schedule this reflection meeting: he had his entire day already fully-occupied. He suggests himself that this is one of the challenges that he experiences because of autism. As he had stated in the first interview conducted, he often leaves himself too occupied in such a way that he would like someone or someone to tell him sometimes that he needs to relax a little bit.

Subsequently, when Gerd is introduced, Arjan asks the researcher whether or not he thinks it is annoying that Gerd is being problematic in the communication. The researcher responds by saying that it is indeed annoying – especially that time when Gerd did not show up at an appointment -, but naturally, as one of the characteristics of autism, it should be accepted, understood and dealt with. Subsequently, the researcher introduces the how-wow-now matrix that was made after Gerd's test session. The researcher emphasises on the rainbow light and the fact that Gerd mentions that he potentially would have a sound in order to indicate him more strongly that he needs to start doing something. The latter is understood by Arjan, who expressed his concerns regarding MyDayLight at the first interview already: if the light is out of the field of view, it fails to indicate that the user needs to do something. However, Arjan adds to this that sound can be a very personal preference. In his opinion, he would probably prefer not to have a sound as it can scare him when he is very busy. Furthermore, when he is listening to music, he is afraid that sound might not have an effect on him.

Afterwards, the researcher introduces an idea that was his own initiative: recording your own notification. The researcher justifies this idea by saying that this would be much more natural as sound than an intrusive buzzer. Arjan agrees with this. Interestingly, Gerd had pointed out that he would prefer a simple buzzer over his own recording. Arjan suggests that it simply something that has to be tested with Gerd in order to find out whether or not he likes the idea of recording something on his own.

Subsequently, after discussing Gerd's feedback primarily, the researcher introduces his how-wow-now matrix. This starts with a brainstorm thought of recording a sound for every individual light. Each recording could be set for each activity. Arjan, however, addresses this idea with a critical mind. In his opinion, having the ability to record a sound for each light would not be necessary if a speaker is connected to each lights, which is something that should be thrived to realize. The researcher than thinks out loud how the idea of Arjan could

be transformed into a prototype. The researcher then agrees with Arjan that the sound should be coming from the light and that it is not necessary anymore to have a sound recorded by the user for each individual light. Furthermore, Arjan expresses that he does believe a sound, even though he showed scepticism, could be very useful when the user is in one room and the light is in another room. In his opinion, this could make the inclusion of a sound essential.

The next topic discussed are the activities that he planned with the system in the presence of the researcher and where he put the lights for these activities. It had become clear to the researcher that Gerd put the lights at places where the activities were set to be conducted. If there was no clear location – such as leaving the apartment – Gerd put the light within his field of view. Arjan explains that he would probably use the system in the same way: putting the light at the location of the activity. The problem, as discussed before, is the fact that the light is probably put mostly in the field of view as it will not be noticed if it is not. Arjan asks the relevant question that it should be found out what should be done with the system in order to trigger Gerd enough to make him start doing something. Maybe, a sound could be working for him, suggest Arjan.

Quite suddenly, Arjan also thinks of a potential downside of a recorded sound that he had not though of before: if a sound is recorded with the voice of a supervisor that is telling him to do something, and this recording plays when the user has friends over or lives together with other people with autism in a semi-independent living facility, it might enhance the shame that the user might feel for having autism. The user might not want to have the others know explicitly about their challenges in attention and organization by hearing a voice literally telling the user to do something like some sort of *mother*.

Subsequently, Arjan expresses the necessity of a user-friendly/autism-friendly interface, as people with autism might require special interface needs and/or might have a lower intelligence than others. Arjan also suggests that the supervisor can play a significant role in explaining the interface and the system to the user.

After discussing the interface swiftly, Arjan asks the researcher how it is possible that the user knows for what activity they had previously set a light ready to brighten up. Both Arjan and the researcher conclude that it is best to place the light at the location of the activity and that a sound can be used to make the light more noticeable – especially when the activity is not set to happen within a short period of time and the user might have forgotten about initiating this activity along the way.

The interview is finalized by the researcher asking whether or not Arjan would also like to become part of the project as tester, rather than only as advisor. Arjan responds positively and a meeting is planned on the 10th of May.

Interesting Points: The struggle within Arjan to both support and oppose sound for MyDayLight is interesting: he is positive about it as an extra actuator to push the user to do something and he thinks it could be valuable when it comes to having the light in another room or set for an activity that is not supposed to happen within a short period of time. On the other hand, he expresses how it would not be ideal for himself, as he often gets scared up by it or would not hear it as he often plays music.

Overall, Arjan proves to have a valuable role as advisor within the project. He is very outspoken and provides valuable insights with a critical view that could definitely not have been discovered by the researcher himself. Arjan clearly knows better what the desires and/or challenges are in co-creating with people with autism and this is a valuable asset. Furthermore, Arjan proves to be able to not only reflect the usage of the system on his self, but also on people that are positioned differently on the spectrum; people that might be more limited or not.

Appendix C.7.: Interview Analysis Adam – Iteration 2 (1)

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
User: Adam
10-05-2018

In the database, this interview can be found as:
Audio_Interview_10-05-2018_Adam_ReflectionsOnMyDayLight

Description: In this interview, that takes approximately 20 minutes, Adam has tested the original MyDayLight system. In the other interview conducted in the same afternoon, the interview reflects on the first prototype designed by the researcher in which sound is added as well as a longer rainbow light is brightening up. In this interview, the reflection is not on the system being tested over a few days in the user's natural context, but rather on one intensive test session, as the latter was preferred by the user.

Conversation Course: The conversation starts with the researcher explaining the set-up from the test session: what activities have been done in the test session and where have the lights been placed? The researcher then asks Adam how he was using the system mentally. This can be: as a notification system, as a game or a reward system, among others. Adam replies that he sees MyDayLight as a notification system in the first place, but also – what he seems to describe – as a big stick that ensures he is not neglecting his to be conducted actions. He describes MyDayLight as not only telling him to do something, but also as something that he wishes to follow dedicatedly. Adam then expresses that he can see other users wanting to use MyDayLight to teach them how to improve planning and keeping attention over time.

Subsequently, the researcher asks Adam how he would use the system physically. Where would he put it? Adam explains that he would put it next to himself initially – and to use it for activities, such as leaving on time for an appointment, in case he loses track of time. This is because he is afraid to miss the notification otherwise. Built upon this, the researcher asks what he would do with all seven lights. Would he put them all next to him? Adam explains that only using one light would be more effective for him. Furthermore, Adam even explains that using multiple lights would have a counter effect: he would be occupied whether or not he still knows where he has put all the lights and/or if he still has all of them. This would only distract him. The researcher then notes that the locations of the lights for Adam differ from the locations of where the previous user wished to place him. The previous user, namely, wished to place the lights at the location of the to be conducted activity. Adam explains that this has to do with the fact that he would miss the notification if the light would brighten up out his field of view.

The next question that is asked by the researcher is whether or not Adam appreciates the system for its purposes. Fortunately, Adam replies positively. He appreciates that the system triggers the user in a different way than for example a mobile phone application – or simply the mobile phone alarm clock. In his experience, he would simply start doing different things on the phone than only setting an alarm clock for an activity to happen. MyDayLight

does not allow such distraction. In conclusion, Adam expresses that the 'organization' part of MyDayLight is working perfectly, but there are still some design opportunities to find in MyDayLight. The first one being that a light brightening up is not really noticeable if it not in your field of view. Adam asks a justifiable question: what does it take for MyDayLight to grasps someone's attention. For Adam, only a light brightening up is not enough. To add to this discussion, the researcher calls in sound. As he has heard this numerous times before, from Adam himself as well, it could be an interesting extra asset to make the lights more noticeable. However, both the researcher as Adam agree on sound being a delicate topic, as it will be difficult to find the right balance between noticeability and subtlety. If the sound is too noticeable, it can be perceived as intrusive. If the sound is too subtle, it might have no extra effect on notifying the user to do something. This is especially a difficult topic for autism, where the spectrum would not steer the designer into a certain sound direction, but noticeability and intrusiveness are very relative. Adam explains that he would need more than only a light brightening up to notify him to do something, but an intrusive sound would, on the other hand, only scare him. He would not appreciate it.

Subsequently, Adam and the researcher discuss the design opportunities for MyDayLight. Firstly, Adam sees the addition of sound as the ability to place the lights on locations other than next to himself. Furthermore, Adam sees opportunities in connecting the MyDayLight interface to the mobile phone as well. This would make the system easier and faster to use. To add to this discussion, the researcher tries to explain *embodied empowerment* to Adam. He believes that Adam could be able to understand this design goal and brainstorm further on it. Related to embodied empowerment is the researcher's own idea to add the opportunity to record a sound and have to go through the speaker when a light is brightening up. This recording could be, for example, the voice of a supervisor and this could be the closest to the natural context of the user. This reminds Adam of a subject he has at school: studies of happiness. He explains that people mostly have two different voices speaking in one's head: a good voice and a bad voice. Naturally, the good voice prompts the user to undertake ethically-just actions whereas the bad voice prompts the user to undertake ethically-unjust actions. Adam explains that the researcher's initiative corresponds to the good voice that one hears in his head. Thereby, he approves the idea to explore this idea. It could be that such an own recording could be perceived less intrusive, but more effective at the same time.

Lastly, Adam explains that he would also like to see MyDayLight as a portable system, which is an idea that was brought forward by Shireen during a previous interview. Both Adam and the researcher agree that, in light of embodied empowerment, attaching the system to the body could enhance the embodiment.

Interesting Points: Before diving into the contents of the interview, the first interesting point is the fact that Adam declined to offer to use the system for more than one afternoon testing session together with the researcher. Adam explained that he was not in need of such a system, and therefore, he did not want to test it for a longer period of time. However, after having the first interview together with Adam, the researcher and Adam already agreed on the fact that there could be some occasions where MyDayLight could, in fact, be proven useful. After discussing this paradox, Jelle explained that this could have to do with the shame that is experienced by some people on the autism spectrum. They are ashamed to acknowledge their challenges and, thereafter, they pretend not to experience any challenges. However, in case of Adam, this is a mere hypothesis. It could be true that he indeed does not experience challenges in attention and organization to the extend that he believes it would be worth testing the system on his own for a couple of days.

Another interesting observation was to see how Adam was using the system. Instead of placing the lights at the locations of the activity, which was how Gerd had been using the system, he put solely one light next to him. He foresaw that he was going to miss the light otherwise and decided to already respond to this limitation. It appeared that, if the notification was strong enough, he also would have chosen to put the lights at the location of the activity.

Lastly, it appears that Adam understands the concept of embodied empowerment and also how a sound recording could add to this concept regarding MyDayLight. Just as Shireen, Adam appears to have positive thoughts on the exploration of this idea. Therefore, this will definitely be a part of the next prototype.

Appendix C.8.: Interview Analysis Adam – Iteration 2 (2)

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
User: Adam
10-05-2018

In the database, this interview can be found as:
Audio_Interview_10-05-2018_Adam_ReflectionOnUsageOfFirstPrototype

Description: This interview, that takes approximately 15 minutes, is the second interview of the afternoon of the 10th of May. In this interview, Adam and the researcher reflect on their test session with the prototype form the first iteration and compare it to the original version of MyDayLight initially. This prototype has sound added to a notification and it has the rainbow light brightening up for a longer period of time.

Conversation Course: As for the previous interview, the conversation starts with the researcher explaining the set-up of the test session. Once again, Adam and the researcher have conducted two activities. The first one being a conversation in which Adam is immersed in such a way that is is difficult for him to de-focus his attention. The second one is boiling water in the kitchen. The objective of this set-up, as it was with the previous set-up, is to orchestrate an activity that ensures immersion from Adam's side. This corresponds to the challenges that he experiences that are caused by autism. By choosing these set-ups, it will become clear to what extend MyDayLight can be useful in supporting him with attention and organization.

Subsequently, the researcher asks his first question: do the changes in this prototype add to the effectiveness of MyDayLight being a system that supports attention and organization? Adam replies positively. In his experience, he gets triggered faster because of sound than because of a rainbow light. This is a personal thing, though, as he acknowledges that sound could be a problematic notification for some people on the spectrum. Therefore, Adam proposes the option to have it possible to both use sound as to not use sound. This should be chosen by the user. Subsequently, the researcher asks the user to give his opinion on the decision to have a doorbell as the sound that was used at this moment for notifying the user to start with the planned activity. Interestingly, this sound was not chosen wisely, as a doorbell can be associated with unexpected visitors, which could be experienced as incredibly unsettling by some people with autism. Adam confirms this. Adam does acknowledge the fact that such a sound does grasp someone's attention.

The latter is a dilemma, of course. Naturally, MyDayLight was designed for embodied empowerment, not for persuasive technology. Having an intrusive sound is not at all fit for design for embodiment and could not be considered more persuasive. On the other hand, Adam explains that, one way or the other, it is essential that the user's attention gets grasped. Otherwise, the system has no value to the user. This does not mean that Adam does not appreciate only having light as notification. He explains that people with autism often experience problems with being touched and hearing intrusive sound. Therefore, it is inarguable that there should always be the option to only have light without a sound. In

conclusion, the researcher and Adam summarize the conclusion as having solely a light as most user-friendly, but having a sound as most effective. It is required to find the perfect balance between these two extremes.

Adam does not see only negative sides of intrusive sounds as he does not believe an intrusive sound could automatically not be appreciated. In his opinion, a user with autism is willing to accept an intrusive sound when they believes that the end justifies the means. Adam proposes that the user should decide for theirself how intrusive the sound should be for a planned activity. Adam exemplifies this with a driver's lesson and doing the dirty dishes. In his opinion, it would be accepted by the user if they would have an intrusive sound go off when they has a driver's lesson planned as this is a rather important activity. However, when the dishes need to be done, it would be understandable if the user chose a less intrusive sound. Of course, doing the dishes is not as important as showing up at a driver's lesson.

Building on this, the researcher jumps to design opportunities. He asks whether or not the intrusiveness of a sound should be a variable in choosing what sound to go off. Adam suggests two more variables: duration and volume. By adding these variables, the intrusiveness of sound is not only determined by the character of the sound, but also two other variables. By doing this, the user could, for example, decide to have a subtle tune go off, but for three or for times in a row. Lastly, Adam expresses that he still wonders how a recording would be appreciated in notifying the user that they needs to do something.

Lastly, the user brings up the longer duration of the rainbow light. This is clearly appreciated by Adam. He believes the user should have the time to see the rainbow light brighten up. He also suggests that some sort of feedback to the system could be appreciated. For example, the user could press something on the light that would make the rainbow stop brightening up. For now, Adam suggests to make the rainbow light turn on for even a longer period of time.

Lastly, Adam opens up another discussion: can the disability of the user to plan activities obstruct effective usage of the system. For example, until now, the research has assumed that the user can calculate the importance of certain activities, the duration and the impact. But if the user cannot do this independently, how is it assured that the user can even properly work with MyDayLight? Is a supervisor necessary for teaching the user how to plan? Again, this is a personal matter. The interview is then concluded with Adam stating that it has encompassed all his thoughts and proposed design opportunities.

Interesting Points: Again, before diving into the contents, it is slightly noticeable that Adam primarily reflects on the usage of the system whilst reflecting on other hypothetical users with autism, rather than on himself. However, throughout the interview, this interview character has naturally been steered towards.

As Adam is a very outspoken, opinionated and intelligent young man with autism, his feedback is very clear, constructive and detailed. This is very useful in determining next prototype requirements within a co-design process. He goes that far that he thinks of variables that should be possible in a next prototype, rather than leaving all the design thoughts at the researcher. Naturally, it is the researcher's task to include the user in the design process and prototyping phase as well, but it becomes apparent that Adam does not need much steering or persuasion to cut into that topic.

Appendix C.9.: Interview Analysis Shireen – Iteration 2

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
Advisor: Shireen
14-05-2018

In the database, this interview can be found as:
Audio_Interview_14-05-2018_Shireen_ReflectionOnAdamsFeedback

Description: This interview, that approximately takes 35 minutes, was part of the usage opportunities and appropriation phase (Phase 2) of the second iteration. In interview was requested by the researcher in order to understand better the feedback given by Adam on the prototype developed in the first iteration, to place it in context, to add information to it and to retrieve answers to questions raised by the feedback. The main topics discussed are MyDayLight evoking intrinsic motivation, the role of the supervisor in supporting this and general feedback on the prototype from the second iteration.

Conversation Course: The interview starts with discussing how Arjan had experienced the prototype, and in particular the added sound. Shireen expresses that she understands that sound can be a valuable aspect of the capturing the user's attention. The researcher recalls a moment during the test session where he accidentally made the wrong light go on – the one without sound – and he did not notice the fact that it was brightening up, even though it was in front of him. Adam, however, did see the light go on but decided not to tell the researcher in order to proof a point he had made earlier: without additional indication aside solely a rainbow light, the user will not be triggered enough by the system to start conducting the activity that they is supposed to do after the rainbow light brightening up.

Afterwards, the researcher shows the how-wow-now matrices to Shireen to demonstrate how the interaction opportunities are captured. Shireen notices that it is not mentioned that the system could be made in such a way that it could help Gerd with flirting with a girl – a desire he had expressed in his initiation interview. Shireen did not understand that the matrices were solely for software- and hardware opportunities.

The following topic discussed was the feedback that Adam gave regarding a design opportunity that he described: to only have the rainbow light stop with showing when feedback is given to the system that it has been noticed. Shireen expresses that this is a good idea, but the researcher makes his doubts noticeable: when feedback is needed to system, then what is it that distinguishes MyDayLight from other applications such as mobile applications. Furthermore, placing this potential solution in the context of Toby who easily neglects activities: if the rainbow light doesn't stop showing, can it not become easily negligible and lose its entire effect? Shireen expresses that this could indeed be true, but involving a supervisor in this process could ensure that the system could be used effectively. The supervisor, for example, could ensure that Toby was going to use the system the way it should be used. Maybe, whilst knowing that someone is monitoring you, Toby could use MyDayLight in the way it is supposed to be used.

Subsequently, the feedback of Adam on the design opportunities is discussed, where the researcher explicitly asks what Shireen things of the suggestions that Adam gave regarding a compatible sound system. The researcher expresses that sound could make the system more effective without giving the user a more active role. He recalls that the system is not designed to be persuasive in a way that is noticeable by the user, but the system should push the user to do something without them really noticing it. This opens up the discussion between the researcher and Shireen regarding embodied empowerment. Shireen then mentions that a sound system could also be very useful for Toby, as she believes sound would be more effective in taking Toby out of his focus than solely a rainbow light. When the researcher asks whether or not Shireen suggests anything else to the sound system as it had been described by Arjan, she says no. She suggests that it is more than enough to realize his feedback into a new prototype and test it out again.

Shireen then introduces a new topic: personal intrinsic versus extrinsic motivation. By doing this, she introduces an interesting topic that is related to maybe the fundament of embodiment. Shireen explains that the involvement of the supervisor is an important element of the user's intrinsic motivation. The supervisor could be the person that implements MyDayLight into the user's world in such a way that it triggers the user to conduct certain activities in an intrinsic way. Shireen believes that it takes interventions with the use to make them see why they should try to use MyDayLight in such a way that is effectively contributing to his capability to keep at attention at- and organize activities. She also explains that this is her issue with embodied empowerment, the design perspective in which MyDayLight was designed: a system cannot steer users into a direction of attention- and organization improvement without interventions. She explains that in order to have MyDayLight intrinsically motivate users to conduct certain activities, the users must already have been made clear why it is important in the first place to be motivated to conduct these particular activities.

Adding to this, Shireen emphasises that the researcher himself also plays an important role in making sure that the system is used properly for its purposes. The researcher, subsequently, forms the hypothesis that maybe the co-design process is essential to an effective usage of MyDayLight; potentially, if the fully-developed prototype was delivered to a user without having a co-design process prior to it, the system would maybe not have been used at all. Shireen tries to exemplify her thoughts with the desire from Gerd to flirt with a girl. Shireen mentions that he definitely intrinsically motivated to flirt with a girl, but he simply doesn't know how to do this. Through an intervention, for example by the researcher giving tips on how to flirt, Gerd could start using the system to help him how to flirt. For example, he could use MyDayLight to plan going onto the streets to find a girl to flirt with. For the latter, he does need to know, though, how to flirt in the first place. Both Shireen and the researcher conclude that the usage of the system is connected, without doubt, to the previous conversation held with the supervisor/researcher.

The interview ends with Shireen expressing, once again, her concerns with the embodied embodiment as design perspective that needs to change the behaviour of people with autism. She believes strongly in the role of a supervisor as essential element of evoking intrinsic motivation at the user's side. Only with the presence of a supervisor, or at least someone that is steering an intervention, the system can be used effectively.

Interesting Points: Surprisingly, this interview has not resulted in a new how-wow-now matrix as Shireen simply did not have any further input. She exemplifies once again how outspoken Adam is; he describes the suggested design opportunities in detail and he is not afraid to say what is on his mind. He also shows the capacity to reflect on the design opportunities and argue what interaction possibilities should be possible with MyDayLight to make it also work for other people with autism.

The majority of this conversation was about the effectiveness of MyDayLight as being a supporter of embodied empowerment. Shireen clearly showed scepticism towards MyDayLight as a device changing the behaviour of people with autism intrinsically – which is also the reason why she presents herself as an advocate of sound inclusion. Shireen, as

psychiatrist, emphasised the importance of supervision and interventions in the usage of the system. I her opinion, the supervision is what triggers the desire to change, and without such supervision, the system will not work effectively for what it is supposed to do. This prompts the researcher to take a more supervising role in the co-design process as well. If they desires to have MyDayLight being tested properly – that is, also to analyse the effectiveness of MyDayLight's embodied empowerment – the presence of interventions and supervision is essential.

Appendix C.10.: Interview Analysis Gerd – Iteration 3 (1)

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Unstructured Interview Analysis
User: Gerd
25-05-2018

In the database, this interview can be found as:
Audio_Interview_25-05-2018_DiscussingMyDayLightAndSecondPrototype

Description: In this interview, that takes approximately 30 minutes, Gerd and the researcher reflect back on the first prototype deployment phase held from the 24th of April to the 30th of April. Aside the findings on the new prototype, it is also discussed how the co-design iteration proceeded in the first iteration.

Couse Conversation: The conversation starts with the researcher asking Gerd whether or not he had appreciated the system for its purposes. Gerd explains that he found it a funny device – which is a positive thing – but he had not used it a lot. Gerd explains that this had to do with the fact that he was away from home quite often and MyDayLight is an at-home device. Subsequently, the researcher recalls where Gerd had been putting the lights and asks why he had put them at these locations. Gerd explains that he found these locations to be good reminders of the activity. When the researcher asks if these were the locations where the activities would set to happen, Gerd confirms this; the light would become part of the location.

The following question relates to the mental framing of MyDayLight. The researcher asks Gerd what happens when a rainbow light brightens up; does it activate him, or it is solely giving him a notification? The latter is true, according to Gerd. Gerd also emphasises, when asked by the researcher, that conducting an activity pointed out by MyDayLight did not give him a rewarding feeling.

Subsequently, the researcher jumps to the means for for MyDayLight might be used by Gerd, recalling the personal challenge of Gerd that he has problems showing up at appointments. Gerd then explains that he does not believe MyDayLight could be effective in waking him up, but he does believe it could be used for this purpose. This leads to the feedback on design opportunities that Gerd had been giving throughout the prototype deployment phase of the first iteration. The researcher explains that this has elaborately been included in the second prototype and asks he want to have a look at it later on. Gerd replies positively. The researcher then takes the system out of the suitcase. Gerd has emphasised earlier that he didn't want to test out the system elaborately this afternoon, and therefore, only the sound interface was shown and tested out.

To start with, the researcher first recalls that Gerd has stated he would love to have a sound played with each notification. The researcher also explains that during the prototype deployment phase of the first prototype, user Adam had expressed that he would not immediately appreciate such a sound being played. Subsequently, the researcher starts explaining the second prototype. When told that Adam believed the doorbell as a default tune was badly chosen, Gerd confirms this and explains that he would have chosen a simple

beep. Afterwards, Gerd and the researcher go through all the different tunes that are not optional in the *audio* slider. When asked how the system operates, Gerd explains that he appreciates the interface. When asked if Gerd would use all the different tunes, he explains that he would doubt between the second and fourth tune. The next thing discussed is the recording button. Gerd explains that he thinks it is funny, but finds it too distractive over the other tunes. The researcher recalls the criticism towards the recording option expressed by Adam and asks if Gerd can understand this criticism. Gerd explains that he does completely. To built upon this criticism, and a conversation held with Jelle on the 17th of May, the researcher explains that the criticism might be related to some of the users wanting to hide their challenges; that they are ashamed of it. Gerd explains that it is true that some of the people on the spectrum might be ashamed of it, but he states that he has mostly accepted it himself. Subsequently, coming to design opportunities for the next iteration, Gerd explains that he would get rid of the recording button and would add more options in choosing what kind of tune is played. Lastly, Gerd expresses that he finds the interface user-friendly.

Building upon Adam's feedback from the previous iteration, the researcher now asks what Gerd would think of a feedback system where the user needs to let the system now it has seen the notification. Gerd confirms that he sees potential in it and suggests that the light should brighten up for five minutes and the user has to let the system know within these five minutes that they has seen the notification. By doing it this way, the system allows the user to process it calmly. The researcher subsequently states that feedback to the system could also be achieved without changing MyDayLight's software or hardware, but simply agreeing with the supervisor that a mood has to be uploaded for each activity. If such a mood has not been uploaded for a certain activity, this can be understood as the user not having conducted this activity. However, this would include the supervisor in the process, but the most important reason why Gerd would use this system is to become more independent. Gerd explains that this does not mean that the supervisor can be discarded in total.

Subsequently, the researcher recalls the previous day, where the researcher had been waiting for approximately an hour in front of Gerd's door without being able to wake him up, regardless of ringing the doorbell multiples times and calling him on the phone. Gerd then lets the researcher hear what he normally needs to wake him up: a chaotic rock tune. Gerd explains that if MyDayLight was going to function as him alarm clock, he would need such a tune.

The following topic discussed is something Gerd had said during the first meeting they had had together: Gerd did not like the fact that he had difficulties with flirting with girls and he did not like the fact that he was still a virgin. Later on, Shireen had stated that she though MyDayLight could potentially also be used in such a way that it could help him to flirt. For example, which is also explained to Gerd, the MyDayLight interface could be used in such a way that it tells him everyday at two o' clock to leave his apartment and find a girl to flirt with. However, Gerd explains that he would still find it very difficult to flirt with girls, even while using MyDayLight as a big stick. The researcher then asks it if would make any difference if his supervisor or his mother would support him while using MyDayLight for this purpose. Gerd explains that he doesn't know if this would make any difference.

The conversation concludes with discussing the testing procedure. Gerd and the researcher agree that a collaborative test session would be a better testing procedure than letting Gerd test the new prototype completely on his own. Gerd and the researcher make an appointment to have the new prototype tested more elaborately at the activity centre Dac Ten Kate (Dagbesteding) to following Tuesday, on the 29th of May.

Appendix C.11.: Interview Analysis Gerd – Iteration 3 (2)

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Unstructured Interview Analysis
User: Gerd
29-05-2018

In the database, this interview can be found as:
Audio_Interview_29-05-2018_TestingPrototype2AtDagbesteding

Description: In this interview, that takes approximately 15 minutes, Gerd and the researcher test out the second prototype in a collaborative session. The focus is on the the sound interface that had been created in response to Adam's feedback.

Conversation Course: This interview starts with the researcher describing the set up of MyDayLight at the activity centre where Gerd usually stays during the afternoon. There is one deficit in the set-up, as the internet does not seem to work. Therefore, it has to be staged that the lights are working, as agreed upon by Gerd and the researcher. The researcher pretends to be the computer connecting MyDayLight's interface to the speaker by pressing a button on the laptop that makes a sound play. The researcher is located at the bar of the activity centre and Gerd is sitting on a sofa a couple meters away.

The first tune being played is the least intrusive one. This is the gong. Gerd does not really find the gong effective. When the researcher increases the gong volume, though, Gerd sees this as an improvement. The second tune, a bicycle bell, should be considered more intrusive. However, Gerd finds this less intrusive than the gong. Again, when the volume is increased, it is becoming more intrusive. Gerd also expresses that he finds this tune less pleasing to hear than the gong.

The researcher then decides to recall something Adam had said during the testing session for the second iteration: a user is willing to accept an intrusive tune if this is the most effective tune for an important activity. Gerd agrees with Adam on this matter. Subsequently, the third tune is the doorbell that was considered overly intrusive as Adam in the previous prototype. Gerd, on the contrary, claims that he finds this tune the most pleasing to hear. The researcher then decides to put the volume on its maximum value. This is not appreciated by Gerd.

The next part of the test session includes the possibility to record an own track. During the latest interview with Gerd on the 25th of May, Gerd had explained that he needs a very intrusive rock tune to wake him up. Over the past days, the researcher had thought about using the recording button not to record the voice of a supervisor anymore, but to record the tune Gerd uses himself to wake up. Gerd agrees with this plan. He takes his phone and plays next a tune next to the laptop's microphone that he finds effective. He calls this tune an *annoying* tune. After the tune has been recorded, the researcher makes it play on the laptop. When asked what Gerd thinks of this, he finds it to work effectively. Gerd also shows the researcher how he uses a game to wake him up, alongside the intrusive tune: whenever the intrusive tune plays, he needs to solve a game in order to make the sound turn

off. Gerd also explains that it never gets annoying to the extend where he simply stops using this method. When the researcher asks if such a game would also work for MyDayLight, Gerd replies positively. This would require a more active role for the user, though.

The researcher also returns to the design opportunities Gerd had expressed on the 25th of May, where he had stated that he wants to have more options in choosing what kind of tune to play. He expresses that he has not changed his mind on this. Gerd expresses no further design opportunities.

Appendix C.12.: Interview Analysis Arjan and Erna – Iteration 3

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
User: Arjan & Erna
01-06-2018

In the database, this interview can be found as:
Audio_Interview_01-06-2018_Arjan&Erna_TestingAndDiscussingPrototype2

Description: In this interview, that takes approximately 50 minutes, the researcher demonstrates the usage of the second prototype to autism coach Erna and advisor Arjan and discusses it with them afterwards.

Conversation Course: The conversation starts immediately with discussing the prototype after the third tune, the reception bell being angrily pushed on, is played. The researcher asks Erna and Arjan what they believe is the variable that determines mostly how intrusive the sound is. Erna explains she believes it is mostly the association that the user has with that tune. Moreover, Arjan explains that it is also the repetition frequency of the tune that matters. Erna adds to this that she wonders if a tune that has an overly high repetition frequency evokes resistance or a blockade at the user's side. Erna and Arjan both agree that there probably is a relationship between these two elements.

Subsequently, the second tune is played. This is the bicycle bell. They agree that this one is less intrusive than the reception bell. Still, they believe an intrusive tune works more effectively than a tune that is not intrusive. They acknowledge, though, that such a persuasive design was not the initial design goal for MyDayLight. Erna, however, also acknowledges that an intrusive tune can have a counter effect: it can result in the user simply freezing and not being able to do anything anymore. Erna and Arjan subsequently agree on the fact that is is very personal what a user would prefer as a tune. Therefore, as a design opportunity, Erna suggests that a more elaborate choice menu, in which the user has more options for the tunes, could be a solution. Erna suggests that a category in such a choice menu could consist of bird tunes, animal tunes or musical instruments.

Subsequently, Erna asks the researcher if it becomes apparent what Gerd has thought about the sound when it was being tested with him in the week before. The researcher explains that it had become apparent that Gerd had been appreciating the addition of sound as it evokes the right sensorimotor coupling for him. Erna, who is known to the theory around sensorimotor couplings explains the researcher that for some people on the spectrum, it can take half a year or even longer before they has developed the right sensorimotor coupling that could work for them. After discussing how sound works for Gerd, Erna and Arjan do wonder if the rainbow light still has any effect on Gerd. Having said this, Erna also acknowledges that the rainbow light should be included nonetheless, as there will be a significant amount of users not appreciating the sound. They argue that both options should be possible.

Subsequently, the researcher explains how he got the idea of recording the alarm clock tune that always works very effectively for Gerd. Erna agrees that the opportunity to

record a track is a valuable asset. However, she does believe that the sound interface, with all the options, should be integrated in the main interface. The researcher explains why it is not yet fully-integrated as there are two different programming languages used that communicate with each other. Erna suggests that it one interface could be placed into the other interface – a screen within a screen – make it look like it is one integrated whole. The researcher explains that he will ensure that Erna's proposed design opportunity will be documented in the next how-wow-now-matrix.

The researcher then introduces the feedback option that was brought forward earlier by Adam: letting the system know that the notification has been processed by the user. Erna and Arjan can understand this design opportunity and speak positively of it. The researcher than presents the outcomes of an earlier conversation with Jelle on this topic. Jelle had expressed that the idea of giving feedback to the system could also be implemented without changing any of MyDayLight's software or hardware, but simply using the current system in a way that allows giving feedback. The researcher explains that the user could, for example, set a mood for each conducted activity. If the user has not done this, the supervisor will know that the activity was not conducted. Furthermore, the user must be convinced that they should try to have a mood colour displayed in the interface for each activity. Arjan expresses concerns about such usage. This would require a more active role without having a reason to have such a role. Furthermore, the mood colour would lose its purpose.

The introduction of colour triggers Erna to show a colour card. In her opinion, MyDayLight contains too many colours that can be set as a mood. She explains how four distinct colours create a circular spectrum of moods: blue, green, orange and red. Blue stands for a state of freezing, green for a state of relaxation, orange for a state of excitement and red for a state of stress and panic. From the state of stress, people can end up in the state of freezing where they cannot do anything anymore. However, from the state of relaxation, they can become so relaxed that they also end up in the state of freezing. From this state of freezing, it takes a huge amount of activation to get out of that zone again. Erna emphasizes that the circular spectrum is becoming the dominating mood figure above the traditional pyramid figure. Erna suggests that, if the colour is truly determined to capture the user's mood, it should only be possible to select the four colours of the spectrum, instead of the entire rainbow spectrum as it is possible right now. Erna also emphasizes that current children with autism get taught that these four colours represent those four moods. Thus, MyDayLight would be instantly related to what they have learned as a child. Arjan agrees with this. Erna also explains that decreasing the colour options to the four mentioned colours would make it easier to understand the mood that the user had chosen and also to recognize clearer patterns between when the user chooses which colour; the colours would become more meaningful than they are now. For example, by recognizing a pattern in the colours, the supervisor could identify that the user's medication needs to be more or less intensified. Subsequently, Erna exemplifies how the circular spectrum is currently used and taught in the coaching of a 7-year old boy that she is supervising. According to Erna, the inclusion of the circular spectrum in MyDayLight's design is easily-justified as it follows from the ABC theory that was developed by TEACH, a prominent organization in the United States that focusses on autism treatments.

To take a step back to the idea of a feedback system, the researcher explains that agreeing to solely set a mood as feedback might be problematic when the activity set in the interface is not an actual activity, but more of a simple notification. Then the 'activity' would happen outside the residency and it would become difficult to upload a mood.

Furthermore, the researcher recalls the personal challenges that Toby has and exemplifies them to Erna and Arjan. Erna then explains that she has the feeling that the diagnosis of autism and the subsequent coaching of Toby had come far too late, which is indeed true. Toby's autism was diagnosed just before he turned 18. To connect the story of Toby to the feedback idea, the researcher expresses his concerns that he has the feeling that this would probably not work for Toby; if he forgets to press the button one time, he will neglect to do that afterwards. Arjan understands these concerns. Erna states that, for Toby, it would be important that there is intrinsic motivation needed to activate him, which correlates

to what Shireen had explained on the 14th of May. Erna, Arjan and the researcher agree that a feedback system would not work for Toby, as this would evoke solely extrinsic motivation.

Erna explains that, after hearing the different stories, she sees multiple functionalities in MyDayLight: supportive, alarming and notifying. The researcher mentions that such mental framing is also something he wishes to identify as a research objective. The researcher also explains that he wishes to find out how the system is appreciated, to wish both Erna as Arjan respond that there is a big group on the autism spectrum that would be in need of the system. Erna also explains that she believes that users which solely ambulatory or no supervision would especially appreciate the system, as MyDayLight would replace a part of the supervision. The researcher then explains that this is, in the end, also the goal of the system as a reaction on the controversial ABA treatment that believes autism is curable. This system would not try to cure autism and improve the lives of the users in the end. Erna is familiar with ABA and also opposes it. She believes ABA follows from the stigma revolving around autism.

Erna exemplifies the latter with referring to a significantly big group of people with autism that is a fan of trains. She believes that for them, having a train broadcast signal as notification could work effectively to grab their attention. However, some people would argue that it should not be allowed to use such a trigger to activate this group. Erna disagrees with them: if it works, it works. Arjan sees resemblance between this example and Gerd's case. The researcher then connects this story to the phenomenological term of the lifeworld, the world as it is experienced by the user. Arjan, Erna and the researcher agree that it is important that MyDayLight is personalized to correspond to this lifeworld.

The following topic discussed is the method that could be adhered to for gaining insights on design opportunities regarding MyDayLight. Erna suggests that a focus group with young adults could be a promising method, but the researcher explains that it is hard to find participants that are willing to test out the system. Erna explains that it also could be the way Karakter approaches the potential participants. Maybe they have already been convinced to participate in other projects, and they are no longer prepared to participate in a project such as MyDayLight. This corresponds to Gerd not wanting to share information with Karakter, as he believed Karakter was connected to the GGD, an organization that he not spoke positively of. Erna also explains that, throughout the years, she had noticed a certain resistance from people with autism towards organizations dealing with autism (such as the GGD and Karakter). At the moment, Erna and Shireen are discussing to change the autism treatments, to make them more tailored and individual. This will take a couple of years, though. This topic concludes the interview.

Appendix C.13.: Interview Analysis Corné – Iteration 3

MyDayLight: the development of a co-design process involving participatory design and co-evaluation

Semi-structured Interview Analysis
Supervisor: Corné
26-05-2018

In the database, this interview can be found as:
Audio_24-05-2018_Corné_DiscussingGerdAndautism

Description: In this interview, the researcher is finally able to conduct a long-awaited interview with Corné Stolzenbach, the personal supervisor of Gerd. In this interview, that takes approximately 35 minutes, Corné discusses Gerd's challenges that are caused by autism and connects it to prior experiences with Gerd from the researcher's side. Furthermore, it is discussed how Gerd's usage of the system can be placed, explained and justified within the context of his challenges.

Course Conversation: The interview starts with asking some demographic data about Corné. The first thing asked is what profession Corné has. He explains that he is personal supervisor within the RIBW (Regionaal Instituut voor Beschermd Wonen), which is the *Regional Institute for Protected Living*. Within his profession, he supervises clients of the RIBW in their development. Some of the tasks involved are teaching people how to live independently, how to organize finances and/or how to make people feel better about themselves. The majority of the residents of the RIB has an EPA (Ernstig Psychiatrische Aandoening), which is a Severe Psychiatric Condition.

The subsequent question is whether or not Gerd only has Corné as supervisor, or if there are multiple supervisors. Corné explains that he is the only supervisor that deals with the living conditions of Gerd, but he is also being supervised at the Dagbesteding to develop skills that he could use for a profession. There is also a reserve supervisor for Gerd if Corné is not present.

The next topic discussed are Gerd's personal challenges. The researcher mentions that Gerd had told him that the most striking challenges were coming on time, prioritizing and adhering to agreements made. Corné confirms this. The researcher also mentions that Gerd does not seem to talk about these challenges in detail and asks Corné if this has something to do with the shame surrounding autism. This is confirmed again by Corné. Corné also explains that Gerd has been staying with his mother the past two weeks and out of a conversation with his mother, it had his mother become apparent that Gerd has troubles with closing a day. Therefore, he cannot fall asleep until 3 or 4 o' clock on the sofa. A negative consequence of this is the fact that he often fails to show up at meetings the morning after. Out of the conversation that Corné had with his mother, it also appears that Gerd cannot fall asleep at night because he feels unsafe at night. This is also where the shame comes from. When the researcher mentions that Gerd had not told him this, Corné explains that, although Gerd is not unintelligent, it could be that he simply does not have the ability to look at himself with such a critical mind that he could have drawn that conclusion himself. The researcher

adds to this by mentioning that Gerd had not given permission to the researcher to get in touch with his mother.

The following topic cut into is the problematic communication between the researcher and Gerd so far. The researcher mentions that this probably has to do with the challenges caused by autism. The researcher also mentions that he already has been standing in front of a closed door, with Gerd saying he could not remember having made an appointment, even though it had already been mentioned several times. Corné then starts telling a relevant anecdote: he also had to plan a meeting with Gerd on the the same day as this interview. Gerd had told Corné that he could meet him at 11:00. However, Corné was aware of the fact that Gerd has also planned a meeting with the researcher at 11:00. When Corné confronted him with this, Gerd proposed to meet at 11:30. However, Corné was also aware of the fact that the meeting with the researcher would take 1.5 to 2 hours. Gerd then stated that he must have put this wrongly in his agenda.

Building upon this anecdote, the researcher asks the valid question whether the communication- and organization problems are truly caused only by the challenges caused by autism, or if there is also a problem with Gerd's willingness to participate. Corné states, being completely honest, that it is a problem of both. Corné acknowledges that autism naturally causes him to be limited in some ways, but he also acknowledges the fact that Gerd has had a reputation of being involved in quite some student projects, but then cancels his participation midway. This mostly happens when Gerd needs to start becoming actively involved. When the researcher asks why he often decides to stop midway, Corné, again being completely honest, mentions that he believes it is plain laziness that causes his cancelled participation. Corné also explains that the researcher, if he wants, can mostly certainly hold a mirror to Gerd to confront him with his behaviour. Corné even adds to this that he is sure it is more laziness that explains him not adhering to appointments than it is autism. The researcher then explains that he cannot hold the mirror to Gerd as he must try to keep Gerd part of the project. Corné, however, states that by holding a mirror to Gerd is maybe the only way to make sure that Gerd actually changes his behaviour.

The topic cut into subsequently, building upon the feedback provided by Corné, the researcher mentions the conversation he had had with Shireen, the advisor at Karakter, centre for psychiatry for children and young adults. Shireen had mentioned in a previous interview that she also believes that the role of the supervisor and the interventions he brings along are indispensable for MyDayLight to become effective (the researcher also explains MyDayLight and the proceedings so far, including the inclusion of sound). However, although the researcher had mentioned this conversation because he thought that her opinion was quite equal to Corné's, Corné explains that he cannot find himself in this vision. Corné explains that he understands why she is saying this, but, in his vision, this would only mean that the supervisor would be working very hard to evoke intrinsic motivation at the user's side and the user himself would not have to do anything.

The next topic discussed is what the possible research outcomes could be. The researcher explains that the research methodology is research-through-design and that there is no concrete hypothesis towards the research is building up to. The researcher exemplifies this with stating how he had included sound in the prototype on ground of the user's feedback. Corné then, on its own, re-introduces the role of the supervisor into the topic: if MyDayLight would be used as an effective system for attention- and organization, the motivation to make it a success should come from the user and not from the supervisor. However, the researcher feels, at this point, that he misinterprets what Shireen had told the researcher and also tries to clarify this. He explains that Shireen simply had stated that by simply giving the system to a user, it would not be used. Therefore, according to Shireen, the supervisor should first make it clear to the user how valuable the system could be for them, prior or in parallel to using the system. This is something that Corné agrees with.

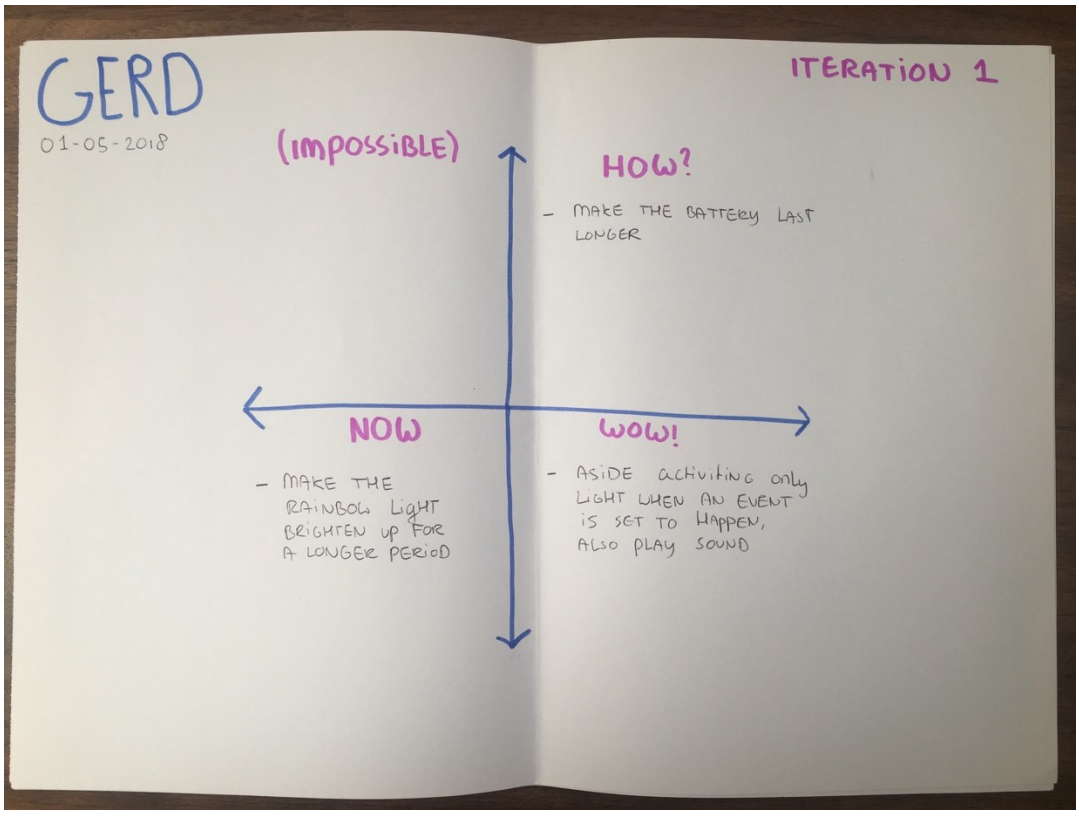
The researcher then asks Corné if he is aware of Gerd using or having used any other application to support him with attention and organization. The researcher also recalls asking this to Gerd himself, where he had responded to use the agenda on his mobile phone. However, since he was not looking at his phone too often, he often missed what he had put

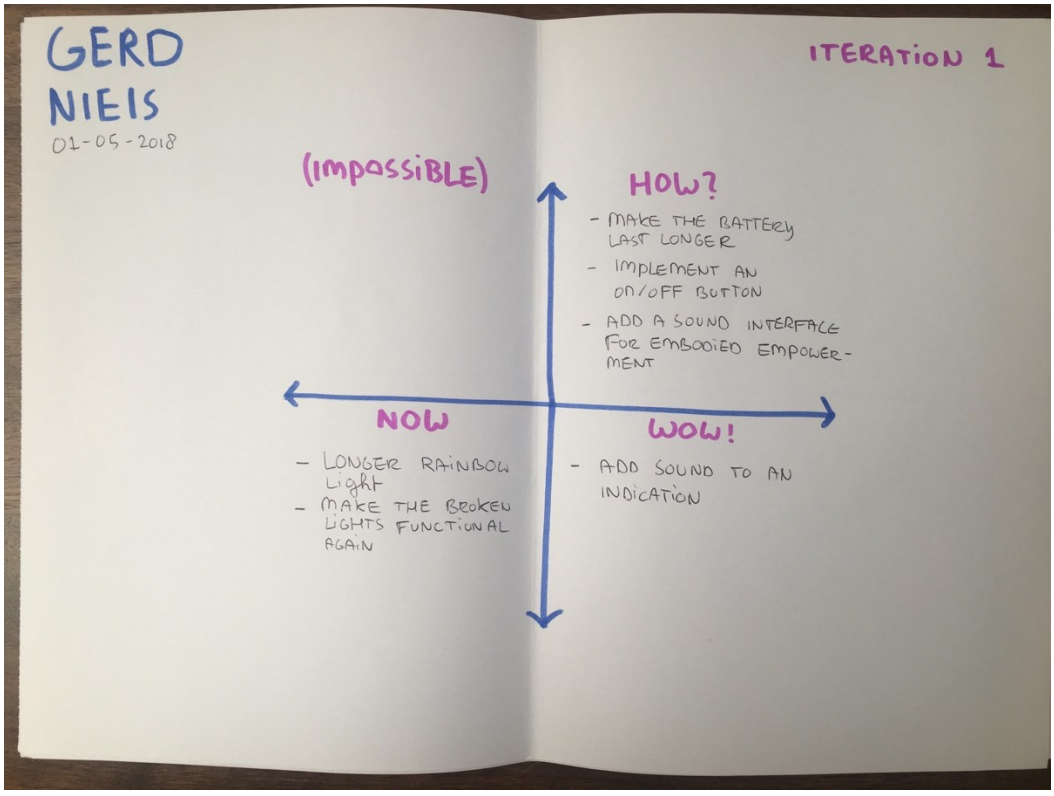
in there. This makes Corné laugh a little bit. According to him, Gerd is looking at his phone constantly. Interestingly, Corné explains how it sometimes feels that his phone has become attached to his hand. He also emphasis that this is typically Gerd. He then also shares that he is aware of Gerd using some kind of connection to the alarm clock on his phone and the speakers in his room to wake him up in the morning. Being brutally honest, Corné believes that *Gerd is taking a giant shit on* his agenda. He does mention that Gerd has good intentions though.

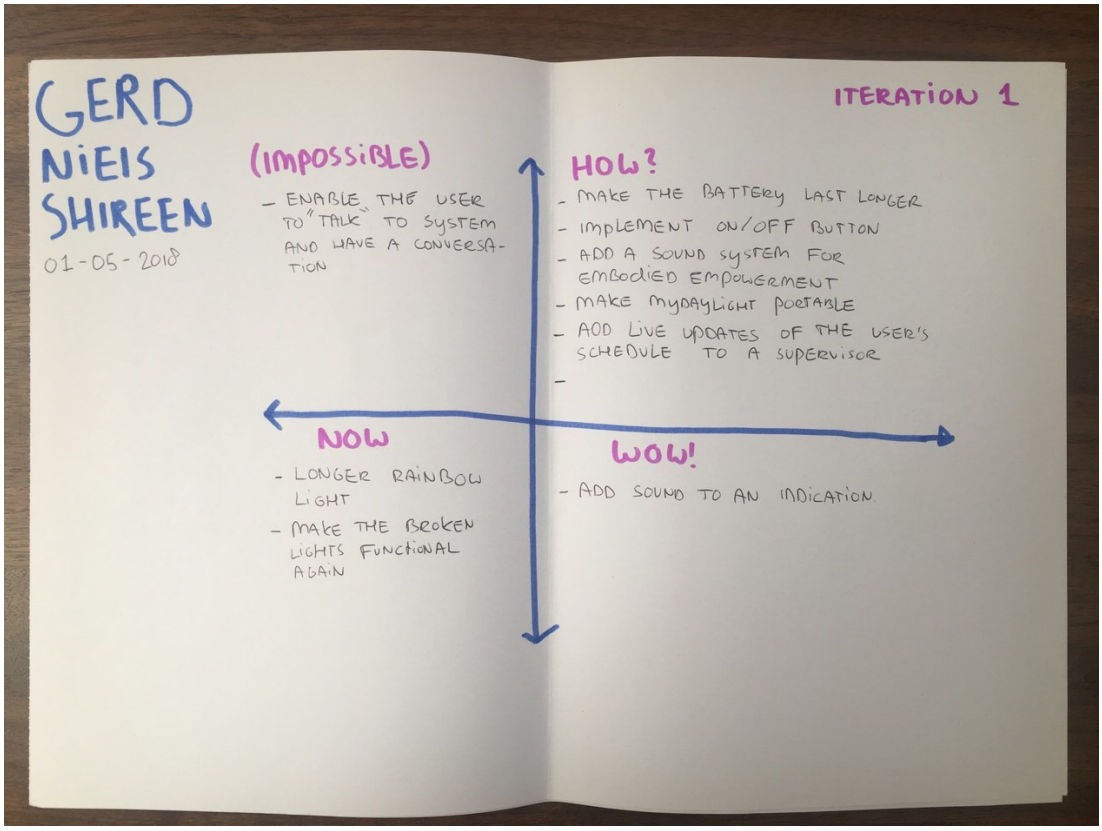
Corné then continues by stating that the researcher can be strict with Gerd to not mitigate his own time and efforts. Building upon this, the researcher shares a prior experience where Gerd and the researcher had agreed to make photographs of MyDayLight in use on the same day as when he had forgotten about the appointment. Even though Gerd was not present at his home, the researcher was still able to take home the system because of a supervisor living next door. When the researcher entered the room, Gerd had already disassembled the entire system and he put it all back in the box. Although speculative, this made the researcher think that Gerd must have been aware that someone was supposedly coming, as he maybe would not have disassembled the system already if he did not know this. Corné also believes that Gerd, in this case, must have known that someone was coming to collect the system and that he was lying blatantly. Corné also believes that this is typically Gerd and corresponds to what he has heard about Gerd during numerous occasions already from his parents and people that he worked with him in the past.

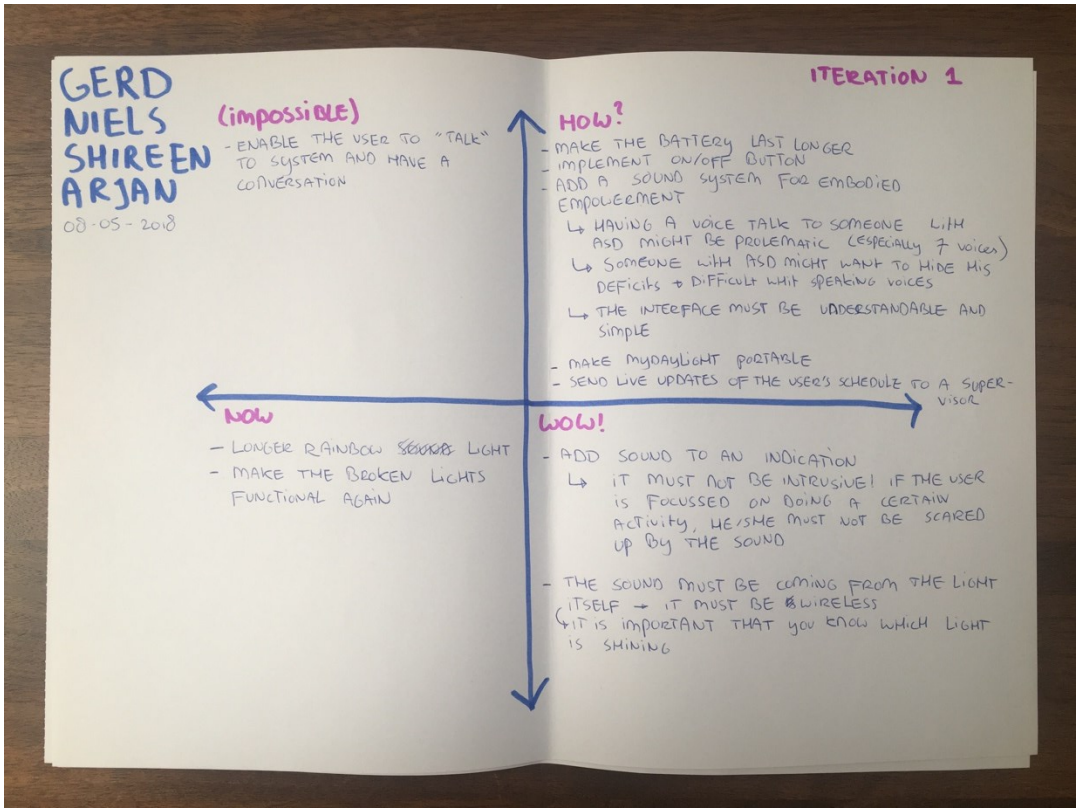
The next thing asked is what would be best for the future: leaving the system at Gerd's place and let him test it on its own, or organize an intensive test session together with the user. Corné believes the latter would be more effective and emphasises that the researcher, in this case, must also take an active role as supervisor. The researcher agrees that this is probably better than having Gerd use the system – as delicate as it is now – then leaving it at his place and have it tested by Gerd on his own. This also concludes the interview.

Appendix D.1.: HWNMs Iteration 1

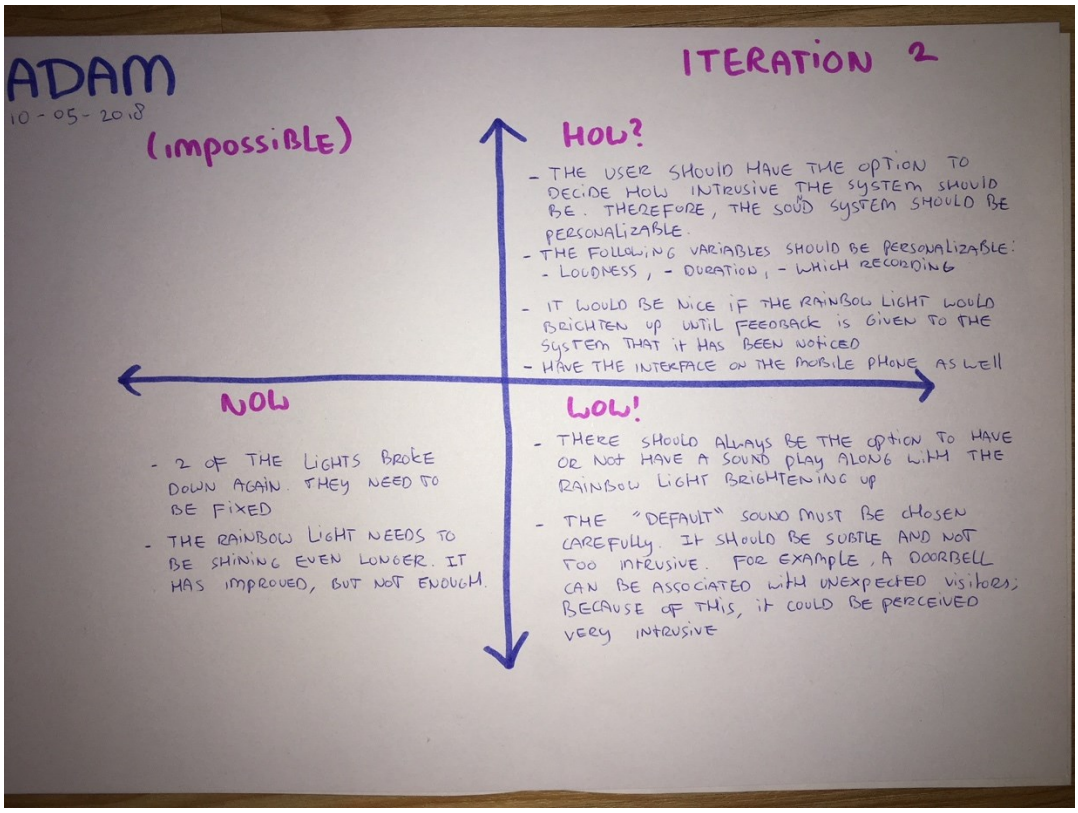


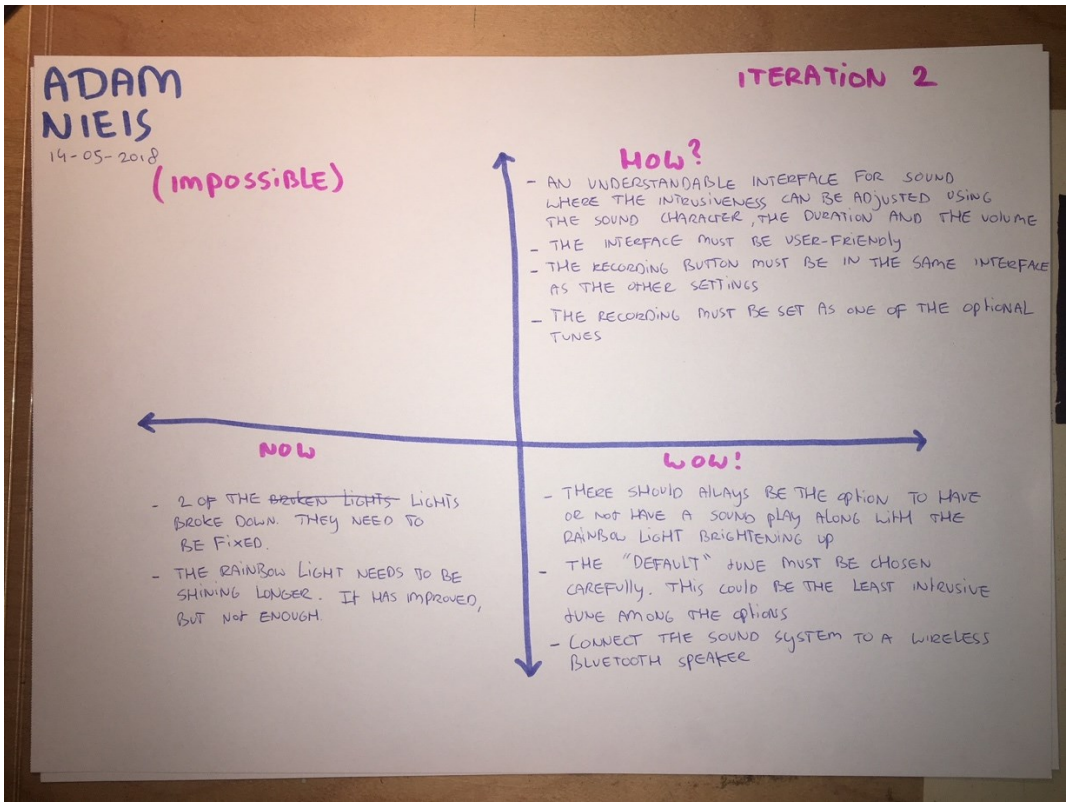



GERD
NIELS
SHIREEN
01-05-2018
ITERATION 1
(IMPOSSIBLE)
- ENABLE THE USER TO "TALK" TO SYSTEM AND HAVE A CONVERSATION
HOW?
- MAKE THE BATTERY LAST LONGER
- IMPLEMENT ON/OFF BUTTON
- ADD A SOUND SYSTEM FOR EMBODIED EMPOWERMENT
- MAKE MYDAYLIGHT PORTABLE
- ADD LIVE UPDATES OF THE USER'S SCHEDULE TO A SUPERVISOR
NOW
- LONGER RAINBOW LIGHT
- MAKE THE BROKEN LIGHTS FUNCTIONAL AGAIN
WOW!
- ADD SOUND TO AN INDICATION

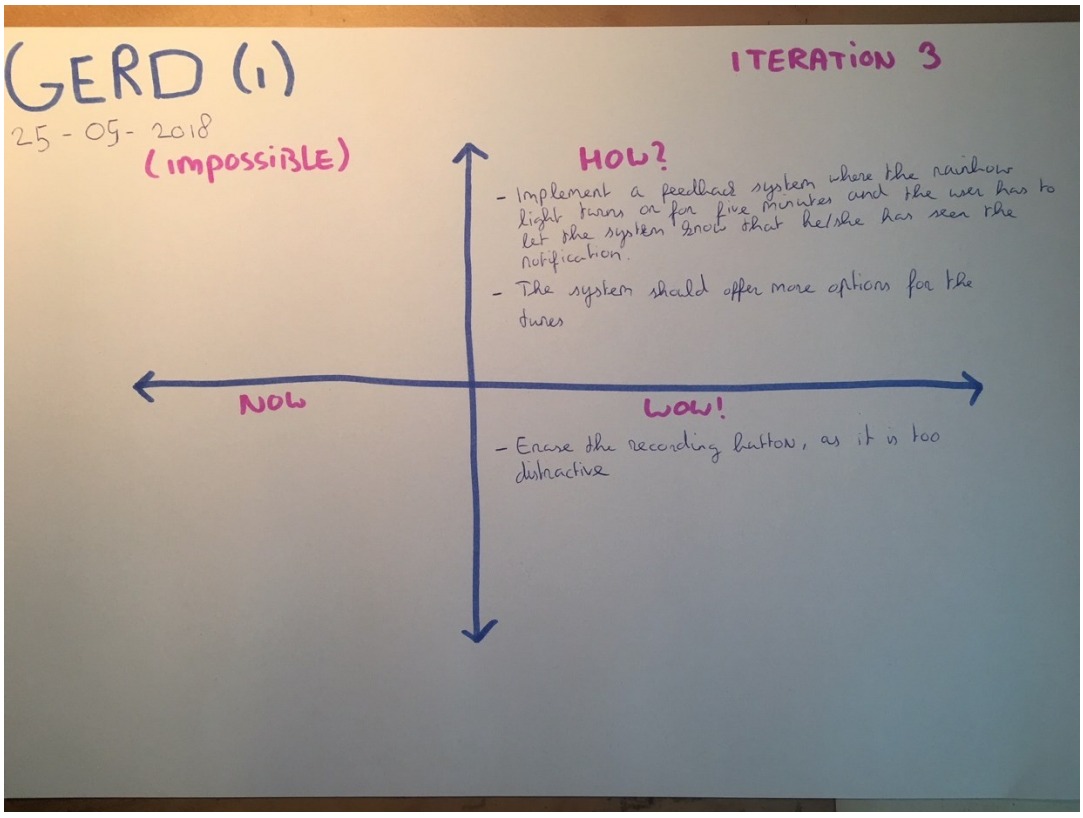

GERD
NIELS
SHIREEN
ARJAN
08-05-2018
ITERATION 1
(impossible)
- ENABLE THE USER TO "TALK" TO SYSTEM AND HAVE A CONVERSATION
HOW?
- MAKE THE BATTERY LAST LONGER
- IMPLEMENT ON/OFF BUTTON
- ADD A SOUND SYSTEM FOR EMBODIED EMPOWERMENT
↳ HAVING A VOICE TALK TO SOMEONE WITH ASD MIGHT BE PROBLEMATIC (ESPECIALLY 7 VOICES)
↳ SOMEONE WITH ASD MIGHT WANT TO HIDE HIS DEFICITS → DIFFICULT WHIT SPEAKING VOICES
↳ THE INTERFACE MUST BE UNDERSTANDABLE AND SIMPLE
- MAKE MYDAYLIGHT PORTABLE
- SEND LIVE UPDATES OF THE USER'S SCHEDULE TO A SUPERVISOR
NOW
- LONGER RAINBOW LIGHT
- MAKE THE BROKEN LIGHTS FUNCTIONAL AGAIN
WOW!
- ADD SOUND TO AN INDICATION
↳ IT MUST NOT BE INTRUSIVE! IF THE USER IS FOCUSSED ON DOING A CERTAIN ACTIVITY, HE/SHE MUST NOT BE SCARED UP BY THE SOUND
- THE SOUND MUST BE COMING FROM THE LIGHT ITSELF → IT MUST BE WIRELESS
(IT IS IMPORTANT THAT YOU KNOW WHICH LIGHT IS SHINING

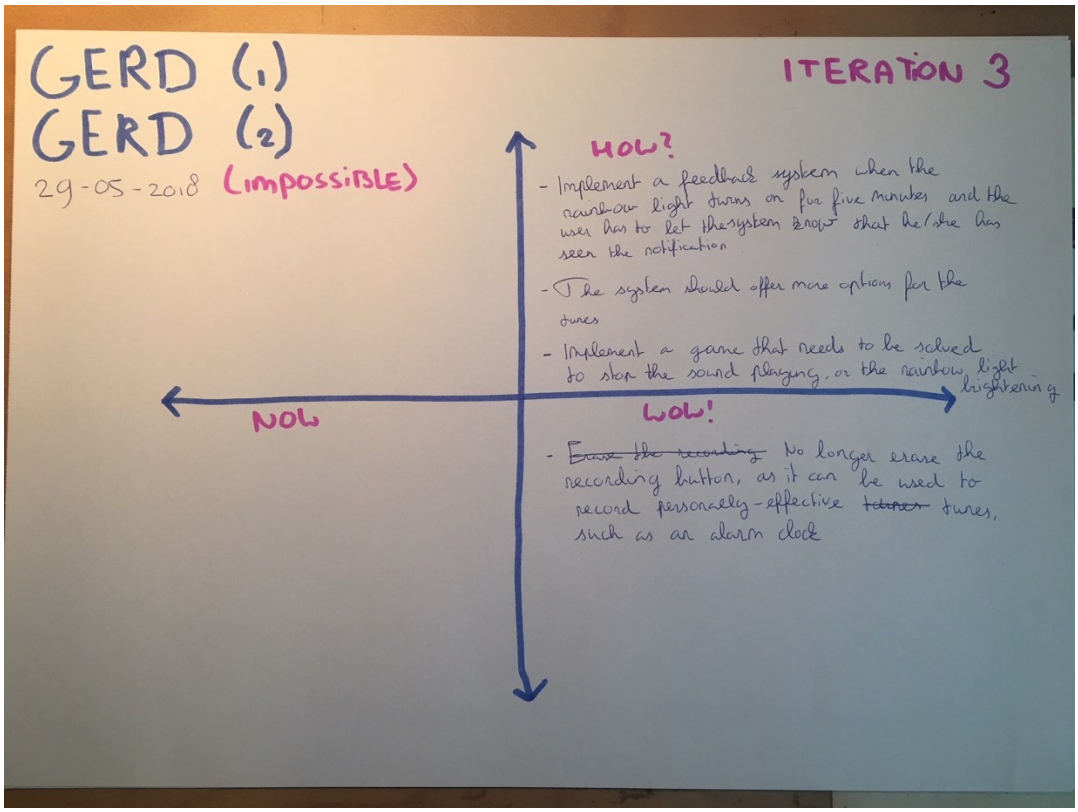
Appendix D.2.: HWNMs Iteration 2

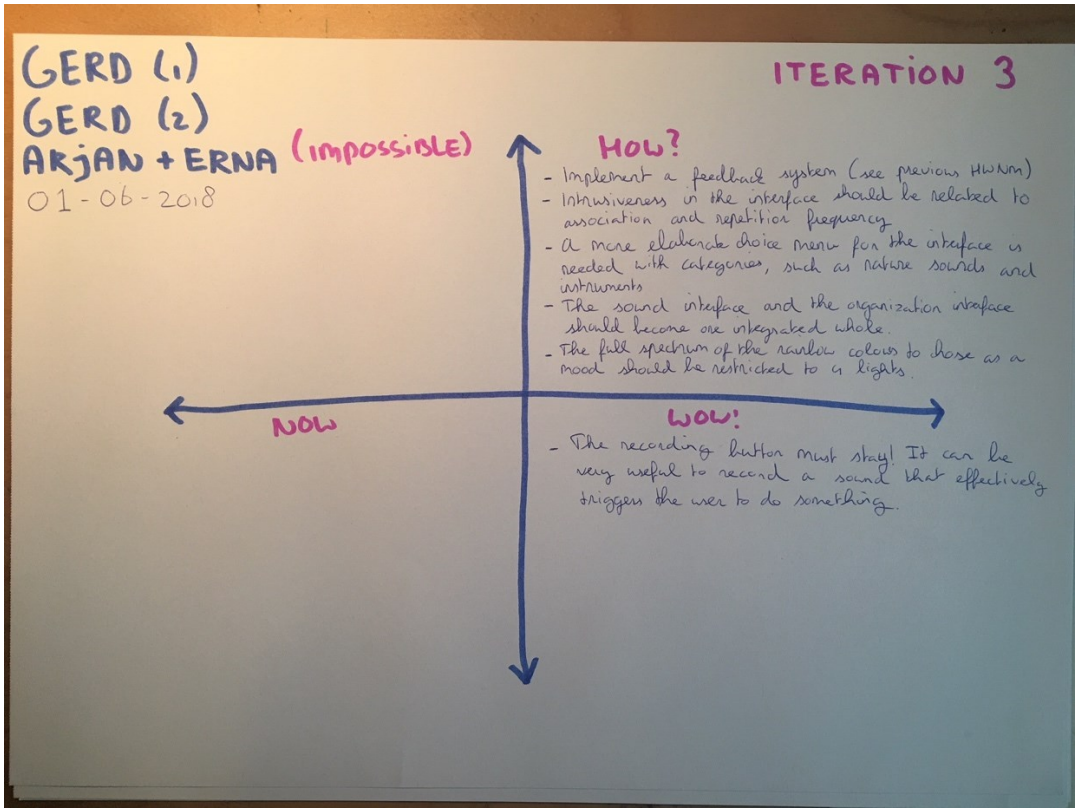


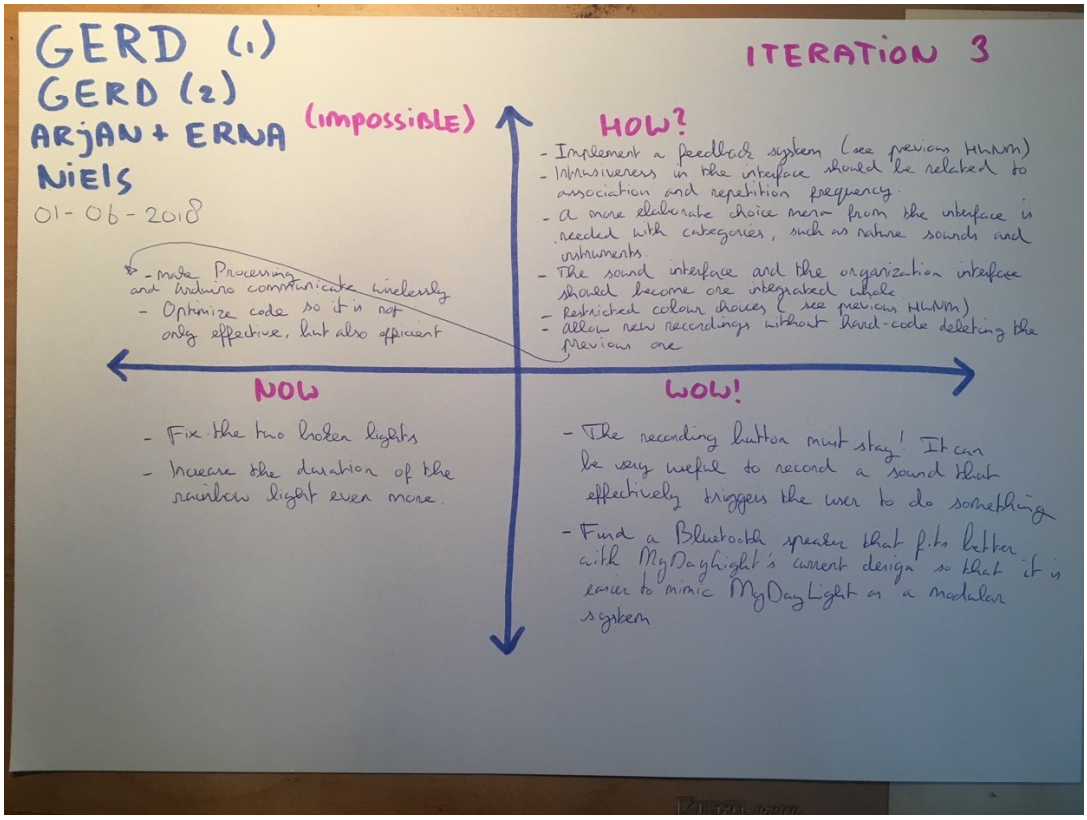


Appendix D.3.: HWNMs Iteration 3






GERD (1)
GERD (2)
ARJAN + ERNA
01-06-2018
ITERATION 3
(IMPOSSIBLE)
HOW?
- Implement a feedback system (see previous HWNM)
- Intrusiveness in the interface should be related to association and repetition frequency.
- A more elaborate choice menu for the interface is needed with categories, such as nature sounds and instruments
- The sound interface and the organization interface should become one integrated whole.
- The full spectrum of the rainbow colours to those as a mood should be restricted to 4 lights.
NOW
WOW!
- The recording button must stay! It can be very useful to record a sound that effectively triggers the user to do something.


GERD (1)
GERD (2)
ARJAN + ERNA
NIELS
01-06-2018
ITERATION 3
(IMPOSSIBLE)
HOW?
- Implement a feedback system (see previous HWNM)
- Intrusiveness in the interface should be related to association and repetition frequency.
- A more elaborate choice menu from the interface is needed with categories, such as nature sounds and instruments.
- The sound interface and the organization interface should become one integrated whole
- Restricted colour choices (see previous HWNM)
- Allow new recordings without hard-code deleting the previous one
- make Processing and Arduino communicate wirelessly
- Optimize code so it is not only effective, but also efficient
NOW
- Fix the two broken lights
- Increase the duration of the rainbow light even more.
WOW!
- The recording button must stay! It can be very useful to record a sound that effectively triggers the user to do something
- Find a Bluetooth speaker that fits better with MyDaylight's current design so that it is easier to mimic MyDaylight as a modular system

Appendix E.1.: Arduino Code - Iteration 1

```
/*
  MyDayLight
  Control for a MyDayLight lamp, connected to WiFi.

  Toggles LED ring on and of on push.
  Registers encoder data and changes color accordingly.
  Sends encoder value to server.
  Sends on/off to server.
  Receives on/off from server.

  Based on SimpleWebServerWiFi and WiFiWebClient by Tom Igoe, 2012/2010
  Based on strandtest created by Adafruit Neopixel
  Based on Prototype 5.1 by Laura Gabriella Sanchez Guzman, 2017
  Adapted by J.C. van Huizen, 2018


  By Laura Beunk, 2017/2018
*/

/*COMMUNICATION*/
// Messages are received in listenformsg, and interpreted with the interpretMsg function.
// Messages can be sent with the sendMsg function.


void interpretMsg( String sub, int val){

  // actions depending on the subject
  if (sub == "state") {

    Serial.print("\nReceived state value: ");
    Serial.println(val);

    if (val){
      setBrightness(defaultBr);
    } else{
      setBrightness(0);
    }

  } else if (sub =="color"){

    Serial.print("\nReceived color value: ");
    Serial.println(val);
    if (col == defaultCol){
```

```
    col = val;
   }
   defaultCol = val;

  } else if (sub =="brightness"){

   Serial.print("\nReceived brightnesss value: ");
   Serial.println(val/100.0);

   defaultBr = val/100.0;
   if (br != 0){
    setBrightness(defaultBr);
   }
  } else if (sub=="newEvent"){
   Serial.println("NEW EVENT!!!!");
   if (val){
    setBrightness(defaultBr);

    for(int plays = 0; plays<10; plays++){
    rainbow(1,100);
    }

    Serial.println("Response");
    delay(1000);
    Serial.print("ResponseOver");


    col = defaultCol;
    encoderReset();
   }
  }else {

   Serial.print("\nMessage subject \"");
   Serial.print(sub);
   Serial.println("\" not recognized");

  }

}


//--------------UTILS-----------------//


// Sends a message in a JSON object with an id and subject with value.
```

```
void sendMsg(String sub, int val) {

  // Build up the message body: {"id":id,"sub":val}
  String str = "{";

  str += "\"id\":";
  str += id;
  str += ", \"";
  str+= sub;
  str+="\":";
  str += val;
  str += "}";

  // Length (with one extra character for the null terminator)
  int str_len = str.length() + 1;

  // Prepare the character array (the buffer)
  char charmood[str_len];

  // Copy it over
  str.toCharArray(charmood, str_len);
  postMsg(charmood, str_len - 1, "api/updatelamp");

}


// parses a message based on a JSON object with a sub(ject) and a value
void parseMsg(String msg) {

  StaticJsonBuffer<200> jsonBuffer; //create a buffer to store the json object

  JsonObject& root = jsonBuffer.parseObject(msg); // parse the msg into JSON

  // catch error
  if (!root.success()) {
    Serial.println("\nJSON parseObject() failed");
    return;
  }

  String sub = root["sub"];
  int val = root["val"];

  interpretMsg(sub,val);

}
```

```
//Listens for messages
void listenForMsg(){

 WiFiClient client = server.available();   // listen for incoming clients (requests from server)

 if (client) {                     // if you get a client,

  String requestBody = "";
  String lastline;

  Serial.println("\n------Request------");
  while (client.connected()) {
   if (client.available()) {

    char c = client.read();                    // read out the request

    Serial.print(c);                           // print the request in serial

    if (c == '!') {
     // send a response
     client.println("HTTP/1.1 200 OK");
     client.println("Content-Type: text/html");
     client.println("Connection: close");
     client.println();
     client.println("Request received");

     Serial.println("\n------End Request-----");
     Serial.println("\nResponse sent");
     break;
    }

    requestBody += c;

   }
  }

  if (requestBody.length()) {
   lastline = requestBody.substring(requestBody.indexOf('?') + 1);
   parseMsg(lastline);
  }

  delay(1);
  client.stop();                   // Disconnect from client
```

```
    //Serial.println("disconnected");
  }
}

//Listens for messages
void listenForProcessingMsg(){

  WiFiClient client = server.available();   // listen for incoming clients (requests from server)

  if (client) {                     // if you get a client,
    Serial.println("\n------Request------");
    while (client.connected()) {
      if (client.available()) {

        char c = client.read();                 // read out the request

        Serial.print(c);                        // print the request in serial

        client.println("Hello world");


      }
    }

    delay(1);
    //client.stop();                // Disconnect from client
    //Serial.println("disconnected");
  }
}


// Post message to server (use sendMsg to send messages, this function will be invoked)
void postMsg(char msg[], int msglength, char path[]) {   // make a post request to the server

  Serial.print("\nSending message: ");
  Serial.println(msg);
  if (sendclient.connect(localserver, 4000)) {
    //Serial.println("connected to server");
    // Make a HTTP request:
    sendclient.print("POST /");
    sendclient.print(path);
    sendclient.print(" HTTP/1.1");
    sendclient.print("\n");
    sendclient.println("Connection: close");
    sendclient.print("Host: ");
```

```
    sendclient.println(arduinoIP);
    sendclient.println("Content-Type: application/json");
    sendclient.println("Cache-Control: no-cache");
    sendclient.print("Content-Length: ");
    sendclient.print(msglength);
    sendclient.print("\n");
    sendclient.println();
    sendclient.println(msg);
    sendclient.println();
    sendclient.println();
    Serial.println("\nResponse: ");
  } else {
    Serial.println("\nFailed to connect to server");
    blinkColor(1000, red);
  }

  delay(1000);

  while (sendclient.available()) {
    char c = sendclient.read();
    Serial.write(c);
  }

  // if the server's disconnected, stop the client:
  if (!sendclient.available()) {
    //Serial.println();
    //Serial.println("disconnecting from server.");
    sendclient.stop();
  }

}
```

Appendix E.2.: Processing Code - Iteration 1

```
/*
Processing 3.3.7
Made by J.C. van Huizen
06-05-2018
Creative Technology
University of Twente

In this prototype, a doorbell tune will ring everytime it receives
an incoming string from the Arduino to which it is connected. The
objective of this prototype is to find out the effect of sound to
to user.

*/

// Serial and Sound libraries are used
import processing.serial.*;
import processing.sound.*;
SoundFile file;
Serial myPort;

void setup(){

  printArray(Serial.list());
  myPort = new Serial(this, Serial.list()[0], 9600);

  // the testsound is a doorbell. When this program is started, the
  // doorbell rings to demonstrate that it works
  file = new SoundFile(this, "testsoundmp3");
  file.play();
}

void draw(){

  //while there is data incoming, read the strings
  while(myPort.available()>0){
    String inString = myPort.readString();

    //print what is incoming to see if the data from the Arduino
    //is succsfully transmitted
    println(inString);

    //if the string contains "Response", make sure the doorbell is
```

```
    //played
    if (inString.contains("Response")){
      println("Yes");
      file.play();
    }
  }
}
```

Appendix E.3.: Arduino Code - Iteration 3

```
/*COMMUNICATION*/
// Messages are received in listenformsg, and interpreted with the interpretMsg function.
// Messages can be sent with the sendMsg function.

void interpretMsg( String sub, int val){

  // actions depending on the subject
  if (sub == "state") {

    Serial.print("\nReceived state value: ");
    Serial.println(val);

    if (val){
      setBrightness(defaultBr);
    } else{
      setBrightness(0);
    }

  } else if (sub =="color"){

    Serial.print("\nReceived color value: ");
    Serial.println(val);
    if (col == defaultCol){
      col = val;
    }
    defaultCol = val;

  } else if (sub =="brightness"){

    Serial.print("\nReceived brightnesss value: ");
    Serial.println(val/100.0);

    defaultBr = val/100.0;
    if (br != 0){
      setBrightness(defaultBr);
    }
  } else if (sub=="newEvent"){
    if (val){
      setBrightness(defaultBr);

      Serial.print("StartSound");
      delay(100);
```

```
    Serial.print("StopSound");

    for(int plays = 0; plays<8; plays++){
    rainbow(1,100);
    }

    //write something

    col = defaultCol;
    encoderReset();

    //send to processing
    sendProcessingMsg("newEvent",1);
   }
  }else {

   Serial.print("\nMessage subject \"");
   Serial.print(sub);
   Serial.println("\" not recognized");

  }

}


//--------------UTILS------------------//


// Sends a message in a JSON object with an id and subject with value.
void sendMsg(String sub, int val) {

  // Build up the message body: {"id":id,"sub":val}
  String str = "{";

  str += "\"id\":";
  str += id;
  str += ", \"";
  str+= sub;
  str+="\":";
  str += val;
  str += "}";

  // Length (with one extra character for the null terminator)
  int str_len = str.length() + 1;
```

```
  // Prepare the character array (the buffer)
  char charmood[str_len];

  // Copy it over
  str.toCharArray(charmood, str_len);
  postMsg(charmood, str_len - 1, "api/updatelamp");

}

void sendProcessingMsg(String sub, int val) {

  // Build up the message body: {"id":id,"sub":val}
  String str = "{";

  str += "\"id\":";
  str += id;
  str += ", \"";
  str+= sub;
  str+="\":";
  str += val;
  str += "}";

  // Length (with one extra character for the null terminator)
  int str_len = str.length() + 1;

  // Prepare the character array (the buffer)
  char charmood[str_len];

  // Copy it over
  str.toCharArray(charmood, str_len);
  postProcessingMsg(charmood, str_len - 1, "api/updatelamp");

}
// parses a message based on a JSON object with a sub(ject) and a value
void parseMsg(String msg) {

  StaticJsonBuffer<200> jsonBuffer; //create a buffer to store the json object

  JsonObject& root = jsonBuffer.parseObject(msg); // parse the msg into JSON

  // catch error
  if (!root.success()) {
    Serial.println("\nJSON parseObject() failed");
    return;
  }
```

```
  String sub = root["sub"];
  int val = root["val"];

  interpretMsg(sub,val);

}


//Listens for messages
void listenForMsg(){

  WiFiClient client = server.available();   // listen for incoming clients (requests from server)

  if (client) {                     // if you get a client,

    String requestBody = "";
    String lastline;

    Serial.println("\n------Request------");
    while (client.connected()) {
      if (client.available()) {

        char c = client.read();                   // read out the request

        Serial.print(c);                          // print the request in serial

        if (c == '!') {
          // send a response
          client.println("HTTP/1.1 200 OK");
          client.println("Content-Type: text/html");
          client.println("Connection: close");
          client.println();
          client.println("Request received");

          Serial.println("\n------End Request-----");
          Serial.println("\nResponse sent");
          break;
        }

        requestBody += c;

      }
    }
```

```
    if (requestBody.length()) {
      lastline = requestBody.substring(requestBody.indexOf('?') + 1);
      parseMsg(lastline);
    }

    delay(1);
    client.stop();                    // Disconnect from client
    //Serial.println("disconnected");
  }
}


// Post message to server (use sendMsg to send messages, this function will be invoked)
void postMsg(char msg[], int msglength, char path[]) {   // make a post request to the server

  Serial.print("\nSending message: ");
  Serial.println(msg);
  if (sendclient.connect(localserver, 4000)) {
    //Serial.println("connected to server");
    // Make a HTTP request:
    sendclient.print("POST /");
    sendclient.print(path);
    sendclient.print(" HTTP/1.1");
    sendclient.print("\n");
    sendclient.println("Connection: keep-alive");
    sendclient.print("Host: ");
    sendclient.println(arduinoIP);
    sendclient.println("Content-Type: application/json");
    sendclient.println("Cache-Control: no-cache");
    sendclient.print("Content-Length: ");
    sendclient.print(msglength);
    sendclient.print("\n");
    sendclient.println();
    sendclient.println(msg);
    sendclient.println();
    sendclient.println();
    Serial.println("\nResponse: ");
  } else {
    Serial.println("\nFailed to connect to server");
    blinkColor(1000, red);
  }

  delay(1000);

  while (sendclient.available()) {
```

```
    char c = sendclient.read();
    Serial.write(c);
  }

  // if the server's disconnected, stop the client:
  if (!sendclient.available()) {
    //Serial.println();
    //Serial.println("disconnecting from server.");
    sendclient.stop();
  }

}

// Post message to processing server (use sendMsg to send messages, this function will be invoked)
void postProcessingMsg(char msg[], int msglength, char path[]) {   // make a post request to the server

  Serial.print("\nSending message: ");
  Serial.println(msg);
  if (sendclient.connect(localserver, 12345)) {
    //Serial.println("connected to server");
    // Make a HTTP request:
    sendclient.print("POST /");
    //sendclient.print(path);
    sendclient.print(" HTTP/1.1");
    sendclient.print("\n");
    sendclient.println("Connection: keep-alive");
    sendclient.print("Host: ");
    sendclient.println(arduinoIP);
    sendclient.println("Content-Type: application/json");
    sendclient.println("Cache-Control: no-cache");
    sendclient.print("Content-Length: ");
    sendclient.print(msglength);
    sendclient.print("\n");
    sendclient.println();
    sendclient.println(msg);
    sendclient.println();
    sendclient.println();
    Serial.println("\nResponse: ");
  } else {
    Serial.println("\nFailed to connect to server");
    blinkColor(1000, red);
  }

  delay(1000);
```

```
  while (sendclient.available()) {
    char c = sendclient.read();
    Serial.write(c);
  }

  // if the server's disconnected, stop the client:
  if (!sendclient.available()) {
    //Serial.println();
    //Serial.println("disconnecting from server.");
    sendclient.stop();
  }

}
```

Appendix E.4.: Processing Code - Iteration 3

```
/*
Processing 3.3.7.
 Sound Interface connected to MyDayLight
 Johannes Cornelis van Huizen
 18-06-2018

 Creative Technology Graduation Project
 University of Twente

 The recording code of the main sketch is partly taken
 from Minim's audio recorder example
 Retrieved from:
 http://code.compartmental.net/minim/audiorecorder_method_save.html

 PS. I wish to give thanks to Laura Beunk
 for helping me with realizing wireless com.
 */

//ControlP5 for sliders, sound for tracks
//minim libraries for recording and playing recorded tracks
//Serial for serial communication
//Net for wireless communication
import controlP5.*;
import processing.sound.*;
import ddf.minim.*;
import ddf.minim.ugens.*;
import processing.serial.*;
import processing.net.*;

int volume = 50;           // Default volume
int duration = 1;          I/ Default duration
int audio = 1;             // Default audio track
int recordingNumber = 0;    // Amount to tracks already recorded

SliderLayout slider1;       // Slider1 manages the volume
SliderLayout slider2;       // Slider2 manages the duration
SliderLayout slider3;       // Slider3 manages the audio track

// In total, the user can choose between 12 audio files
AudioFile[] audioFile = new AudioFile[12];

Minim minim;                    // Recording class
```

```
RecordingButton newRecordingButton;   // The recording button
Interface newInterface;               // Interface Design
ResetRecording newResetRecording;     // Reset the current recording
SoundOptions newSoundOptions;         // Manages the categories of sound
Serial myPort;                        // The USB port used for Serial Com.
Server s;                             // Client and server for Wir. Com.
Client c;

//Connection: You can choose between Wireless, Serial and Keyboard (hardcode)
//If you choose Wireless, the communication will be over WiFi
//If you choose Serial, the communication will be over USB
//If you choose Keyboard, you can start sounds by pressing a key
String connection = "Wireless";
String input;

// for recording
AudioInput in;
AudioRecorder[] recordings = new AudioRecorder[10];
boolean recorded;

// for playing back
AudioOutput out;
FilePlayer player;

boolean globalAudio;          // Keeps track if the recorded track is selected
boolean playInstruments;      // Choose Instruments category
boolean playCity;             // Choose City sounds category
boolean playAnimals;          // Choose animals sounds category
boolean wirelessIndication;   // needed to keep track of incoming wireless data

void setup() {
  size(1000, 700, P3D);

  // 12 optional sound tracks
  audioFile[0] = new AudioFile(this, "audio1.wav");
  audioFile[1] = new AudioFile(this, "audio2.wav");
  audioFile[2] = new AudioFile(this, "audio3.wav");
  audioFile[3] = new AudioFile(this, "audio4.wav");
  audioFile[4] = new AudioFile(this, "audio5.wav");
  audioFile[5] = new AudioFile(this, "audio6.wav");
  audioFile[6] = new AudioFile(this, "audio7.wav");
  audioFile[7] = new AudioFile(this, "audio8.wav");
  audioFile[8] = new AudioFile(this, "audio9.wav");
  audioFile[9] = new AudioFile(this, "audio10.wav");
  audioFile[10] = new AudioFile(this, "audio11.wav");
```

```
  audioFile[11] = new AudioFile(this, "audio12.wav");

  // Initialize the three sliders for volume, duration and audio
  amplitudeSlider();
  durationSlider();
  chooseAudio();

  // Initialize recording button, interface, resetbutton and category manager
  newRecordingButton = new RecordingButton();
  newInterface = new Interface();
  newResetRecording = new ResetRecording();
  newSoundOptions = new SoundOptions();

  // De-comment myPort if you selected Serial communication:
  // myPort = new Serial(this, Serial.list()[0], 9600);

  s = new Server(this, 12345);   //Incoming data in port 12345
  wirelessIndication = false;

  minim = new Minim(this);
  in = minim.getLineIn(Minim.STEREO, 2048);
  out = minim.getLineOut( Minim.STEREO );
  textFont(createFont("Arial", 12));

  //Allow 10 recordings
  recordings[0] = minim.createRecorder(in, "data/recordedsound1.wav");
  recordings[1] = minim.createRecorder(in, "data/recordedsound2.wav");
  recordings[2] = minim.createRecorder(in, "data/recordedsound3.wav");
  recordings[3] = minim.createRecorder(in, "data/recordedsound4.wav");
  recordings[4] = minim.createRecorder(in, "data/recordedsound5.wav");
  recordings[5] = minim.createRecorder(in, "data/recordedsound6.wav");
  recordings[6] = minim.createRecorder(in, "data/recordedsound7.wav");
  recordings[7] = minim.createRecorder(in, "data/recordedsound8.wav");
  recordings[9] = minim.createRecorder(in, "data/recordedsound9.wav");

  recorded = false;        // needed to let the system know if something is recorded
  playInstruments = true;   // Instruments sounds as default category
  playCity = false;
  playAnimals = false;
}


void draw() {
  background(#92ADB7);
```

```
  // Functions to set volume, duration and what audio to play
  setVolume();
  setDuration();
  setAudio();

  //Play the sound when needed
  testSound();

  initiateRecording();              //Show soundwaves
  newRecordingButton.display();     //Show recording button
  newSoundOptions.menuSelection();  //Select the right category
  newInterface.display();           //Show interface
  newResetRecording.display();      //Show reset button
}

//All the actions if a mouse is released:
void mouseReleased() {

  //If the recording button is pressed and there is not yet something recorded
  if (!recorded && newRecordingButton.recordingButtonisPressed) {
    newInterface.recordedFeedback = true;
    newRecordingButton.displayText = true;
    // to indicate that you want to start or stop capturing audio data,
    // you must callstartRecording() and stopRecording() on the AudioRecorder object.
    // You can start and stop as many times as you like, the audio data will
    // be appended to the end of to the end of the file.
    if (recordings[recordingNumber].isRecording()) {
      recordings[recordingNumber].endRecord();

      //something is recorded
      recorded = true;

      //write "Recorded" on the interface
      newRecordingButton.displayText = false;
    } else {
      recordings[recordingNumber].beginRecord();
    }
  }


  if (recorded && !newRecordingButton.recordingButtonisPressed) {
    // we've filled the file out buffer,
    // now write it to a file of the type we specified in setup
    // in the case of buffered recording,
    // this will appear to freeze the sketch for sometime, if the buffer is large
```

```
  // in the case of streamed recording,
  // it will not freeze as the data is already in the file and all that is being done
  // is closing the file.
  // save returns the recorded audio in an AudioRecordingStream,
  // which we can then play with a FilePlayer
  if ( player != null ) {
    player.unpatch(out);
    player.close();
  }
  player = new FilePlayer( recordings[recordingNumber].save());
  player.patch(out);
}
// reset the recording
if (newResetRecording.resetButtonisPressed) {
  recorded = false;
  newInterface.recordedFeedback = false;

  //the next recording will have a different position in the array
  recordingNumber++;

  //if 10 recordings have been made, the user must re-start the program
  if (recordingNumber == 9) {

    //tell the user that they needs to re-start the program
    newResetRecording.maximumReached = true;
  }
}

//select instruments as category
if (newSoundOptions.instruments == true) {
  playInstruments = true;
  playCity = false;
  playAnimals = false;
  newSoundOptions.setOptionInstruments = true;
  newSoundOptions.setOptionCity = false;
  newSoundOptions.setOptionAnimals = false;
}

//select city sounds as category
if (newSoundOptions.city == true) {
  playInstruments = false;
  playCity = true;
  playAnimals = false;
  newSoundOptions.setOptionInstruments = false;
  newSoundOptions.setOptionCity = true;
```

```
    newSoundOptions.setOptionAnimals = false;
  }

  //select animal sounds as category
  if (newSoundOptions.animals == true) {
    playInstruments = false;
    playCity = false;
    playAnimals = true;
    newSoundOptions.setOptionInstruments = false;
    newSoundOptions.setOptionCity = false;
    newSoundOptions.setOptionAnimals = true;
  }
}

// use SliderLayout to create a volume slider
void amplitudeSlider() {
  PVector position = new PVector(50, 450);
  PVector range = new PVector(0, 100);
  PVector size = new PVector(150, 200);
  slider1 = new SliderLayout(this, "volume", volume, position, range, size);
  slider1.setupSlider();
}

// set selected volume to selected audio track
void setVolume() {
  float setVolume = volume;
  for (int i = 0; i < audioFile.length; i++) {
    audioFile[i].audioVolume = setVolume/10;
  }
}

// use SliderLayout to create a duration slider
void durationSlider() {
  PVector position = new PVector(250, 450);
  PVector range = new PVector(1, 10);
  PVector size = new PVector(150, 200);
  slider2 = new SliderLayout(this, "duration", duration, position, range, size);
  slider2.setupSlider();
}

// set selected duration to selected audio track
void setDuration() {
  float setDuration = duration;
  for (int i = 0; i < audioFile.length; i++) {
    audioFile[i].audioDuration = setDuration;
```

```
  }
}

// choose what audio to play
void chooseAudio() {
  PVector position = new PVector(450, 450);
  PVector range = new PVector(1, 5);
  PVector size = new PVector(150, 200);
  slider3 = new SliderLayout(this, "audio", audio, position, range, size);
  slider3.setupSlider();
}

// set the audio according to:
// - what category has been selected
// - what track of that category has been selected
void setAudio() {
  int setAudio = audio;
  if (playInstruments) {
    if (setAudio == 1) {
      audioFile[0].play();
    } else if (setAudio == 2) {
      audioFile[1].play();
    } else if (setAudio == 3) {
      audioFile[2].play();
    } else if (setAudio == 4) {
      audioFile[3].play();
    }
  }

  if (playCity) {
    if (setAudio == 1) {
      audioFile[4].play();
    } else if (setAudio == 2) {
      audioFile[5].play();
    } else if (setAudio == 3) {
      audioFile[6].play();
    } else if (setAudio == 4) {
      audioFile[7].play();
    }
  }

  if (playAnimals) {
    if (setAudio == 1) {
      audioFile[8].play();
    } else if (setAudio == 2) {
```

```
      audioFile[9].play();
    } else if (setAudio == 3) {
      audioFile[10].play();
    } else if (setAudio == 4) {
      audioFile[11].play();
    }
  }

// in the sliders, option 5 is the recorded track
  if (setAudio == 5) {
    globalAudio = true;
  } else {
    globalAudio = false;
  }
}

void initiateRecording() {
  stroke(255);
  // draw the waveforms
  // the values returned by left.get() and right.get() will be between -1 and 1,
  // so we need to scale them up to see the waveform
  for (int i = 0; i < in.left.size()-1; i++) {
    line(i, 50 + in.left.get(i)*50, i+1, 50 + in.left.get(i+1)*50);
    line(i, 150 + in.right.get(i)*50, i+1, 150 + in.right.get(i+1)*50);
  }
}

//play the sound according to the type of communication chosen
void testSound() {

  //for wireless communication:
  if (connection == "Wireless") {

    //if data is received:
    if (wirelessIndication) {

      //make sure that the sounds are enabled to play
      for (int i = 0; i < audioFile.length; i++) {
        audioFile[i].playSound = true;
      }
    } else {
      for (int i = 0; i < audioFile.length; i++) {
        audioFile[i].playSound = false;
      }
    }
```

```
  //if a track has been recorded and is selected as well:
  if (wirelessIndication && recorded) {
    if (globalAudio == true) {
      player.play();
    }
  }

  //after receiving wireless data, reset the boolean to false
  wirelessIndication = false;
}

// for keyboard:
if (connection == "KeyBoard") {

  // if keyboard is pressed, enable the sounds to be played
  if (keyPressed) {
    for (int i = 0; i < audioFile.length; i++) {
      audioFile[i].playSound = true;
    }
  } else {
    for (int i = 0; i < audioFile.length; i++) {
      audioFile[i].playSound = false;
    }
  }

  //if something is recorded and a key is pressed:
  if (keyPressed && recorded) {

    //if it has been selected as well:
    if (globalAudio == true) {
      player.play();
    }
  }
}

// for Serial communication
if (connection == "Serial") {

  //if data is coming on over the Serial link
  if (myPort.available()>0) {
    String inString = myPort.readString();

    // checks for "StartSound" message from the Arduino
    // and enables the tracks to be played
```

```
    if (inString.contains("StartSound")) {
      for (int i = 0; i < audioFile.length; i++) {
        audioFile[i].playSound = true;
      }

      // stops enabling this when the "StopSound" messages is received
    }
    if (inString.contains("StopSound")) {
      for (int i = 0; i < audioFile.length; i++) {
        audioFile[i].playSound = false;
      }
    }

    //if data is received and something is recorded:
    if (inString.contains("StartSound") && recorded) {

      // if it has been selected as well:
      if (globalAudio == true) {
        player.play();
      }
    }
   }
  }
}

//function to check if wireless data is incoming
void serverEvent(Server s, Client c) {

  //delay allows a handshake procedure
  delay(1000);

  //if data is received:
  if (c.available()>0) {

    wirelessIndication = true;
    // read out the request
    input = "fail";
    input = c.readString();

    // pick out the part with the values
    input = input.substring(input.indexOf("{")+1, input.indexOf("}")); //values between curly brackets

    //response
    s.write("HTTP/1.1 200 OK\n");
    s.write("Content-Type:text/html\n");
```

```
    s.write("Connection: Closed\n");
    s.write("\n");
    s.write("Received");

    //s.disconnect(c);
    c.stop();
  } else {
    println("c.available not bigger than 0");
    c.stop();
  }
}
```

```
// A class to display the interface
// Primarily draws backgrounds for the slider menus

class Interface {
  PVector sliderBackPosition;    //the sliders have a background
  PVector sliderBackSize;        //the backgrounds have a size
  float rounding;                //rounding corners
  color backColour;              //background colour
  boolean recordedFeedback;      //let's the user know if something is recorded

  Interface() {
    sliderBackPosition = new PVector(45, 650);
    sliderBackSize = new PVector(160, 25);
    rounding = 5;
    backColour = #5A6F76;
  }

  //draw the slider's backgrounds
  void display() {
    fill(backColour);
    for (int i = 0; i<3; i++) {
      rect(sliderBackPosition.x+(i*200), sliderBackPosition.y, sliderBackSize.x, sliderBackSize.y, rounding);
    }

    //draw two rectangles if something is recorded
    if (recordedFeedback) {
      fill(#C7C9AA);
      rect(725, 450, 200, 15, 5);
      rect(725, 660, 200, 15, 5);
    }
  }
```

```
}
```

```
//class for drawing and constructing slider menus

class SliderLayout {

  ControlP5 cp;      //slider construction from ControlP5 library
  int value;         //sliders have a value
  String name;       //sliders have a name
  PVector position;  //sliders have a position on the interface
  PVector range;     //sliders have a range of values
  PVector size;      //sliders have a size
  boolean ticked;

  // main arguments to be determined in the main sketch
  SliderLayout(PApplet pa, String name,int value, PVector position, PVector range, PVector size) {
    cp = new ControlP5(pa);
    this.name = name;
    this.value = value;
    this.position = position;
    this.range = range;
    this.size = size;
  }

  // draw sliders
  // audio slider has a slightly different design
  void setupSlider() {
    if (name.contains("audio")){
      cp.addSlider(name)
      .setPosition(position.x, position.y)
      .setRange(range.x, range.y)
      .setSize(int(size.x), int(size.y))
      .setNumberOfTickMarks(5);
    } else{
      cp.addSlider(name)
      .setPosition(position.x, position.y)
      .setRange(range.x, range.y)
      .setSize(int(size.x), int(size.y));
    }
```

```
  }
}
```

```
//class for playing the selected tracks
//according to the set volume and duration

class AudioFile {

  SoundFile file;         //audio file construction taken from library
  boolean playSound;      //played when enabled in the main sketch
  float audioVolume;      //each track has a volume
  float audioDuration;    //each track has a duration
  String playThisFile;    //play the selected track

  AudioFile(PApplet pa, String playThisFile) {
    file = new SoundFile(pa, playThisFile);
    playSound = false;
    audioVolume = 0.3;
    audioDuration = 1;
  }

  // play the selected track according to the duration and volume
  void play() {
    file.amp(audioVolume);
    if (playSound) {
      for (float i = 1; i<=audioDuration; i++) {
        println(i);
        file.play();

        //wait with playing the track again until it has been played completely
        delay(int(file.duration()) * 1000);
      }
    }
  }
}
```

```
//class that draws are recording button
//and keeps track of when it is pressed

class RecordingButton {
  PVector position;         //it has a position in the interface
  PVector size;             //it has a size
  color inner;              //it has a colour for the inner circle
  color outer;              //it has a colour for the outer circle
  color mouseOverButton;              //change colour of mouse if over button
  boolean recordingButtonisPressed;     //if it pressed or not
  boolean displayText;       //write "Recording" if something is recorded


  RecordingButton() {
    position = new PVector(825, 550);
    size = new PVector(100, 100);
    inner = #DB3E3E;
    outer = 0;
    mouseOverButton = #892929;
    recordingButtonisPressed = false;
    displayText = false;
  }

  //draw the recording button
  void display() {
    fill(#5A6F76);
    rect(725, 450, 200, 225, 5);
    fill(outer);
    ellipse(position.x, position.y, size.x, size.y);

    if (mouseX < position.x+50 && mouseX > position.x-50 && mouseY < position.y+50 && mouseY >
position.y-50) {
      fill(mouseOverButton);
      recordingButtonisPressed = true;
    } else {
      fill(inner);
      recordingButtonisPressed = false;
    }
    ellipse(position.x, position.y, size.x-10, size.y-10);
    noFill();

    //write "Recording" if something is recorded
    if (displayText == true) {
      textSize(25);
      text("Recording", 770, 650);
```

```
   }
  }
}
```

```
//class for resetting a recording
//allows to record 10 tracks before the need to restart the program

class ResetRecording {
  PVector position;              //reset button position
  PVector size;                  //reset button size
  color mouseOffButton;          //colour of button when mouse not on it
  color mouseOverButton;         //colour of button when mouse on it
  boolean resetButtonisPressed;  //keep track of button pressed or not
  boolean displayResetText;      //let user know when they needs to re-start
  boolean maximumReached;        //keep track of maximum recordings reached

  ResetRecording() {
    position = new PVector(825, 350);
    size = new PVector(50, 50);
    mouseOffButton = #93D37E;
    mouseOverButton = 100;
    resetButtonisPressed = false;
    displayResetText = false;
  }

  //draw the reset button
  void display() {
    if ( mouseX >= 775 && mouseX <= 875 && mouseY >= 300 && mouseY <= 400) {
      // if (mouseX >= position.x-25 && mouseX <= position.x+25 && mouseY >= position.y-25 && mouseY
<= position.y+25) {
      resetButtonisPressed = true;
      fill(mouseOverButton);
      textSize(20);
      text("Delete Current Recording", 715, 300);
      ellipse(position.x, position.y, size.x, size.y);
    } else {
      resetButtonisPressed = false;
      fill(mouseOffButton);
      ellipse(position.x, position.y, size.x, size.y);
    }
```

```
    //let the user know when the maximum is reached
    //and re-starting the program is needed for new recordings
    if (maximumReached) {
      fill(100);
      textSize(25);
      text("You have reached the maximum amount of recordings", 100, 200);
      text("Please restart the program to record new tracks", 100, 230);
    }
  }
}
```

```
//class for drawing a menu in which categories can be selected
// also manages which category is selected

class SoundOptions {

  PVector choiceMenuButtonPosition;  //menu buttons have a position
  PVector choiceMenuSize;           //menu buttons have a size
  PImage[] images = new PImage[3];   //menu buttons contain an image
  int rounding;                     //menu buttons have round corners
  color c;                         //default colour for buttons
  boolean instruments;              //used if instruments category is selected
  boolean city;                     //used if city category is selected
  boolean animals;                  //used if animals category is selected
  boolean setOptionInstruments;     //set intruments category if selected
  boolean setOptionCity;            //set city category if selected
  boolean setOptionAnimals;         //set animals category if selected

  SoundOptions() {
    choiceMenuButtonPosition = new PVector(615, 450);
    choiceMenuSize = new PVector(60, 60);
    images[0] = loadImage("music.png");
    images[1] = loadImage("city.png");
    images[2] = loadImage("deer.png");
    rounding = 5;
    c = #93D37E;
    instruments = false;
    city = false;
    animals = false;
    setOptionInstruments = true;
    setOptionCity = false;
```

```
    setOptionAnimals = false;
  }

//draws the buttons and changes their colour of the mouse is over it
  void menuSelection() {

    //draw the buttons if the mouse is not over them
    for (int i = 0; i<3; i++) {
      fill(#93D37E);
      rect(choiceMenuButtonPosition.x, choiceMenuButtonPosition.y + (i*65), choiceMenuSize.x,
choiceMenuSize.y, rounding);
      image(images[i], choiceMenuButtonPosition.x+7, choiceMenuButtonPosition.y+(i*65)+7,
choiceMenuSize.x/1.3, choiceMenuSize.y/1.3);
    }

    //change the colour of the button if the mouse is over them
    //also, let's the main sketch know on which category the mouse is situated
    if ( mouseX >= choiceMenuButtonPosition.x && mouseX <=
choiceMenuButtonPosition.x+choiceMenuSize.x
      && mouseY >= choiceMenuButtonPosition.y && mouseY <=
choiceMenuButtonPosition.y+choiceMenuSize.y) {
      fill(100);
      rect(choiceMenuButtonPosition.x, choiceMenuButtonPosition.y, choiceMenuSize.x,
choiceMenuSize.y, rounding);
      instruments = true;
      city = false;
      animals = false;
    } else if (mouseX >= choiceMenuButtonPosition.x && mouseX <=
choiceMenuButtonPosition.x+choiceMenuSize.x
      && mouseY >= choiceMenuButtonPosition.y+65 && mouseY <=
choiceMenuButtonPosition.y+choiceMenuSize.y+65) {
      fill(100);
      rect(choiceMenuButtonPosition.x, choiceMenuButtonPosition.y+65, choiceMenuSize.x,
choiceMenuSize.y, rounding);
      instruments = false;
      city = true;
      animals = false;
    } else if (mouseX >= choiceMenuButtonPosition.x && mouseX <=
choiceMenuButtonPosition.x+choiceMenuSize.x
      && mouseY >= choiceMenuButtonPosition.y+(2*65) && mouseY <=
choiceMenuButtonPosition.y+choiceMenuSize.y+(2*65)) {
      fill(100);
      rect(choiceMenuButtonPosition.x, choiceMenuButtonPosition.y+(2*65), choiceMenuSize.x,
choiceMenuSize.y, rounding);
      instruments = false;
```

```
    city = false;
    animals = true;
   }

// draws the pressed button based on the category selected
// information is retrieved from the main sketch
   if (setOptionInstruments) {
    fill(200);
    rect(choiceMenuButtonPosition.x, choiceMenuButtonPosition.y, choiceMenuSize.x,
choiceMenuSize.y, rounding);
    image(images[0], choiceMenuButtonPosition.x+7, choiceMenuButtonPosition.y+7,
choiceMenuSize.x/1.3, choiceMenuSize.y/1.3);
   }
   if (setOptionCity) {
    fill(200);
    rect(choiceMenuButtonPosition.x, choiceMenuButtonPosition.y+65, choiceMenuSize.x,
choiceMenuSize.y, rounding);
    image(images[1], choiceMenuButtonPosition.x+7, choiceMenuButtonPosition.y+65+7,
choiceMenuSize.x/1.3, choiceMenuSize.y/1.3);
   }
   if (setOptionAnimals) {
    fill(200);
    rect(choiceMenuButtonPosition.x, choiceMenuButtonPosition.y+(2*65), choiceMenuSize.x,
choiceMenuSize.y, rounding);
    image(images[2], choiceMenuButtonPosition.x+7, choiceMenuButtonPosition.y+(2*65)+7,
choiceMenuSize.x/1.3, choiceMenuSize.y/1.3);
   }
  }
}
```