Taimo

A tool for people with low-functioning autism and their caregivers, enhancing activity and time management.

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Final Master Project
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SEVERINUS

ABSTRACT

People with low-functioning autism prove a challenging target group in daily care situations. Difficulty in communication between caregivers and their clients is a frequent cause of agitation and escalation. This report describes the iterative user-centered design process, performed in collaboration with experts, caregivers and their clients, aimed at creating a tool to help facilitate these daily challenges.

Taimo provides a communication platform for people with-low functioning autism and their caregivers. The system consists of an interactive timer, indicating remaining time for activities through music, and allowing its users a certain amount of control over this time. Through a smartphone application, caregivers are provided with remote observation and control, assisting them in their daily care tasks.

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1. INTRODUCTION

Autism

Autism spectrum disorder (ASD) is a neurodevelopmental disorder generally defined by a triad of impairments, concerning issues in social interaction, communication and imagination [1]. The disorder has been extensively researched over the past decades, especially when the estimated percentage of the population that deals with this condition became clear. Worldwide, an estimated 1 in 100 have to cope with ASD, increasing to nearly 3 in 100 from ages 4-12 [2].

These numbers are significantly higher compared to studies from the previous century [3]. More recent studies suggest an impairment at a more fundamental cognitive level, defining additional needs, for instance a need structure and predictability [4, 5]. Impact on the daily life of people with ASD and close family varies depending on severity. In many cases, however, this impact requires severe adjustments in social and professional life, with negative consequences affecting both the person with ASD and their parents [6, 7].

Low-functioning

This project will be aimed at people with autism and severe intellectual disabilities, commonly referred to as low-functioning autism [8]. In addition to the impairments caused by ASD, decreased skills in memory and language are often observed [9]. However, even though the combination of cognitive impairment and autism is both a common appearance, with an estimated 38%, and has a severe impact on symptoms, research on the subject is scarce [10, 11]. Although defining different types of autism is difficult and scientific agreement has not been fully achieved, research on this lower end of the spectrum started with research by Kanner [12]. Certain children examined in his clinic exhibited bizarre and unknown behavior such as exclaiming repetitive sentences and extreme temper tantrums, significantly worse and different compared to known cases of autism thus far [12].

Therapy

After a diagnosis for any type of autism has been established, next steps generally include occupational therapy, aimed at developing or maintaining a regular day structure [13]. Furthermore, professional help will include speech therapy and a psychologist. Approaches in therapy will vary heavily for different individuals depending on their condition [14].

A new direction in research for ASD has originated, namely one that investigates the potential of applying technology to help cope with certain aspects of the condition [15]. For example, different studies investigate the potential of learning communicative and social skills through serious games or virtual reality for example [16, 17]. Another seemingly successful option is to add embodiment to this technology, in the shape of robots or other interactive products. These types of solutions appeal to people with ASD due to an interest in technology, and its ability to compensate for difficulties in social interaction. Furthermore, the technology offers a certain predictability and structure, which fits the preferred lifestyle of people with ASD [5, 18, 19]. Similar to most research on autism, these experiments are primarily aimed at high-functioning autism.

Although work in this area is experimental and room for improvement is abundantly present, it does show potential. Due to the difficulty of care for this target group, effective assistive technology is desirable. This project focusses on the research and design of an intelligent interactive tool, aiding in the daily management of activities and related communication between caregivers and clients. In order to accomplish the inclusion of personal preferences and needs, caregivers from Severinus are thoroughly included in the resulting concept.

Figure 1. The final prototype in context

2. PROJECT BRIEF

Client

Severinus is a care institute with several locations around Veldhoven, The Netherlands. Their care is aimed towards people with different types of mental disorders. Among their clients, many have to cope with disorders such as ASD and dementia. For this project, a cooperation with "De Bussel" has been set up, a day care facility for clients with severe low-functioning autism, also known as mental retardation. Like many healthcare organizations, Severinus is considering technological solutions to help their clients live with the consequences of their impairments.

Within this facility, my main contacts are Elle Alkemade, the team leader of the facility and Mirjam Hanegraaf, activity supervisor.

Target group

The clients at "De Bussel" are people with severe intellectual disabilities. As a result, although the clients are between the ages of 12 and 60, their cognitive levels are similar to children between the ages of 1 and 6. Matching with insights from literature, the clients have a need for structure and predictability, both in their overall day planning as well as during activities. Due to linguistic difficulties, communication with the clients needs to be supported through visual aids such as images or physical objects [20].

Intellectual disability is a frequent comorbid disorder in people with ASD, with 38% of children with ASD estimated to additionally cope with an intellectual disability [11]. From the clients at "De Bussel", two clients with ASD have been selected to participate as users in this project. In correspondence with their parents or caretakers, consent to engage in research while being monitored and recorded has been arranged.

Figure 2. *Caregiver and client at "De Bussel"*
Available: https://www.severinus.nl/zorgaanbod/dagbesteding/bussel.[Accessed 9 1 2019]

Challenge

The main goals of Severinus' daycare facilities are to improve independence, avoid boredom and promote day-night rhythm, in order to improve overall quality of life for their clients. A major aspect in achieving these first two goals is communication. The target group hardly uses verbal communication, and when they do, it is generally limited to pitch variations of incomprehensive sounds. This makes it difficult for the clients to express themselves to their caregivers. Although getting to know the clients helps in understanding the way they ask and tell things, caregivers indicate that they are frequently unaware of their clients' needs and wishes.

The other way around, caregivers struggle to relay information to their clients regarding subjects such as meals, activities, time and planning [21]. From observations and interviews with caregivers at Severinus, it became clear that both clients and caregivers intensively use pictures or icons of such activities to communicate regarding such subjects [Appendix A]. During previous experiments, the caregivers used special clocks in addition to these pictograms, to add a time element [22]. Although this sense of time put the clients at ease, several elements of such clocks worked counterproductive. Clients adjusted the remaining time themselves, did not like the sound it made and got frustrated when the timer ended and nothing happened because the caregivers did not notice it ending.

Therefore, a system aimed at improving activity and time management, and the relevant communication between caregivers and clients in this regards, was chosen as the main challenge for this project.

Motivation

Throughout my studies at Industrial Design, I have worked on various projects. Towards the end of my Bachelor's, I worked on a project for dementia. The target group interested me due to the obvious implications of their condition on their daily life. Furthermore, plenty of research already exists, which can support choices, ideation and reflection during the design process. Combined with the possibility of relatively low thresholds regarding getting in touch with the target group and testing prototypes, I consider designing for such a group to be an interesting challenge with possibilities of achieving great impact. My motivation in designing for ASD is based on similarities in these aspects. Although needs, wishes and personal traits differ greatly, I see resemblance in the design process and the potential of improving quality of life.

Figure 3. *GUIDEmentia, a previous project aimed at people with dementia*

I believe in the potential value of Assistive Technology to aid in the daily life of people coping with such disorders. Developments in technology related to sensing, analyzing data and actuating through digital information, haptic feedback or even robots continue to grow. Countless of applications, potentially significantly improving quality of life for many, can be developed using these technologies. I believe that effective development of such products and services, especially for people with mental or physical disorders, cannot be achieved without a human centered approach. Requirements, needs and wishes should be taken into account, and tests to compare options and validate approaches need to be performed. Development in tools for people with low-functioning autism is limited, and potential for improvement is abundantly present.

Goals

In correspondence with my vision on care solutions, the main goal of this project is to provide caregivers with a versatile and customizable tool. People are different, cognitive impairments develop differently and moods change. In the foreseeable future, care requires people who can recognize these elements and adapt their approach through their experience and empathy. A major goal of this project is to find synergy in the combination of human and technological care. Focus lies on supporting the caregivers, rather than taking over and automating tasks. The resulting product should provide caregivers with information and options, in order to allow them to define and execute the proper care for their clients. Although quality of care for the clients is the main criterion for measuring success in this project, efficiency is be taken into account as well.

The second main stakeholder in this project are the clients themselves. Interaction and communication in the proposed system concern both the caregivers and their clients. Foremost, the goal is to help the users understand their current situation and its upcoming shifts in order to avoid stress and incomprehension regarding these subjects. Furthermore, this project explores the possibilities in gathering input from the users of this target group, both consciously and unconsciously. Information helps caregivers to provide the best fitting care and approach for their clients, which benefits all parties.

Figure 4. *Client from Severinus during outdoor activity*
Available: https://www.severinus.nl/client/clientenraad/. [Accessed 9 1 2019]

Related work

Specific products and services for low-functioning autism are currently not available. Instead, parents, caregivers and therapists create environments, structures and activities for each individual. In certain cases, products designed for autism or dementia can be applied, such as simplified clocks or tablet computers. Complexity of most of these products is still too high for the target group of this project.

Difficulty with time planning is common in many disorders and not unique to ASD. Tools and tricks already exist, some as actual products, others as homemade solutions created by parents or caregivers for specific situations. One popular solution found in many homes are rectangular cards with icons describing activities, socalled pictos. When verbal communication regarding day planning does not work, these visual representations often aid in understanding [23]. Main advantages include the low cost in purchase and expansion, as many are homemade. Furthermore, it allows parents and caregivers to customize and personalize pictograms for specific needs and wishes. For daily applications, time and effort will have to be invested in order to maintain an up to date planning for people with ASD.

An effective and inexpensive product to visualize time is the Time Timer. Existing in various shapes and sizes with different features, its main use is for setting timers for up to an hour [24]. Instead of using numbers, the timer consists of a red disk which decreases in size as time passes. The timer provides an abstract representation of remaining time for people who cannot read traditional clocks. The timer is easy to understand and use, and applicable in numerous applications. Variants using additional colors and software-based Time Timers are available as well. Due to the timer being a relatively simple mechanical object, features are somewhat limited. Starting and adjusting the timer is carried out on the product itself, thus disturbing and potentially upsetting clients. For some clients at “De Bussel”, see-through boxes for the timers have been installed on the walls to prevent the clients tempering with them.

In conclusion, the most efficient tools for low-functioning autism consist or relatively simple systems that are widely applicable. Due to their simplicity, potentially valuable features are limited, and its use requires considerable effort from caregivers. Additional research and development is recommended.

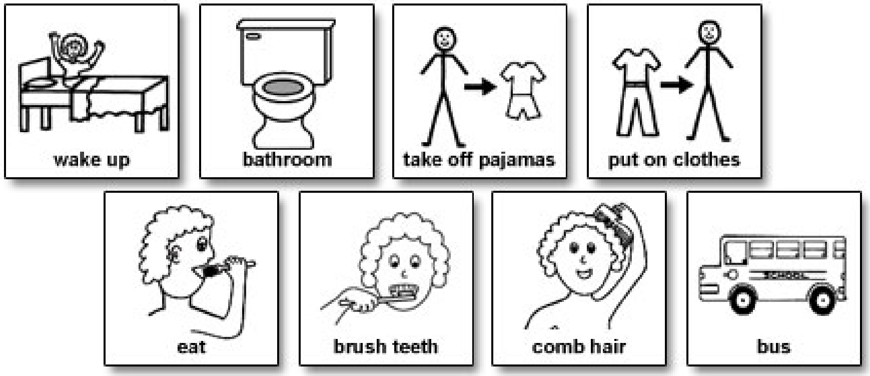


Figure 5. *Examples of pictos*
Available: http://thefirststeps.weebly.com/visual-support.html. [Accessed 9 1 2019]

Figure 6. *A Time Timer*
Available: https://www.reallygoodstuff.com/audible-time-timer/p/158138/. [Accessed 9 1 2019]

Learning goals

General

Caregivers are always looking to find the best fitting care for their clients, with time and planning proving to be relevant elements. Since clock reading and time management are known issues, time related solutions for people with ASD have already been widely researched. From discussions with the caregivers at Severinus, it can be concluded that overlap in tools and therapy between high- and low-functioning autism occurs, albeit in limited quantity. Timers designed for ASD are an example of such tools not fitting in care approaches for low-functioning autism. A major goal of this project is finding a more effective method of visualizing time for this target group.

Although time shapes the basis of this project, it explores communication of other types of information. The resulting system should assist people with low-functioning autism and their caregivers throughout their day, which is not limited to time alone. Based on observation and discussions with caregivers from Severinus, these additional types of information are defined [Appendix A]. Similar to finding a way of visualizing time, the medium and characteristics of the way this information will be communicated should be defined.

Furthermore, generating knowledge is not the main goal of this project. Instead, a feasible and realistic solution applicable in daily situations is developed. Implementation of such a system is a relevant problem since it should be capable of integration in a daily care context. Both practical and security related concerns are discussed and solved in cooperation with caregivers and relevant staff members at Severinus.

Personal

Throughout my education, I have developed an interest in designing for specific target groups in a healthcare context. I consider motivation easy to find in designing for groups that are relevant to design for, by providing independence and more pleasant and efficient care. Low-functioning autism is a common disability with extensive care requirements, both financially and in terms of effort. I believe that user centered design solutions could in various occasions positively impact their care. In order to realize such solutions, I am eager to discover design requirements, including similarities and differences compared to other cognitive disabilities.

This project is my first experience in designing for people for whom an organization, in this case Severinus, has responsibility. Due to the need for extensive user testing with this target group in order to retrieve insights, an ethical and safe approach in interaction with Severinus' clients was essential. Requirements for safety in the prototypes were provided, both in physical and privacy related aspects. Performing a project with such stakeholders and requirements in a professional manner is an experience I consider highly necessary and one that I reflect on for all future projects.

Approach

Every person is different, and additional cognitive disabilities only increase this difference. There is no single solution that solves the same problem for everyone. While the caregivers of people with low-functioning autism do not always understand their clients, they do possess valuable knowledge and experience. With that in mind, throughout the design process, this project has focused on applying caregivers' knowledge in the resulting tool.

The target group of this project is one which is difficult to communicate with. Although insights and knowledge regarding users during a design process generally do not solely depend on interviews with the target group, conversation is not an efficient tool at all for the users in this project [25]. Instead, insights were gathered through observation, both from the user's regular activities and during interaction with prototypes (interventions).

A framework for a proposed design process for ASD has already been developed and was applied during this project [26]. In practice, this framework shows similarities to most iterative design processes, although focus lies in the actual encounters with the specific target group. In addition to this, feedback and insights from caregivers at Severinus and experts were applied in ideation and evaluation phases.

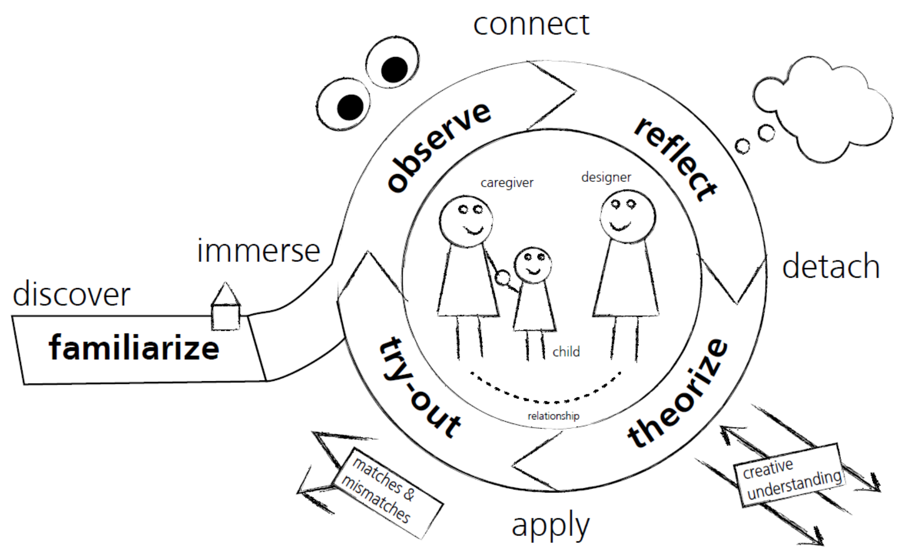


Figure 7. *A framework developed for autism related design processes [26, Chapter 7, Figure 1]*

> "If you've met one person with autism, you've met one person with autism."
>
> *Dr. Stephen Shore*

3. FINAL CONCEPT

The system

Taimo consists of a timer, a stress detection wearable and a managing application. Using the timer, caregivers are able to provide their clients with structure in their daily activities. The timer and its functions are wirelessly controlled using the managing application, allowing adjustments at any time without disturbing their clients. When caregivers are not present or otherwise occupied, the wearable will monitor the clients' stress levels and notify caregivers when necessary.

Taimo aims to find synergy in the combination of human and technological care. Rather than taking over and automating tasks from the caregiver, Taimo serves as a tool. It informs the caregivers who can then determine their approach based on this knowledge and their own experience.

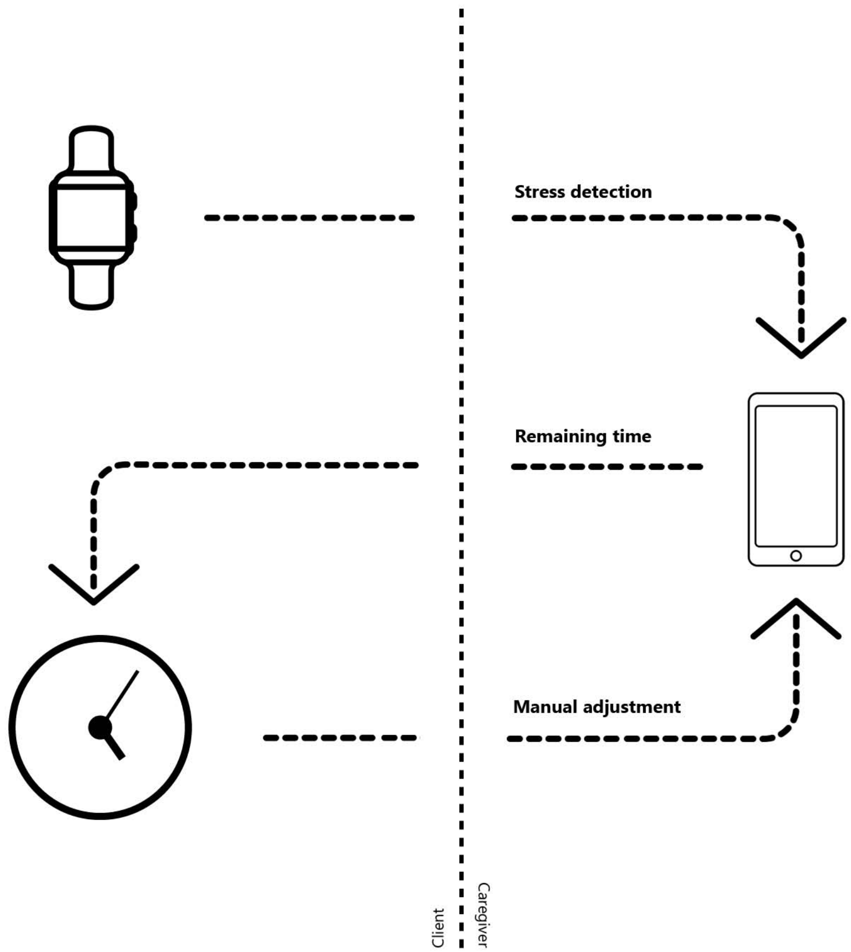


Figure 8. Overview of the Taimo system

The timer

The timer features six music icons, each representing a song. When a timer is started, depending on the amount of time, a number of icons will light up. The control knob in the center will rotate towards the last icon. Its corresponding song will start playing, audible through either headphones or external speakers. After a song has ended, its light will fade, the knob will rotate towards the next icon and its corresponding song starts playing. After the final song has ended, the timer is finished.

Managed by their caregivers, users are provided a certain amount of control over the timer. At any time, they can rotate the know forward- or backwards, thus extending or decreasing time. After a predefined number of songs have been skipped, the knob will block further rotation and continue its regular cycle.

Figure 9. *Front view of the timer*

Figure 11. System flow for timer

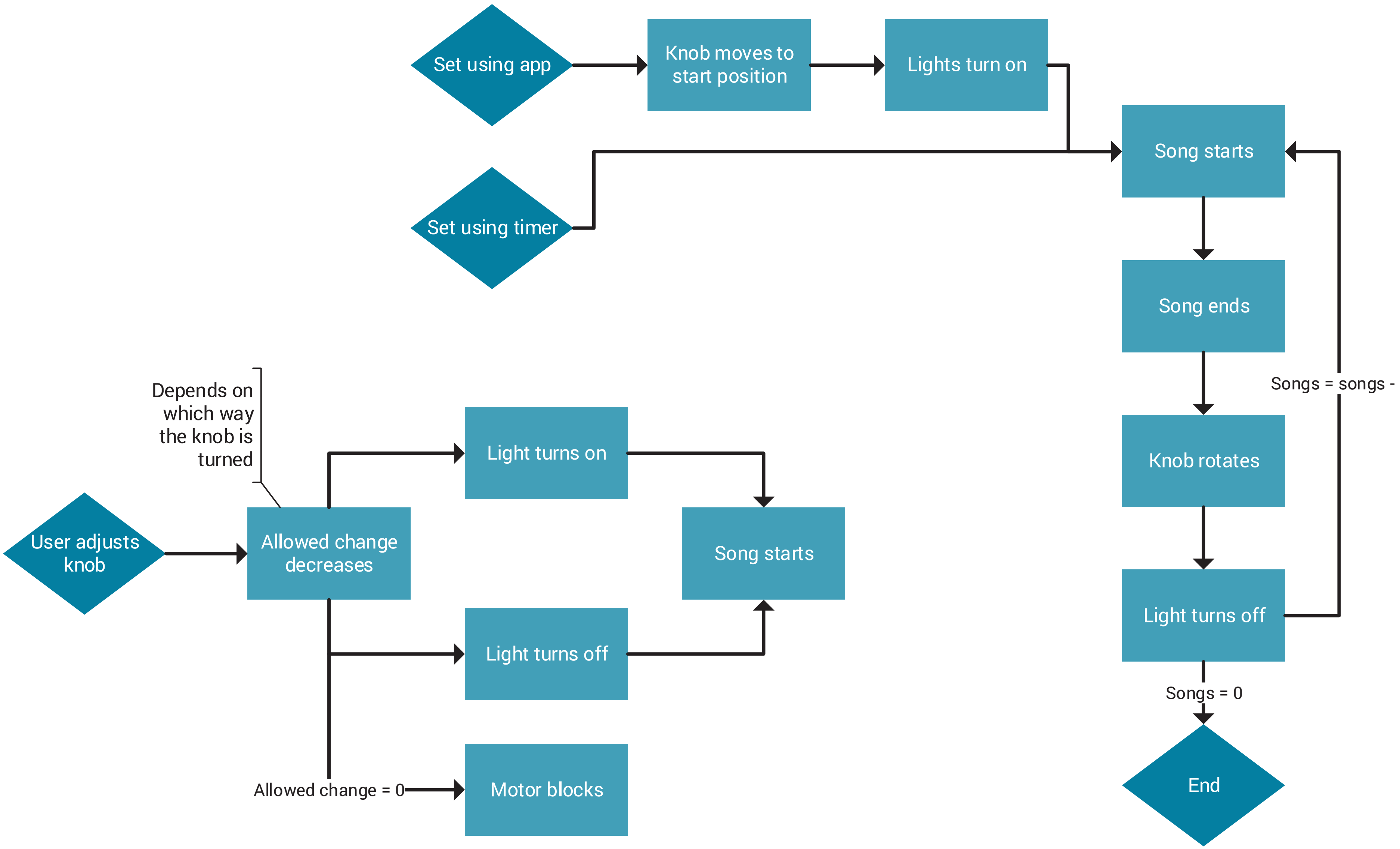


Figure 10. System flow for time adjustment

The application

The managing application allows caregivers to remotely start timers, setting its length and genre of music depending on their situation. After the timer has started, caregivers can at any time adjust that length. Instead of stopping the current song, the timer will fill the remaining time by choosing either longer or shorter songs, depending on whether time has been extended or decreased. In case of big changes in remaining time, it can alternatively skip or add songs.

In addition to managing the timer, the application is used for visualizing stress related data. When stress levels become excessive, or when clients adjust their timer, a notification will be sent to the phone. Based on the information the caregivers are provided with, they can decide on addressing the situation remotely or visit their client, depending on the situation.

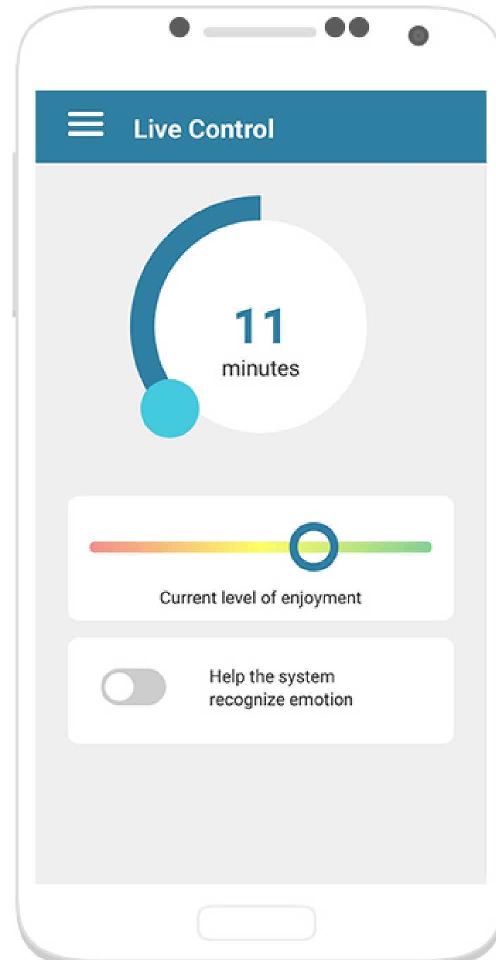


Figure 12. Main page of the application

4. DESIGN PROCESS

— February

◀ Observation

◀ First iteration

— April

First iteration

Exploration

This project started out by getting familiar with the target group, people with low-functioning autism. Initial goals were not set at the start of the project, but were developed in collaboration with the caregivers at Severinus as design opportunities were discovered. Since communication with the target group itself is not possible, these opportunities were gathered through observations [Appendix A] and discussions with the caregivers.

A large part of the client's day consists of activities such as playing with puzzles or color sorting games. In certain occasions, clients clearly indicated a desire to switch to a different activity as they lost interest in their current one. This often got denied by the caregivers due to the distraction it caused to the other clients. Supporting the caregivers in managing activities for their clients throughout the day served as a starting point for this project.

Concept

A first concept was generated. The main goal of this concept was to visualize the type of product and system that could be integrated as a realistic solution. Furthermore, I believed a first visualization would be useful in discussions with the stakeholders.

This concept was based on one of the main goals of Severinus, namely providing their clients with interesting, yet not stress inducing activities. The concept consisted of a simple color matching game combined with emotion sensing. Through sensing its users' state of mind, the game could increase or decrease its difficulty, thus adapting to their needs for challenge and tranquility. As a result, clients would be less inclined to get up and try switching activities, including the resulting disquiet.

Figure 13. Visualization of the first concept

— March

First iteration

Evaluation

— April

Evaluation

The concept was discussed with two caregivers at Severinus and the faculty coaches. Although the concept would be extremely difficult to properly realize and rather extensive for only one activity, the main insight proved to be the value in applying intelligence. Caregivers cannot always be present, for example when their client is in a secluded “Snoezel” room or when their attention is drawn elsewhere. Having an intelligent system keep an eye on their clients and registering emotions related to frustration, would in their opinion be a valuable addition to their delivered care.

Second iteration

Ideation

The main drawback of the first concept is its limited applicability. The resulting product would serve as a tool for a single activity. A possibility for greater impact was selected as an additional requirement for the next iteration. Difficulty in communication between caregiver and client was determined as a subject with major opportunity for improvement. Rather than creating one activity for Severinus’ clients, the resulting system would serve as a tool for all activities.

Together with the caregivers, the types of information that are valuable but difficult to communicate were determined. Remaining time for activities was among those. Existing timers are already being used to a certain extent, but unpractical in certain properties. Furthermore, caregivers do not always know when their clients are not enjoying their activity until their clients get up from their chair or draw attention vocally. Being able to detect such dissatisfaction in an earlier phase would aid in caregivers maintaining a stable environment for their clients.

The resulting concept includes a timer, visualizing remaining time for activities in a physical manner. Apart from visualizing time, the product allows clients to adjust remaining time themselves. The main goal is to allow clients to communicate content regarding their current activity to their caregivers. In order to avoid clients from disrupting overall planning, adjustment to the timer is limited.

On the caregivers’ request, the timer is managed using a smartphone application. Each caregiver already carries an employer issued smartphone, and remote controlling and monitoring reduces distraction to their clients. Using the application, timers can be started and adjusted. An additional feature here is that when remaining time is reduced for example, the knob on the timer will not shift to its new position directly, but increase the speed at which it is travelling towards the end position. As a result, caregivers can manage time for their clients without it consciously affecting them, avoiding possible distraction and frustration.

In addition to this, the previously mentioned stress detection is included in this concept. Using a wrist worn

— March

First iteration

Evaluation

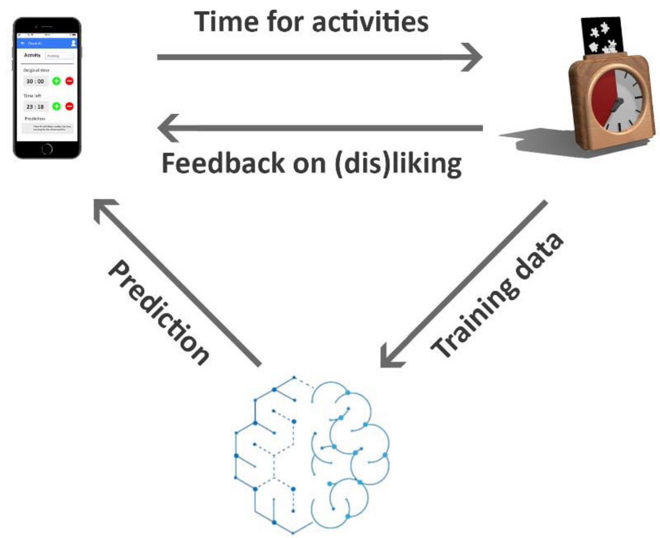
Second iteration

— April

wearable, several physiological parameters, such as electrodermal activity, heart rate variability and movement are measured and wirelessly communicated to the smartphone. Using individually optimized machine learning algorithms, this data will be analyzed and notify the caregivers when stress is detected.

Finally, predefined timers can be set for various activities. These timers are connected to activities through matching pictos featuring NFC tags. By placing a picto on the timer, it will automatically start the corresponding timer. By doing so, part of the process will be automated and become more efficient.

Figure 14. *The proposed system*



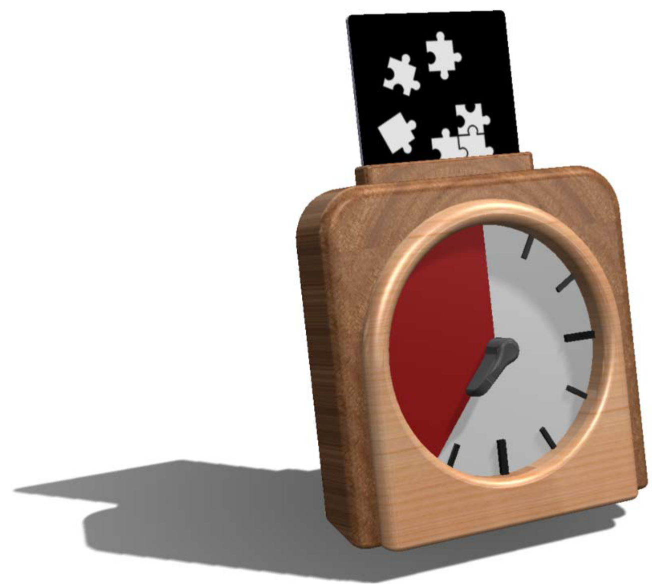


Figure 15. *Render of the timer*

— April

Prototype

Next to further defining the concept for this project, this iteration served as an experiment to determine an effective method of visualizing time for this target group, and allowing users to alter it. In order to find this method, three different ways of visualizing time were created.

The first timer resembles the previously mentioned Time Timer, with a red circular object slowly decreasing in size [24]. This type of clock clearly is somewhat based on a traditional analog clock, which may aid in a connection between the object and the concept of time. The pointer is 3D printed into a shape that is easy to grip, allowing for manual adjustment.

The second timer uses a linear way of visualizing time. Through the addition of a belt and pulleys, the same electronics can be used for linear movement. The timer will end when the arrow reaches the matching shape on the right of the clock.

Inspired by a fellow student's work, the third timer uses music to visualize time [27]. This clock is based on the fact that music has been successfully applied in other scenarios for autism, although mainly for children without additional impairment [28, 29]. The timer consists of six icons, each representing one song. After each song, the pointer will move to the next icon and the light at the previous icon will fade out.

Prototype development

Figure 16. Option 1, Time Timer

Figure 17. Option 2, linear time

Figure 18. Option 3, time through music

— May

— April

Prototype development

Initial tests

— June

Apart from an MP3 player and LEDs in the third prototype, each used the same electronics. The knob is powered using a NEMA17 stepper motor, controlled by an A4988 stepper driver. Stepper motors operate using several electromagnets, rotating by powering these magnets one after another. By disabling all magnets, the motor shaft can turn freely, in this case allowing users to adjust the timer. When at least one magnet is powered, the shaft will block this movement. Since knowing the position of the motor when rotating the shaft manually is not possible, a rotation sensor (rotary encoder) is connected to the motor shaft through gears. All components are connected to an Arduino Uno microcontroller and kept in place using lasercut and 3D printed parts.

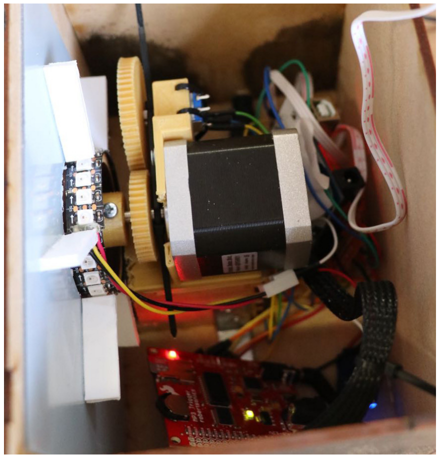


Figure 19. *Electronics in option 3*

The initial setup for the user test consisted of short sessions with observations. The clock was introduced by the caregiver of Severinus at the start of an activity such as puzzling, starting with the first prototype. The timer was set to 30 minutes, and the user was told that the activity would stop as soon as the timer finished.

For this user test, three users participated. For each user, the introduction to the prototype was different, as were the activities they were used for. The first user used the clock during puzzling. The user was somewhat distracted by the observer, seeking physical contact multiple times. He consistently checked the timer multiple times per minute and regularly pointed at it. The experience was very new and the user seemed enthusiastic to show the clock to his caregivers. The user was clearly distracted by a small indication LED on the adapter used to power the clock.

When the timer ended, the puzzle was replaced with a different activity and the clock was removed without struggle.

For the second user, the clock was introduced during an outside swinging session. At the same time, another client was being entertained with bubble blowing which significantly distracted the user, in addition to distraction of the active swinging itself. At no point during this session did the user seem to pay any attention to the clock.

The third user was introduced to the clock at the start of a “Snoezel” session. As per usual, the user was left alone in the room, and could be observed through a window. An uncomfortable gaze was clearly visible from the start, due to the abrupt addition of the timer to his room. Roughly a minute after closing the door, the user picked up the clock and smashed it on the floor, thus ending the session.

— June

◀ Start long-term user tests

— July

Evaluation

A long-term test plan was created in cooperation with Severinus' caregivers [Appendix B]. Due to the clients' sensitivity for changes in their environment, tests were performed by the caregivers. Parents and guardians were contacted to request permission for participation in these tests. Although permission was only given twice, the prototypes could be deployed for general use for other clients, thus providing the caregivers with additional insights.

As a result of the unfamiliarity of the clients with the prototypes, acclimation was necessary [30]. Each of the three prototypes was used for a duration of three weeks, during which caregivers kept track of development and remarkable events through forms. At the end of every three weeks, a short interview was conducted regarding the caregivers' experiences. A more elaborate session was planned at the end of testing the third option.

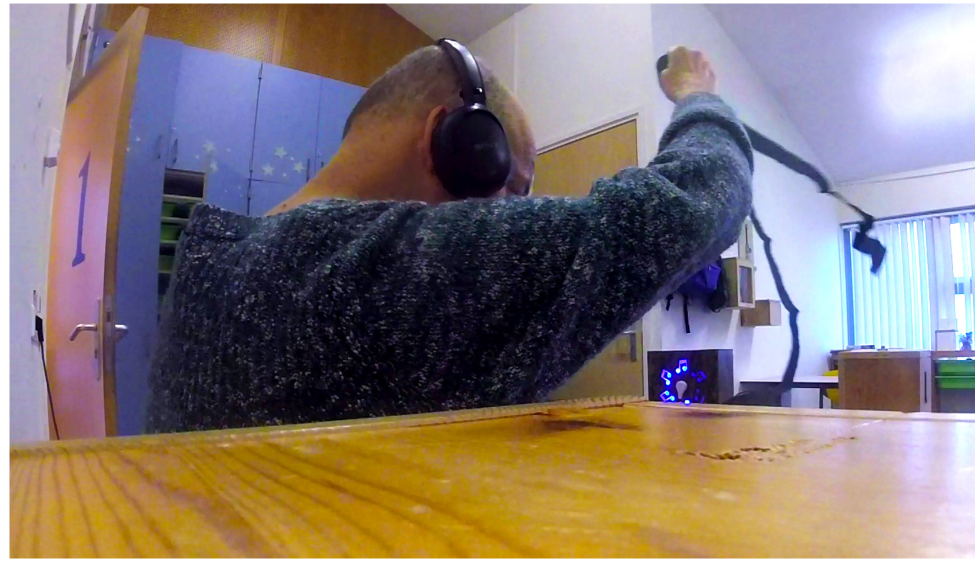


Figure 20. *Testing option 3*

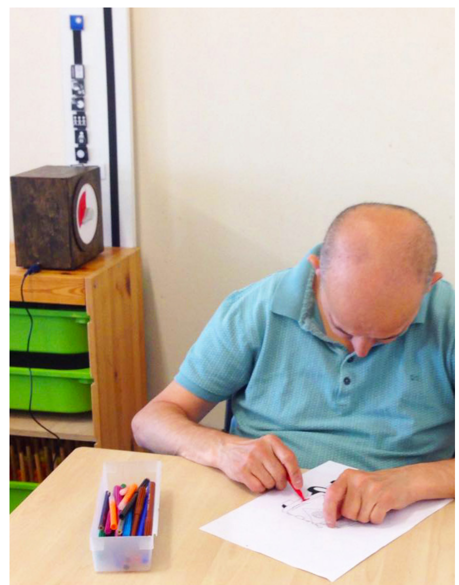


Figure 21. *Testing option 1*

— August

End long-term user tests

Meeting Kyra Frederiks

— October

Results

Most insights were derived from these sessions with the caregivers of Severinus, who best know their clients and the effect the prototypes had on them. The filled in forms served mainly as input for these sessions. Due to their usual workload, keeping up with these forms did not always happen consistently. The written comments did show a certain familiarization over time. Whereas initially the timer was somewhat ignored and sometimes misunderstood, for example mistaking moving to the next song on the third prototype with the timer ending, the caregivers considered the timers to be effective tools in the end.

Comments from both the forms and the discussions were grouped per prototype in Affinity diagrams to find differences in quality between the different versions [31]. Based on the results, a hierarchy from least to most effective option was clearly visible, and points for improvement were identified.

Video evaluation

One session, testing the final version, see figure 20, was recorded to simulate how this comparison would have been executed. Based on this recording, it was concluded that two cameras would have more thoroughly captured the session, one aimed at the front of the user, the other at the prototype. Data from this session could be summarized as follows:

The caregiver provides the user with a headphone and starts the timer, during which the user looks at the caregiver. After the timer has started, the user is no longer distracted by the caregiver and starts working on his activity, in this case making something out of fabric. The user interacts with the timer twice. When the motor block further adjusting, the user does not attempt any further adjusting. Both before and after adjusting the timer, the user regularly checks the timer, averaging at two times per minute (estimated value due to lack of sight on user's face). Throughout the session, the user is constantly working on his activity and not distracted by his environment, even when noises are clearly audible. At one point, the user briefly looks at the unfamiliar camera, but does not show signs of stress or further curiosity.

Would more of these sessions have been recorded, these conclusions would have been taken into account in addition to conclusions from the caregivers' comments. In this case however, due to the constant presence and observations of the caregivers during the tests, it is unlikely that these sessions would have influenced the choice for this part of the project.

Meeting Kyra Frederiks MSc

A meeting with Kyra Frederiks, PhD candidate of the faculty Industrial Design focusing on design for autism, was planned to discuss analysis of the previously mentioned user tests. Based on this meeting, the concluding advice consisted of video recording for one activity per option, each lasting around 30 minutes. Based on the recording, several aspects could be compared between the different versions, such as the type and amount of interaction with the prototype and time spent looking at the timer.

This approach was discussed with the caregivers but turned down at their request. From their experience, the best fitting option was clear and further comparing would merely disturb their clients. Mainly since this best option was tested lastly, returning to an inferior timer could be confusing. Furthermore, option one was already quite similar to existing timers and option two did not seem viable at all. The third option on the other hand proved a valuable addition, thus was chosen for the next iteration.

Affinity option 1

Time visualization

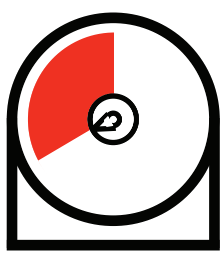
- Easily understood, little familiarization needed
- Similar to existing timer
- Timer ending not very clear
- User indicates timer ending

Interaction

- No interaction at first
- Needs verbal suggestion and gestures
- Rotates until motor blocks

Distraction

- Ticking sound sometimes distracting
- Light on power adapter distracts



The first option, similar to the already known Time Timer, seemed effective. After an acclimatization period, the adjusting of time was demonstrated to the users. Throughout the tests, this feature was used during most activities, for the majority to skip time. It remains difficult to say whether these weeks of testing have been sufficient for the users to fully understand this functionality and consider it a valuable addition to the concept.

Affinity option 2

Time visualization

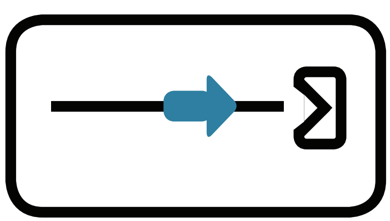
- Position on timeline less clear
- End of time less clear

Interaction

- Slower learning curve
- No independant time changing throughout test

Distraction

- Makes more sound in movement
- Less practical in size



The second option, featuring a linear way of visualizing time, did not seem effective both before and after acclimatization. A potential explanation for its ineffectiveness is an association between time and circular objects. Linear representations of time are commonly used, though most likely not in situations related to this target group.

Affinity option 3

Time visualization

- Each song switch draws attention
- Ending is clear, client tries to get caregiver attention

Interaction

- Faster familiarization
- Precisely rotating to next icon
- One client consistently skips unwanted song

Distraction

- More focused on actvity with headphone
- Long rotation between songs creates more noise

The third option, using music in combination with light, displayed similarities in effectiveness compared to the first option. This version was mainly used in combination with headphones to minimize distraction for other clients. As a result, caregivers noticed increased focus from their clients during the tests. Sounds and movements from other clients did not seem to influence them as much, and users spent considerable attention on their puzzles and similar activities. The users were still seen interacting with and looking at the timer and seemed at ease during the tests.

September

Meeting Erwin Meinders

Third iteration

November

Third iteration

Ideation

After choosing the third option, the concept was further defined. Until now, focus had been on the timer itself and less on the system around it. Based on previous discussions with the caregivers, components of the application were determined, for instance its different pages and the information on them. Furthermore, the application should allow for certain input and output, depending on a timer having been started.

Concept

The application consists of two main pages. The first page is used for managing settings such as predefined time per activity, the amount of songs that can be skipped and volume of the music. These settings are saved and connected to the individual profiles. The purpose of this page mainly includes managing settings that will not often need changing.

Meeting Dr. Ir. Erwin Meinders

Mentech is a small company in Eindhoven, developing Assistive Technology for care related applications. Currently, their main project concerns the development of an emotion recognition system for people with cognitive impairments using learning algorithms. Similar to the proposed direction in this project, it uses a wearable device measuring physiological parameters. Due to the similarities in this regard, a meeting with Erwin Meinders, managing director, was planned.

The main goal of this meeting was to find out how the technological aspect of emotion sensing could be applied in this project. Mentech uses learning algorithms with training data from both a general database and data for specific individuals, in order to personally optimize the system. The main lesson learned from this meeting was the complexity of emotion sensing for people with a cognitive impairment. Although Mentech is not a particularly big company, over a dozen employees are working on solving these problems. At the time of this meeting, however, a first demonstration identifying positive and negative arousal was approximately six months away. Due to their current setups requiring additional hardware in addition to a Windows computer, integration in this project was not possible either. Based on this meeting, the decision was made to keep the stress detection element in this project conceptual, and instead consider how the resulting information could be applied in a system.

Mentech

Innovation

Oktober

Third iteration

Evaluation

November

The second page is aimed at live control and divided in two. The initial screen features a dial representing the number of minutes for the timer. By dragging the blue circle along its path, caregivers choose how long the timer should run. After pressing the start button, a new screen appears. The dial is still present and will display the amount of time left as communicated by the timer. It can however also be used to change this remaining time. If possible, the timer will adapt by choosing different songs for the remaining time, i.e. pick longer songs when the remaining time is increased by the caregiver. If the change is too large for compensation, the caregiver is notified that a song will be added or subtracted.

Below the dial, an abstract representation of stress level is visualized. Using the color spectrum between green and red, it indicates a relative prediction of the stress measured at any time. Furthermore, a collapsible section for training the learning the system is present. As previously mentioned, the relevant learning algorithms rely on training data, which can be personalized. In situations where the caregiver is sure of either very positive or very negative emotions, he or she can teach this to the system by pressing the corresponding icon, which will save physiological data of the past 30 seconds. By doing so, the caregivers help improve the system, benefitting both the clients and themselves.

The application can provide two additional types of notifications, the first one being an alert when the timer was manually changed. Since changes in remaining time could affect the caregiver's planning, being aware of changes is rather relevant. The second notification occurs when high levels of stress are detected. There is always an abundant number of tasks and caregivers will not spend their time monitoring the application for its stress measurements. Since their attention is most likely required in situations where their client is experiencing stress, notifications will be sent in those moments.

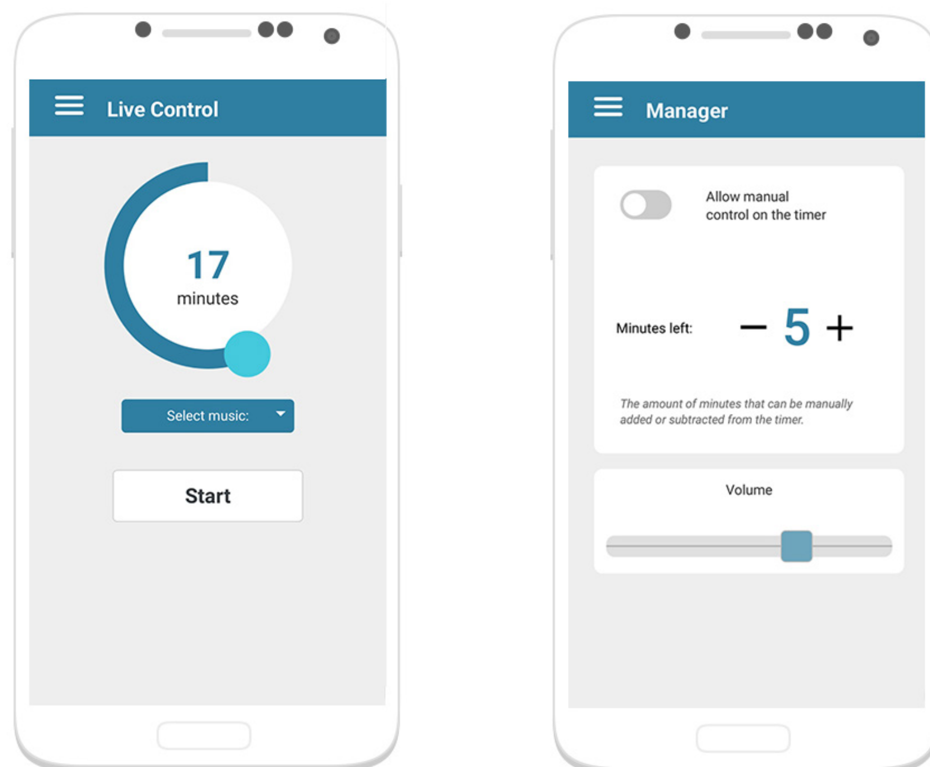


Figure 22. The main screens in the application

— Oktober

Third iteration

Evaluation

— November

Evaluation

The mockup version of the manager application was informally tested with two caregivers at Severinus. Both individually tested its functions and completed the actions of selecting a client, starting a timer and adjusting it. In the subsequent discussion, both provided their opinion with ideas for improvement. Additional questions next to their general sense related to their expected experience in a daily context, the value of the different functions and the effort required for its functionality.

One major insight consisted of a need for additional control over the timer. Specifically, both caregivers considered the ability to select different genres of music to be valuable. Depending on their clients' state of mind, they would for example like to choose between calm, happy and uplifting types of music.

Next to a wish for more control, the caregivers requested the removal of the pre-programmed elements. As mentioned in the previous concept iteration, the system would include pictos with predefined timers. When asked about the actual daily use of such a system, the caregivers indicated that time per session depends on more variables than solely the type of activity.

Instead, the caregivers preferred to determine time per session themselves, based on their perception of their client's mood at that time, as well as fitting the overall planning of their day. As a result, personal profiles in the application were removed for this, satisfying requests for absence of any personal details in the application. For future implementation, such profiles would be required in order to store variables for volume and the amount of songs that can be skipped. Furthermore, these profiles would be required for stress detection based on personal training data. Therefore, agreements with ICT and privacy departments of Severinus would have to be made in future steps.

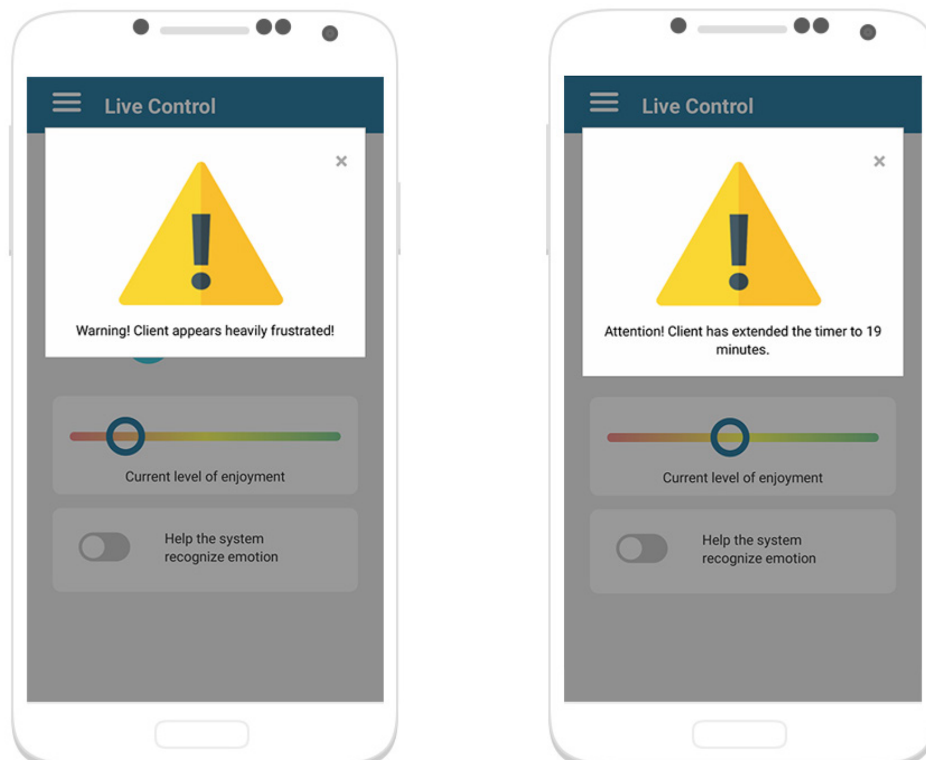


Figure 23. The notification possibilities in the application

— October

◀ Fourth iteration

— November

Fourth iteration

Ideation

The final part of this project focused on material choice for the final prototype. Feedback on the previous prototypes provided certain requirements for these aspects, such as a need for minimalism, rigidity and safety. Since these requirements left sufficient room for exploration, a brainstorm session together with the caregivers at Severinus was prepared.

In order to visualize possibilities, several explorative material samples were prepared. Using various materials, such as wood, fabric, felt, acrylic and silicone, different parts of the final prototype were created at a smaller scale. The prototype consists of a front panel, a middle body, a back panel and an optional protective cover. Each of these elements was created as a puzzle piece, allowing for quick exploration of combinations during the ideation session.

Figure 24. *The material explorations for the final prototype*

— October

◀ Fourth iteration

◀ Evaluation

— November

Evaluation

Insights from the ideation session were largely based on comments and preferences from the caregivers. After trying various combinations, black acrylic panels and dark colored felt around the center of the prototype were selected as materials of choice. The minimalistic look features some appealing soft elements and offers clear contrast for the music icons.

Furthermore, the caregivers considered a protective cover to be essential for the timer. The samples from the ideation session only covered the edges of the front and back panels, which would not suffice according to the caregivers. Additional pieces along the center body of the prototype were added for additional structure and protection. In addition to this, the color of the silicone would be darkened to better match the appearance of the timer.

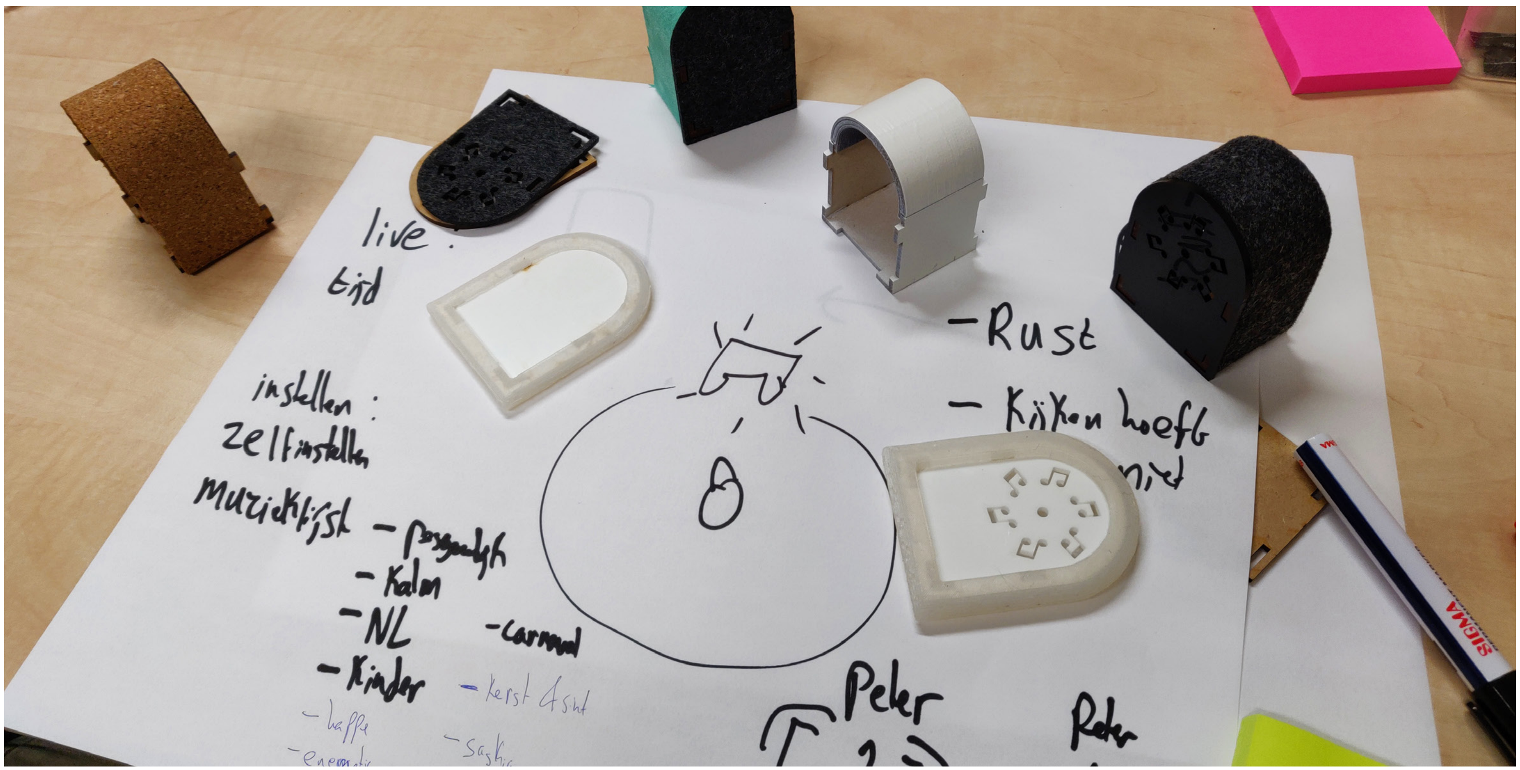


Figure 25. Evaluating materials with the caregivers

— November

Start final prototype

Demo day

— December

Final Prototype

Electronics

In order to establish a connection to the managing application, a local wireless network was created using an ESP8266 based microcontroller [32]. Since this network is not connected to the internet, security and privacy risks are significantly reduced. Using Arduino IDE, a websocket was established, enabling back and forth communication between the timer and the application [Appendix C] [33]. The application itself was developed as a website using HTML, CSS and Javascript [Appendix D].

The sensors and actuators used in the final prototype are quite similar compared to the previous prototypes. It features the small addition of a push button, which is used to find the starting point of the timer's knob.

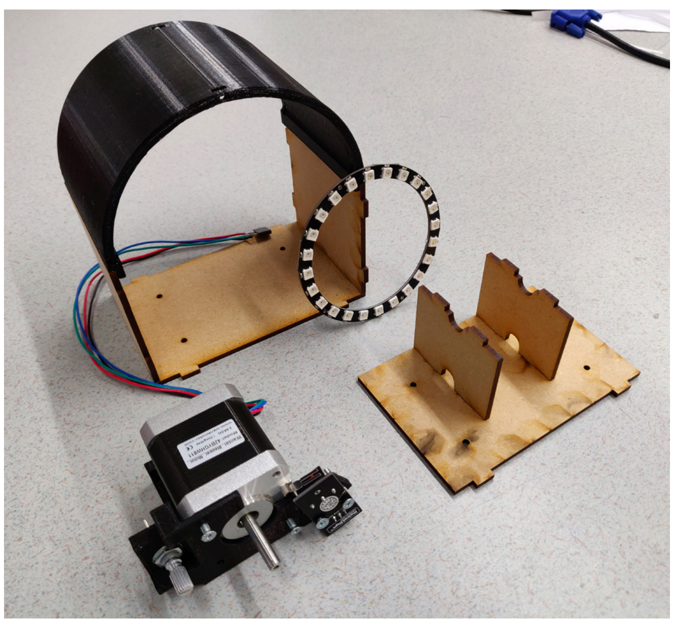


Figure 26. The components of the final prototype

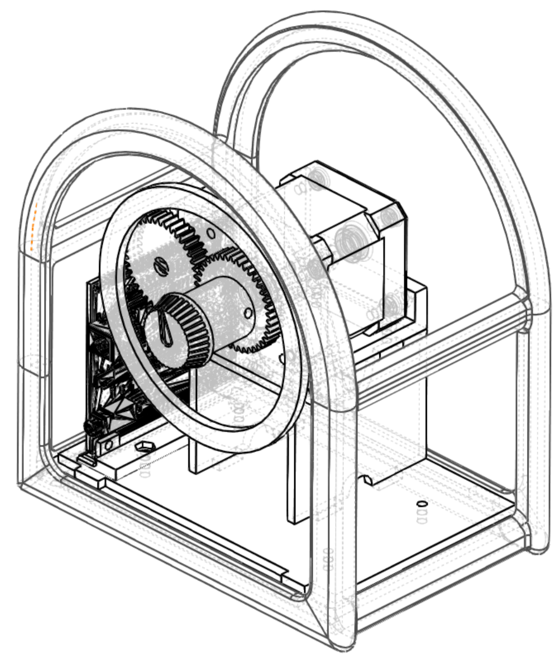


Figure 27. 3D model of the final prototype

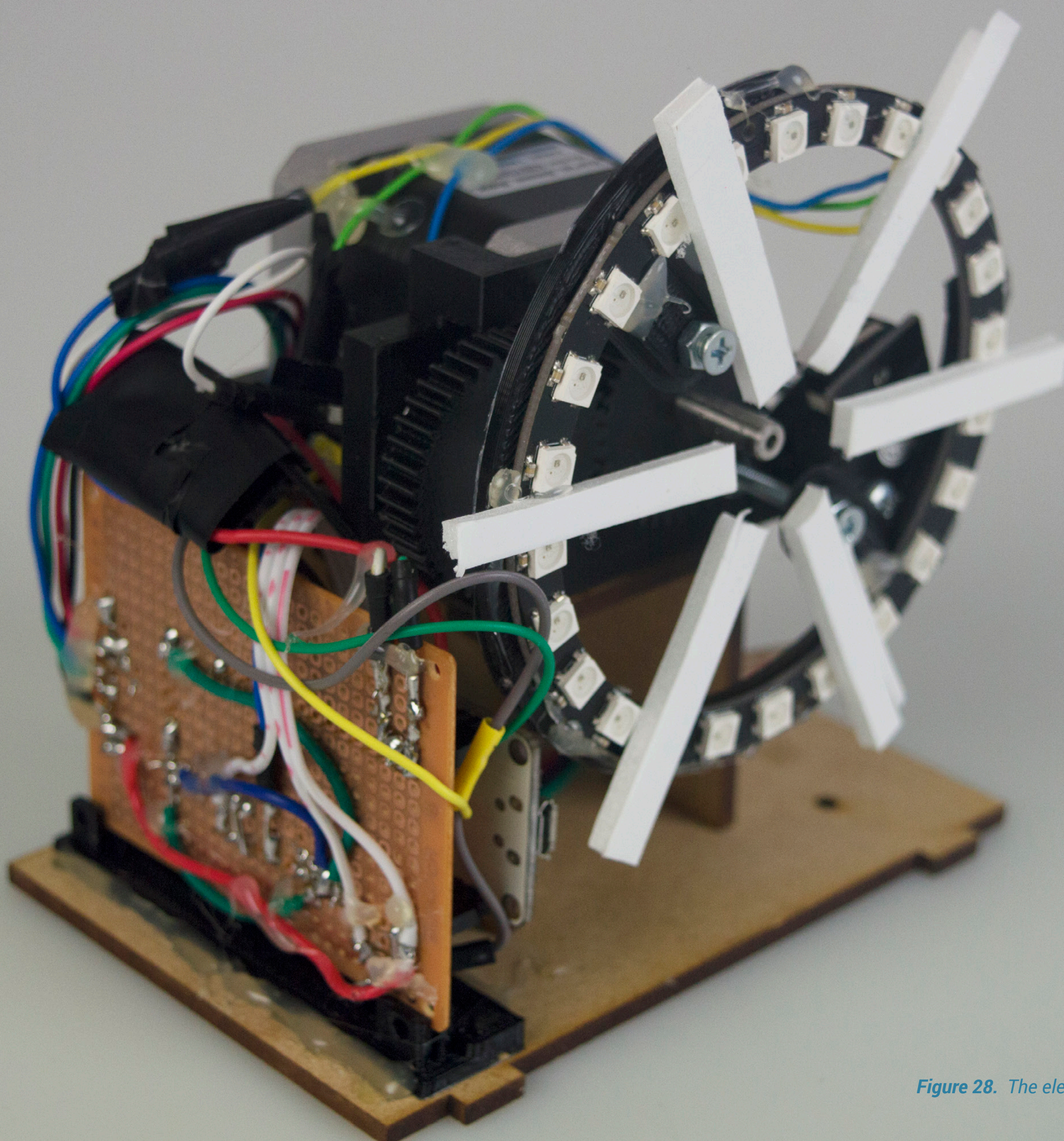


Figure 28. The electronic components of the final prototype

Product

For the final prototype, a previously explained combination of grey felt and black acrylic was chosen, providing a discrete and clean appearance. Similar to the previous prototypes, structure and mechanics were created using a combination of 3D printing and laser cutting.

As per request of the caregivers, a protective cover was created additionally. Based on a 3D model of this cover, molds were modelled and 3D printed. These molds were then filled with silicone which, after demolding, formed half of the final cover. This process was performed twice, consequently gluing the two halves together. The material's properties assure an impact resistant material, protecting both the timer itself and others, should the timer be thrown.

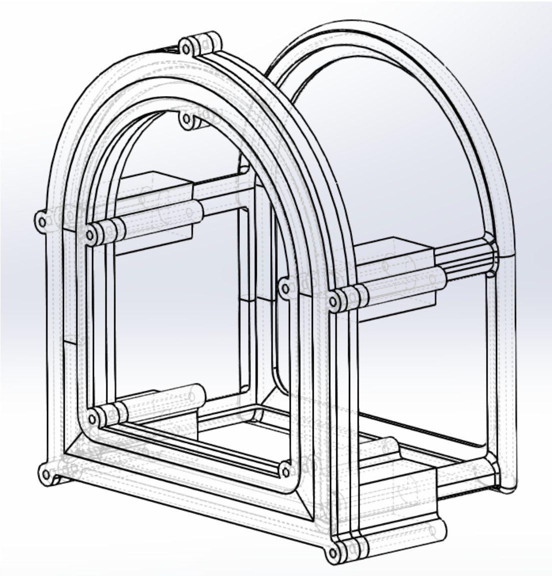


Figure 29. *3D model of the mold for the silicone cover*

Figure 30. *Close-up of the final prototype*

5. RATIONALE

Music

Clients are rarely alone and generally share a room with fellow clients during their day care. Due to the amount of activity in these spaces, their various senses are continuously triggered. Headphones playing music are already a common solution at Severinus to reduce ambient noise and decrease overstimulation. Furthermore, music has shown to have a positive influence on various types of therapy for autism [28] [29]. This knowledge provided the main motivation to combine this tool with the timer. Furthermore, the option to choose different types of music adds personalization to further optimize the experience for the users. Depending on their client's mood, a caregiver can then decide on a type of music best fitting their personal preference and current state of mind.

Light

During observations at the care facility, indication LEDs in a vehicle seemed to attract attention from the clients. Although these were somewhat bright and caused distraction, lights could serve as an effective indication method when applied properly. The main motivation for a second modality in reporting remaining time is flexibility for the caregivers. In certain situations, quiet may be preferred. A basic method of visualizing remaining time would then still be available by starting a timer without providing the client with headphones or speakers. Furthermore, the lights add meaning to the music, since without knowing how many songs are left, remaining time cannot be determined. Although the control knob features an indicating arrow as well, it is less likely to be associated to remaining time, mainly since no end position is visible. Throughout the user tests, the lights appeared effective without causing any distraction to its user or other clients.

Material

An important requirement for implementation of a physical object in an unpredictable context is its safety to other and resistance to impact. Under certain circumstances, people with low-functioning autism can get frustrated, which can lead to undesired escalation [34]. Frustration can be expressed verbally and physically, which can include throwing with objects in their vicinity. Such objects should therefore not be harmful, nor break, when thrown or dropped. Silicone is a popular and inexpensive solution to protect electronics and other objects in such situations, with the capability of being formed to various shapes and colors.

Main requirements for the other materials consisted of a minimalistic but attractive appearance. Felt was chosen to provide a soft touch to the product, which could become water resistant with some post processing. The front and back panel of the prototype were created using black acrylic, featuring a clean surface with sufficient contrast for the music icons. Decisions for these materials were greatly influenced by comments from caregivers in order to ensure a result matching their expectations and requirements.

6. DISCUSSION

User testing

Due to the aforementioned difficulty in gaining insights from the target group, the amount of user tests was limited. The amount of time it took for users to get familiar to the prototype to a point where insights could be gathered, exceeded initial expectations. Furthermore, people with low-functioning autism is a sensitive target group. Users required permission from both their parents or guardians, as well as from Severinus' caregivers to partake in research. For their personal wellbeing, approaches for user testing were developed in cooperation with the caregivers, aimed at minimizing potentially upsetting scenarios. For compensation, the caregivers were more intensively integrated in the design process during ideation and evaluation. However, for validation purposes in future steps, a more elaborate user testing phase should be added to this project.

Light

A direct manipulation of time is a straightforward and relatively simple way of interacting with the system described in this report. While complexity should indeed be avoided for this target group, interaction from its users could be explored in various other ways. More indirect and less conscious interaction, by for example measuring the way users touch the timer, could provide interesting directions to explore. The choice to not further explore these options during this project was a conscious one. The system that was created for this project consists of several elements, each with their own features. Optimizing each feature would take far longer than intended, thus it was decided to keep certain aspects conceptual or in their first iteration.

Material

The choices for the materials and shapes used for the final prototype were based on feedback from the caregivers at Severinus. While their experience based opinions were well substantiated and materials did not seem to heavily affect the clients in previous prototypes, it should be noted that these aspects of the prototype remain in an early phase. A balance between inviting for interaction and serving as a peripheral informing device is required for a successful application. Contrast in color, size and shape of the control knob and light intensity for example each influence this balance. Similar to the previously mentioned need for additional user testing, iterations and further testing regarding the physical aspects of the final product are necessary.

7. CONCLUSION

As can be concluded from the previously described results, the alternative representation of time presented in this report seemingly works well for people with low-functioning autism. A main hurdle to overcome in this regard was finding a balance between a peripheral object without distracting clients from their activities, and providing them with a useful tool for their personal planning and overall peace of mind. Compared to traditional clocks, Taimo is more notable due to its moving objects and light output. Based on the video recording and observations from the caregivers however, this balance does seem to be present. Clients are able to focus on their activity, interact with the timer when they feel a need to, and afterwards are able to return to their activity. For daily care applications, Taimo can therefore be declared a valuable addition.

Drawing conclusions regarding the system revolving around the physical timer is more complicated due to its extensiveness. First and foremost, a general consensus about the value of stress recognition for cognitive disabilities is present. The lack of concepts for care applications is mainly caused by the current state of the art regarding this technology, which is not ready for applications.

The suggested application presented in this report was mainly developed through insights gathered from caregivers. The main conclusion in this regard consisted of defining when and how this information should be communicated, in this case mostly concerning moments with high stress levels. The remaining elements and interactions were developed in a similar manner, taking into account what information should be relayed and how to efficiently achieve this.

In conclusion, intelligent solutions for people with low-functioning autism show great potential. besides the practical solutions proposed in this report, a that lesson I believe can be learned from this project is the approach that should be taken throughout the design process of such products and systems. Incorporating caregivers in the concept, rather than trying to find a solution aimed solely at the end user, both simplifies the system and improves its effectiveness. It decreases time and effort spent in developing automated features which are difficult to properly design and rarely work for everyone. Furthermore, Taimo includes knowledge on a personal level, between caregiver and client, which is not replaceable by technology.

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APPENDIX

Appendix A - Observations

The following is a summary of observations during a regular morning at “De Bussel” over a four hour period.

The room facilitates five clients, managed by two caregivers. Each client has a personal table separate from the other clients’ tables. One of the clients takes a box from a closet himself and starts playing with its contents, the others receive one from the caregivers. Two of the clients are rather curious towards me. They approach me when we first see each other and touch my hands and face to examine me. One of the clients does not seem comfortable with my presence, shown by suspicious gazes and by throwing a paper tissue in my direction. The remaining two clients pay no attention to me. None of the clients pay a lot of attention to each other.

The types of activities include sorting pons by three different colors, playing with Duplo building blocks and making a puzzle with rather large wooden pieces. The clients have different cognitive levels, which show in the type of activities. The puzzle is the most complex one. Although progress was made, it was not completed in the approximately 30 minute activity.

Four out of the five clients use pictograms, which are placed on their desk or hung on the wall using Velcro. Besides showing their current activity, they can be placed next to each other, to visualize a general planning. The caregivers use verbal communication as well, often supported by gestures such as pointing. These types of instructions, such as requests to sit down, are not always effective and need additional physical guidance from time to time.

All clients produce vocal sounds nearly continuously, each in their own way. Through differences in pitch and volume, senses of frustration or enthusiasm can be derived from these sounds. One of the clients pronounces different words, mostly the same with slight variations, and without a real meaning to them. Some of the clients are rather expressive in their physical behavior as well. Through stomping their feet and slapping their hands on the table, the perception of enthusiasm in certain cases is enhanced.

A sense of frustration was perceived when certain elements of the room were different from what they should be. One client got rather upset over a pair of shoes which placed at an irregular spot, since they needed cleaning. Similar reactions were seen when doors were not closed. During a small bus trip to a forest where we went for a walk, an indication light on the dashboard was switched off. One of the clients kept pointing in its direction, accompanied by frustrated sounds, until it was switched on.

APPENDIX

Appendix B - Test plan

Different types

For this project, Tim will test three types of visualizing time. The end goal is to indicate remaining time for clients, which can be adjusted by both the client (self-management) and caregivers (remote).This way we can more accurately understand the clients' needs. If we choose to extend the remaining time for an activity, the clock will simply tick slower without changing its current state. The same can be done the other way around.

With regards to the client changing the time, margins can be set beforehand. For this test, the limit will be five minutes.

The first prototype has a round shape, similar to timers we have already used. Time will be visualized solely using a red shape decreasing in size.

The second prototype uses a linear approach. An arrow will move from left to right. A matching shape at the end of the line indicates the end of the timer.

The third prototype uses a round shape featuring six music icons. Each icon symbolizes a song which can be personalized per client. Time can be set by the amount of songs per timer. Each icon lights up when it has not yet been played. After each song, the pointer will move to the next song and the light will dim.

Phases

Each of the prototypes will be tested in two phases:

1. Testing without client adjusting time
2. Testing with client adjusting time

Each of the prototypes will be tested for 15 days. In the morning Bussel 1 will test with Peter during his puzzles, watching TV and drawing. In the afternoon, Bussel 3 will test with Zakaria during his game activities. Including the second phase can be done when the basics of the clock are understood.

Tim will regularly pick up the prototype in the afternoon and return it in the morning. The prototype will be stored in the office so it can be picked up and returned without disturbing clients.

Prototype 1
May 31 – June 20

Prototype 2
June 21 – July 4

Prototype 3
July 5 – July 25

APPENDIX

Appendix C - Arduino code

Appendix D - Application code

https://drive.google.com/open?id=14lpEt9oSrTKhS84Z8_
Z7k5hiWaZsMuNB