Get moving with the Oura Ring

Re-designing the interaction with the Oura ring through co-creation to motivate older adults to increase physical activity.

BSc Thesis Creative Technology
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mocia
healthy lifestyle, healthy brain

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Preface

First and foremost, I would like to thank my supervisors Lara Siering and Femke Nijboer for their support and guidance through this research. I am very grateful for all the meetings and feedback you gave me throughout this project, it gave me motivation to finish it.

I would also like to thank Bas Beld for helping me with finding participants during a somewhat difficult time with COVID-19. Together we managed to find enough participants and I could test the prototype at a place close to them.

Lastly, I would like to thank all the participants that participated in my ideation and evaluation session. Without your insight and opinions, I could not have made this project happen.

Abstract

Physical activity can play a crucial role in the process of healthy ageing. It can be a preventive factor against noncommunicable diseases such as cardiovascular disease, stroke, diabetes, types of cancer and neurodegenerative diseases. Yet only half of the Dutch population complies to the prescribed guidelines. Smart wearables, like the Oura ring, can play an important role in the motivation of physical activity. However, the interaction with these smart wearables lack inducement as adoption among older adults seems to stay behind.

This study aims to re-design the interaction with a smart ring to motivate older adults to increase physical activity.

The co-creative technique of contextmapping as described by Sleeswijk-Visser and colleagues (2005) is used to conduct generative sessions with seven older adults to gather insight about their attitude and opinion towards interaction with digital technologies and physical activity. Analysis resulted in five themes that affect the older adults' interaction with digital technology: intrusiveness, individuality, autonomy, utility, and usability. Together with relevant literature regarding design suggestions for older adults, these form the bases for the development of an interactive wall clock was that shows the progress of a predefined goal of steps in a circular way using a LED-strip.

Evaluation with six older adults indicates that the double function of clock and motivator encompasses utility and makes it non-intrusive. The straightforward but undemanding insight of a user-defined goal allows the user to maintain its individuality and acknowledges autonomy, and the clear and colourful visuals mitigate misunderstanding and therefore can be experienced as highly usable.

While improvements and recommendations are indicated, the prototype is experienced as clear, potentially motivating and excellently usable with a SUS-score of 87,1. Therefore, it is suggested that by using the co-creative method of contextmapping, an effective and motivating interaction with the Oura ring can be designed.

Table of Contents

Table of Figures

1. Introduction

1.1 Introduction

In 2014, the World Health Organization announced a new pandemic: the pandemic of inactivity. Worldwide, one in four people do not perform the amount of physical activity as prescribed (WHO, 2014 and Boulton et al., 2017). Since then, not much has changed as by 2020 only half of the Dutch population met the physical activity guidelines (CBS, 2020). As people live longer, it is more important than even to spend the additional years in good health and support a high health-related quality of life. As widely elaborated in the book *Hart voor je Brein* by Erik Scherder and Leonard Hofstra (2020), physical activity can play a crucial role in this process and therefore enable healthy ageing.

Physical activity is defined as any skeletal muscular movement that results in energy expenditure. It includes exercise, sports, and other physical activities that are conducted as part of one's daily routine, occupation, leisure, or active transportation (Caspersen et al., 1985).

The health advantages of physical activity are well established. Increased levels and frequency of physical activity are related with a decreased risk and enhanced health in a variety of key areas. Physical activity is a preventive factor against noncommunicable diseases such as cardiovascular disease, stroke, diabetes, types of cancer and neurodegenerative diseases such as Alzheimer and dementia. Regular physical activity is also connected with improvements in mental health, emotional, psychological, and social well-being, as well as cognitive function (Kruse et al., 2019; Nieman et al., 2005; Alack et al., 2019; Yan et al., 2001; Klentrou et al., 2002).

While physical activity can lead to a significant increase of health among all ages, most of these diseases or in inabilities occur in the later stage of life (WHO, 2021). Therefore, physical activity is even more beneficial for older adults to help prevent these diseases and slow down cognitive decline and functioning.

Bennett and Winters-Stone (2011) described multiple ways to motivate this age group to perform more physical activity. An example includes an individual approach where older adults participate in a motivational training and are called afterwards through the week to keep motivated. While these efforts eventually led to an increase in physical activity, they still require motivational counsellors and health practitioners to do so.

Nevertheless, a more individual approach to increase the amount of physical activity can be achieved with e-Health technology (Marchant et al., 2021). E-Health enables feedback, insight, and communication about physical function, allowing the user to be more aware of its personal circumstances. An example of this e-Health technology that is central in this study are smart wearables. They can measure and communicate information regarding physical performance to the user and research has provided support that wearable devices can be beneficial to the user. They can enhance users' physical activity through monitoring progress, sending motivational notifications, providing social support, and other tested techniques (Cadmus-Bertram et al., 2015; Lyons et al., 2014; Mercer et al., 2016; O'Brien et al., 2015). Therefore, e-Health, and in particular smart wearables, can be an effective way to stimulate to more physical activity.

Despite the known benefits for older adults, wearable devices are primarily appealing to the younger generation. In the United States, 17% of users are between the ages of 25 and 34, while only 3.3% are 65 years or older (Wurmser, 2019). While there do not exist exact numbers for the Netherlands, the overall adoption of e-Health in general stays behind with only 1 in 3 older adults making use of e-Health technology in their daily live (ZBVO, 2019).

Looking at literature, multiple explanations for this phenomenon can be distinguished. First, older adults seem less likely to adopt new technology unless they see benefits to themselves (Heinz et al. 2013). Second, older adults often lack confidence in using computer technology and perceive difficulties when using new technologies (Barnard et al., 2019). This could ultimately result in older adults not implementing or adopting a new technology, such as a smart wearable, in their lives. Third, besides not implementing the technology in the first case, the perceived difficulties could lead to discontinuation of use. A qualitative systematic review of Moore et al. (2020) reviewed twenty papers and several e-Health technologies. Several factors influence the acceptance and use of wearable devices by among older adults. These include: intrinsic and extrinsic motivation for device use, ease of use, device purpose, and perceived added value to the user's life. They state that designers should be aware that useful device features alone do not lead to continued use. They suggest that a support structure should be designed around user that for improves motivation, encourages engagement with peers, and adapts to the user's preferences.

For this research the smart wearable being used is the Oura ring as seen in figure 1. It is a smart ring which main measurements are sleep, physical

activity, and heart rate. It communicates this data to an application on a smartphone, as seen in the snapshot in figure 1.

Figure 1 - Oura ring with application (Oura, 2022)

The goal of this research is to determine how the interaction with such a smart wearable ring should be designed to stimulate older adults to motivate in more physical activity in their daily lives.

This project is part of the 'Maintaining Optimal Cognitive function In Ageing' (MOCIA) research program. A NWO crossover programme, which has the aim to strengthen the Dutch knowledge and innovation system. During the seven-year programme (2020-2027), MOCIA research will result in a predictive, preventive, personalised and participatory multidomain lifestyle intervention for older adults at risk of cognitive decline.

1.2 Research Questions

The main research question is:

RQ: How should the interaction with a smart ring be designed to motivate older adults to perform more physical activity?

To answer this research question, sub-questions are:

SQ1: What is healthy ageing?

SQ2: What type and quantity of physical activity is needed to improve one's health?

SQ3: How do existing interaction technologies engage the user to be physically active?

SQ4: How do older adults imagine the interaction with a smart ring that motivates physical activity?

Sub-question 1, 2 and 3 will be addressed with a literature review and analysis of existing technologies. Sub-question 4 has a more human centred approach and makes use of a co-creation.

2. Literature review

2.1 Ageing

At the biological level, ageing results from the impact of the accumulation of a wide variety of molecular and cellular damage over time. While certain cells are reproduced over a lifetime, the organisms that perform that process likewise age and lose their effectiveness (Jin, 2010). This natural process gradually reduces physical and mental capabilities, increases the risk of disease, and eventually results in mortality.

Healthy ageing

Cell modifications and degenerations are complex and cannot be plotted linearly over the course of a person's life. While ageing is frequently connected with age, it often has little to do with a person's actual age in years. It is preferable to consider the inner organisms and processes involved in this cell regeneration. Nevertheless, to give a nuance to this process, literature distinguishes multiple ways in which an individual can experience ageing, such as healthy ageing.

The field of healthy ageing is broad and features different aspects and perspectives. The World Health Organisation made an infographic which describes the different factors and requirements for healthy ageing which will serve as guideline for this elaboration (WHO, 2014).

First, it is stated that there is a distinction between individuals in their ageing process, as illustrated in figure 2. In most literature, age is considered as the number of years from the date of birth, also known as chronological age. However, cognitive age is a better measure of predicting the behaviour among older adults (Hong et al., 2013). This cognitive age refers to the individuals' self-perception of their age.

Figure 2 - Individual aspect of ageing (WHO, 2014)

Second, the two main factors influencing the health on older age are the individual aspect and the environmental aspect, as seen in figure 3. On the one hand there is the individual which could experience physical and cognitive change due to genetics or disease. Likewise, the behaviour and the things an individual does or does not do, influence the way the body functions. On the other hand, there is the environment and resources available for the individual such as assistive technologies and adaptive housing.

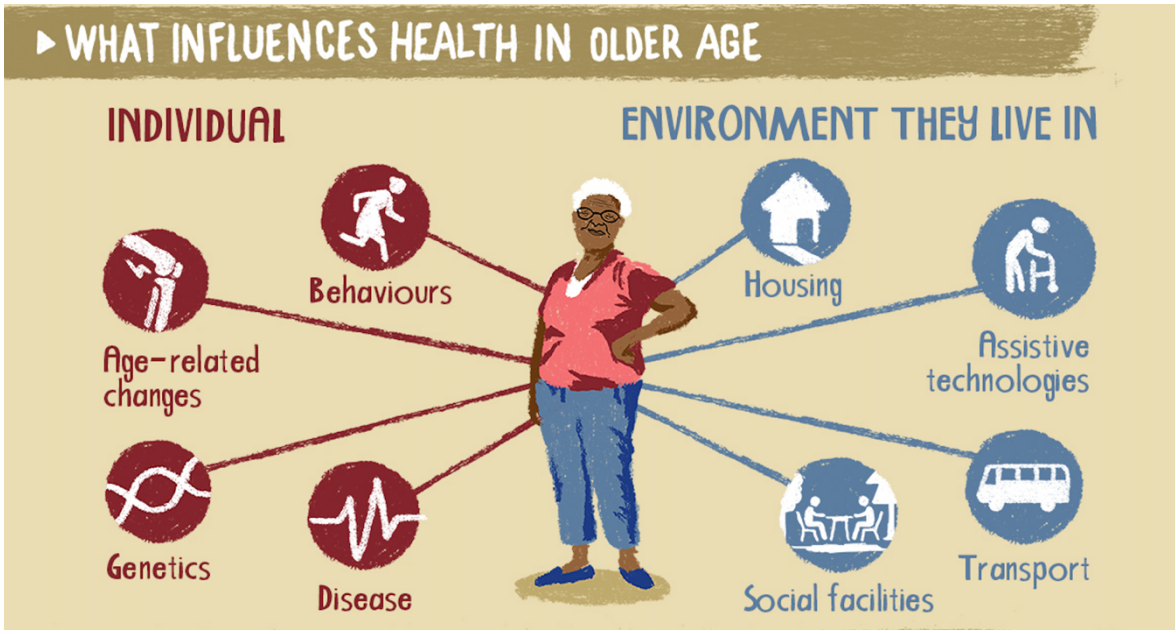

Figure 3 - Influences of health (WHO, 2014)

Lastly, as seen in figure 4, the WHO state that for healthy ageing to succeed there are four essential requirements. 1) A change in how we think about ageing and older people, 2) The creation of age-friendly environments, 3)

Alignment of health systems to the needs of older people and 4) The development of long-term care systems.

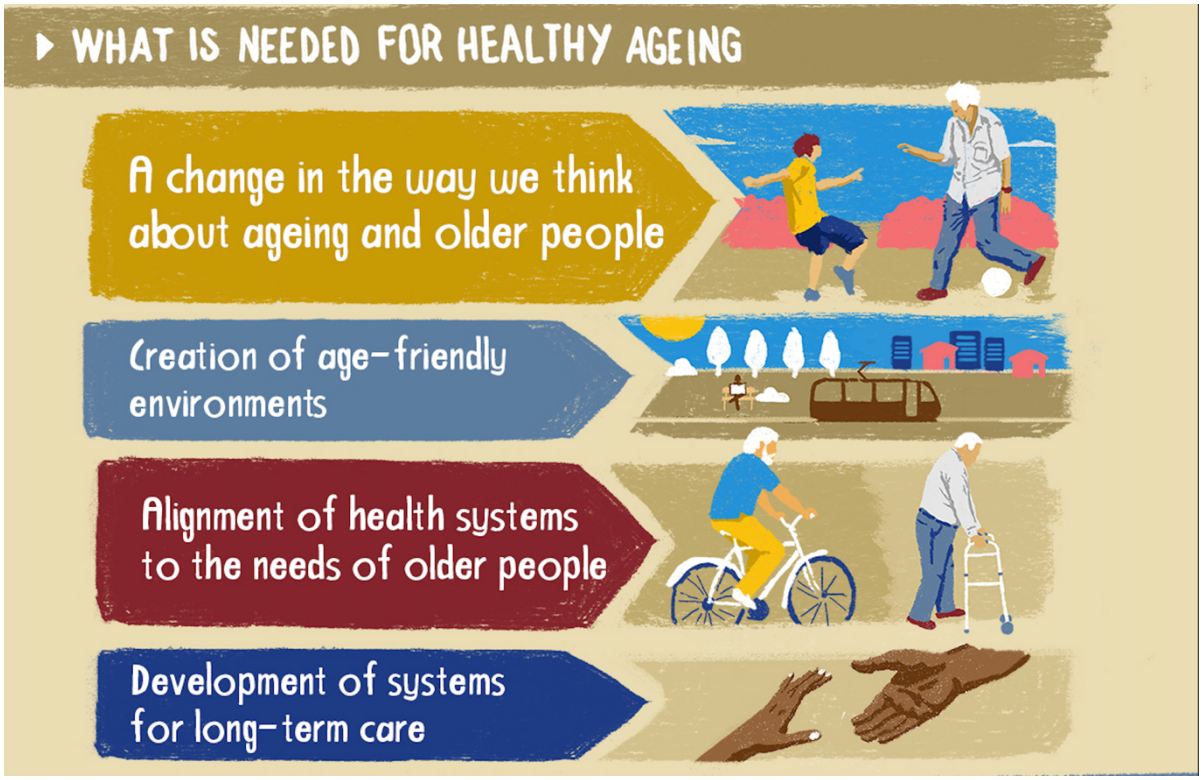

Figure 4 - Requirements healthy ageing process (WHO, 2014)

This infographic summarizes and acknowledges the broad concept of the healthy ageing process. However, to be concluding to this research, it will focus on the individual influence; change in behavior of physical activity, and how to align a health system; e-Health, to the needs of older people.

Physical activity

While recommendations vary, best practices with their accompanying health benefits are described in the next section. This is based on literature stated in the book *Hart voor je Brein* written by Scherder and Hofman (2020, p. 141-145).

While most the recommendations originate from meta-analysis, when not available the latest results of studies are given.

Improvement cardiovascular working

- HIIT (High Intensity Interval Training) done every hour for 6 minutes with one minute warming up, jumping as much as possible for 4 minutes and cooling down of 1 minute (Sperlich et al., 2018).
- Walking half an hour after one hour of sitting, then interrupting every half an hour with 3 minutes of brisk walking (Kruse et al., 2019).

- Three times a week, 45 minutes of cycling or other more intense physical activity

Improvement of the immune system

- Slight increase of the level of NK-cells (Natural Killer) by physical activity for 30 minutes per day (Nieman et al., 2005).
- Three times a week, 25-30 minutes of moderate intense for increased activity of T-cells and NK-cells after ten months of observation (Alack et al., 2019).
- Two times a week, 60 minutes of moderate intense activity for older adults (60+) for an increase of neutrophil activity (ability to remove unwanted micro-organisms in the body) after three years of observation (Yan et al., 2001)
- Three times a week, 30 minutes of moderate intense physical activity increases the concentration of Immunoglobin A after twelve weeks. Immunoglobin A is important in the defence against infections (Klentrou et al., 2002).

Improvement of cognitive functioning

- Four times a week, 30 minutes of moderate intense physical activity (Vidoni et al., 2015).

Improvement for mental health

- Three to five times a week, 45 minutes of moderate intense physical activity after a month of observation (Chekroud et al., 2018)

Norms

Organisations such as the World Health Organization and the RIVM state that a total amount of minutes per week and an amount of strength and balance practices need to be performed to improve health in general. Since previous literature also considered this norm, this research uses the norms of the RIVM (RIVM, 2015):

- Perform 150 minutes of moderate intense physical activity, such as walking or cycling, per week
- Perform 2 strength-practices, with special balance practicing for older adults, per week

In conclusion, half an hour per day of moderate intense activity, in combination with interrupting sedentary behaviour and strength and balance training can improve the health of older adults. Nevertheless, it should be stated that any movement is better than no movement (Scherder & Hofman, 2020). However, for this research the aim is to stimulate older

adults in at least 30 minutes of walking, which translates to around 3000 steps (Bee, 2016).

2.2 E-Health

A technology present in the domain of healthy ageing is e-Health. According to Ross and colleagues (2016) e-Health, the use of computers or information technology to solve healthcare problems, is critical to address the challenges healthcare systems face due to an ageing population, improved treatments, and scarcity of resources. It covers a broad range of digital technologies and interventions used by a variety of stakeholders (Pagliari et al., 2005).

To generate a better understanding of e-Health, Shaw et al. (2017) conducted research into the various domains of e-Health by interviewing stakeholders in the field. Analysis of the interview data revealed 3 dominant e-Health domains: health in our hands, interacting for health, and data enabling health. As seen in figure 5.

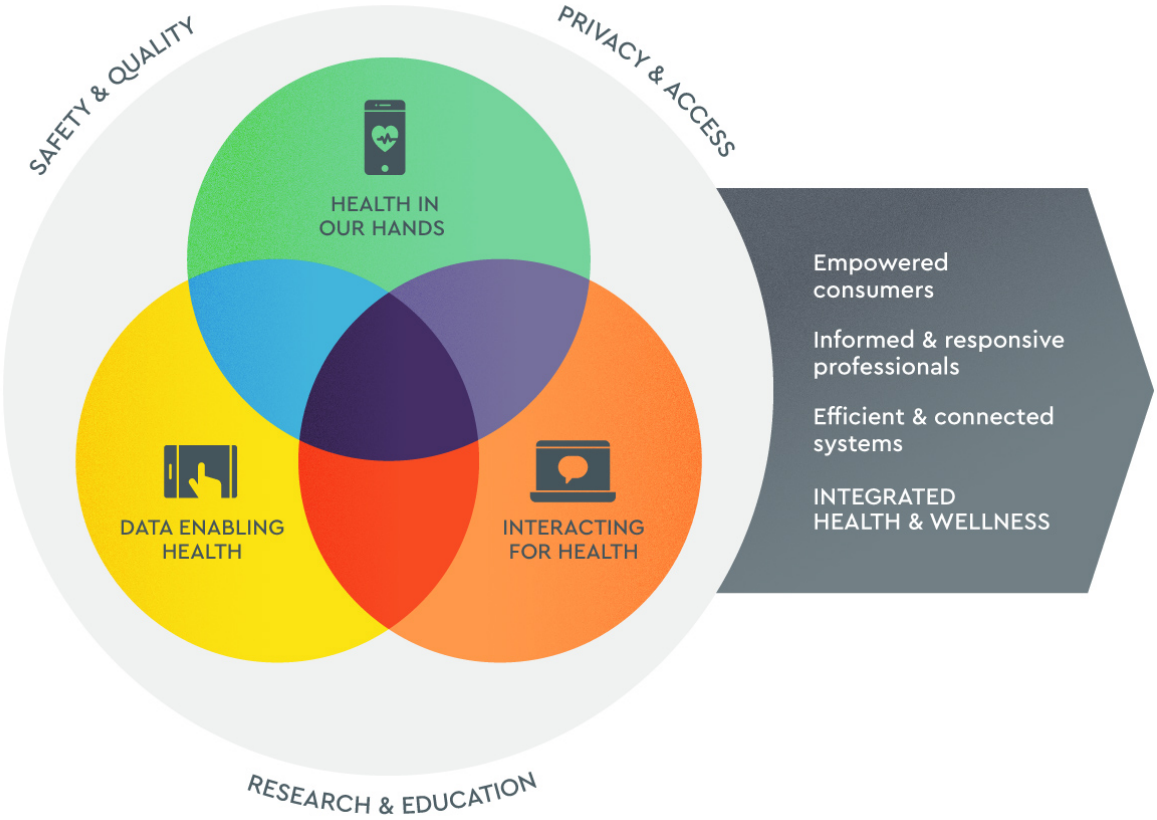

Figure 5 - Domains of e-Health technology (Shaw et al. 2017)

Separately, these domains describe the use of digital technologies to monitor, track, and inform; the use of digital technologies to facilitate communicative encounters between health stakeholders; and the use of

data to improve health and health services. However, for this study it is important to investigate if e-Health can motivate in more physical activity.

According to Marchant et al. (2021), e-Health can modify the practice of physical activity. Research during the COVID-19 pandemic showed that, besides being more aware about physical activity, users of e-Health mainly increase the level of vigorous physical activity. A study conducted by Mouton and Cloes (2015) used mixed interventions that resulted in an increase in physical activity, physical activity readings, and increased awareness. Kim and Glanz (2013) expand to this with a text message trail and found out that motivating text message increase both step count and perceived activity level. Another study, conducted by van het Reve and colleagues (2014), demonstrates an improvement in physical performance when a tablet is used to facilitate at-home exercise. Not only was increased activity observed, but also decreased fall efficacy, which may result in increased physical activity in the future as individuals gain confidence. Overall, e-Health technology has the potential to be beneficial by encouraging healthy behaviours such as increasing physical activity and raising awareness of the importance of physical activity.

A technology present in this field of e-Health are smart wearables, like the Oura ring. With the rise of mobile devices, the development of smart wearables is not staying behind (Fang & Chang, 2016). Wearable devices are available to a wide variety of users and are becoming increasingly popular, mainly among young users. Besides personal reflection and motivation, smart wearables can also be integrated with health-care systems to accurately provide feedback to physicians and caretakers. It can provide vital health information about the users as well as activity levels (Lobelo et al., 2016). According to Popescu (2014), wearable devices have the potential to help and support older adults in autonomy and improve their wellbeing.

Especially within the scope of physical activity, smart wearables could be important. By receiving motivational notifications, monitoring progress such as the number of steps in a day or by providing social support, smart wearables can be supportive for the users and enhance physical activity (Cadmus-Bertram et al., 2015; Lyons et al., 2014; Mercer et al., 2016; O'Brien et al., 2015). Hence, smart wearables are a suitable tool in enhancing physical activity and can eventually motivate older adults to perform more physical activity.

Nevertheless, the studies mentioned above mostly featured measurements done with smart watches or wristbands. Henriksen and colleagues (2020) compared the Oura Ring with research-based smart wearable devices such as the ActiHeart and ActiGraph that have been validated by gold standard

methods. Twenty-one participants wore the Oura Ring as well as the well-established wearables and the results were compared. Besides other values being measured such as heart rate and sleep duration accuracy, a strong correlation between the Oura Ring and the ActiGraph accelerometer was found in the number of steps ($p<0.001$, r 0.77, 95% CI 0.62-0.87) as well as moderate to vigorous physical activity ($p>0.001$, r 0.70, 95% CI 0.49-0.82). While the Oura Ring may not be as precise as the research-based wearables, it can measure the amount and intensity of physical significantly to be acceptable.

While the benefits of e-Health and smart wearables regarding physical activity are well established, the actual usage and implementation among older adults stays behind. One in three older adults in the Netherlands makes use of e-Health in their daily lives (ZBVO, 2019). Even less people make use of smart wearables, only 3.3% of the users of smart wearables in the US are age 65 or higher (Wurmser, 2019). The usage of e-Health and especially smart wearables seems to stay behind in this age group.

Literature distinguishes multiple factors that could be held responsible for this low adoption. Farivar and colleagues (2020) state that, when a technology is too complex, the intention to use it goes down. In a mixed methods study they developed a research model to study the impact of cognitive age, perceived complexity, and subjective well-being on older adults' use intention. Their main findings include that the most salient deterrent is the perception of complexity when working with wearable devices, such as reading and interpreting the outputs. They state that multiple factors influence the intention to use a certain smart wearable. An overview of this model can be seen in figure 6.

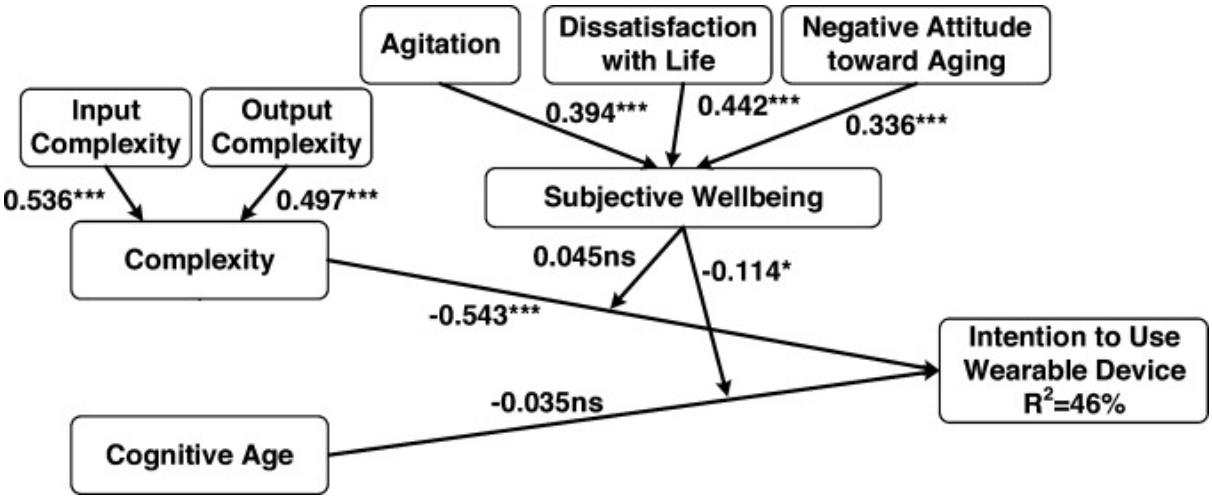

Figure 6 - Factors of adoption of e-Health amongs older adults (Farivar et al., 2020)

A suggestion to overcome these difficulties with the implementation is suggested by Moore and colleagues (2020). They provided a framework

based on the Social Cognitive Theory (Bandura et al. 1999). This theory anticipates on the fact that individuals become motivated and guide their actions through their own beliefs and self-efficacy. For the intention to use smart wearables in relation to motivate to more physical activity, this self-efficacy is of major importance in the older adult's assessment of goals and actual engagement in physical activity. According to their results, they state that useful functions alone do not necessarily lead to a higher adoption of these smart wearables. To successfully integrate a system, such as a smart wearable in their lives, a support structure should be designed that aids implementation. This is in line with findings by Heinz and colleagues (2013) that state that older adults are less likely to adopt a new technology until they see the benefits for themselves. Useful functions alone do not lead to successful implementation and adoption.

To support development and implementation of e-Health a study conducted by Latulippe and colleagues (2020) suggest that co-design can aid in the development of an e-Health technology for functionally dependant older adults. While the involvement of participants in co-design does not guarantee innovation, it does guarantee that a development will comply to help seeking process and literacy level.

2.3 Conclusion

The way a person ages is experienced differently by every individual. It is a personal process which is influenced by individual factors as well as environmental aspects. Nevertheless, performing a sufficient amount of physical activity can be a preventive factor to diseases that often occur at a higher age, thus prolonging and positively affecting the healthy ageing process. While the recommendations vary, 150 minutes a week of moderate intense physical activity and two times a week of strength and balance practise yield the best results in a healthy ageing process.

Research showed that e-Health and smart wearables can be an effective way of motivating and increase physical activity. While the positive effect regarding motivation towards physical activity is well established, the usage of it stays behind among older adults. This due to the perceived complexity and lack of positive assessment of utility. Research should perform techniques, like co-design, to successfully develop technologies for this age group.

3. Relevant technologies

In the next section, related e-Health technologies are analysed and discussed. The purpose of this review is to understand how existing technologies interact and possibly motivate the user to perform certain actions.

The strengths and weaknesses of these technologies can serve as inspiration or contribute to the design process of the interaction designed by this project. The different technologies were selected on a few criteria. The technology should have digital interaction, be digital in some way and preferably have something to do with physical activity. Eventually these products and categories were discussed:

- Large smart watch
- Small smart watch/band
- Smartphone (application)
- Smart ring (application)

3.1 Large smart watch

There exist many different smart watches with ranging prices and functions. They are worn on the wrist and can measure different factors such as heart rate, sleep, or activity. While practical functions range, they often share a similar function: the measurement of steps taken on a day. The next section will give a few examples of these smart watches and how these communicate this data through the user.

Smart watches with large screens enable the user to get direct feedback from its usage. Due to the bigger screen size which often comes in colour precise information is displayed. Examples include the Apple Watch or Garmin Forerunner as seen in figure 7:

Figure 7 - Apple Watch (Apple, 2021) and Garmin Forerunner (Garmin, 2021)

The advantages of these watches are that the large screen can display the data in a clear way. Their overall big size also allows for more precise measurement sensors or audio-visual feedback. Besides a screen to interact with, they also include physical buttons to interact with the screen. Relating to this research, Lewis and colleagues (2017) state that this can help older adults to better interact with the product.

Nevertheless, their larger size could also be experienced as less comfortable. The large screen and increased functionality and connectivity can also impact the battery life so require more frequent charging. This functionality also comes at a cost since these watches often are expensive, 300-500 euros. Not to mention that they often require a smartphone to function or to unlock more functionality.

To give an example, figure 8 shows the way the Apple Watch communicates its measured physical activity to the user.

Figure 8 - Apple Watch rings with application (Apple, 2021)

The figure shows the way the watch is worn as well as the app on a smartphone. It displays different types and amount of physical activity in a colourful and circular way. The user can set a certain activity goal and can try to *close* the rings throughout the day. These rings can be displayed next to the time so it can give instant feedback and display progress about physical activity. Figure 9 shows explanation of the different rings.

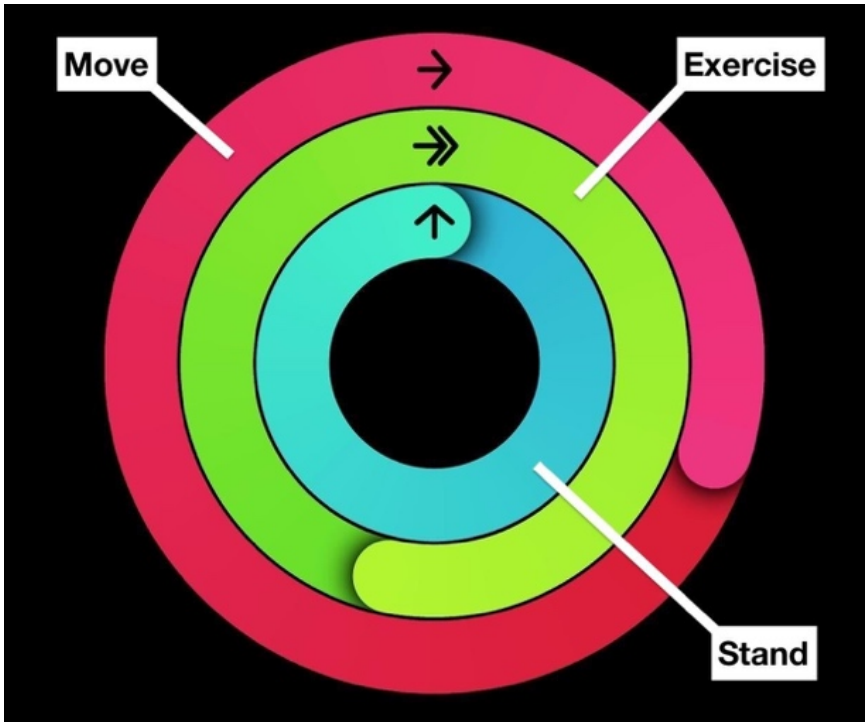

Figure 9 - Explanation of Apple Watch rings (Peterson, 2018)

While this technique is often associated with the Apple Watch there exist different ways these watches try to display the information. Another example as seen in figure 10 makes use of a bar graph. The x-axis corresponds to the time on a day, and the y-axis corresponds to the amount and intensity of physical activity performed at that moment. A different example takes the concept of the game Tetris and makes reaching you activity goal a game. According to the progress regarding the steps on day different blocks disappear, this can be seen in figure 10.

Figure 10 - Apple Watch bar graph (Apple, 2021) and Garmin Steptris watch face (Steptris, 2015)

3.2 Small smart watches/band

There also exist smart watches that have a smaller screen than the previously mentioned examples. Additionally, there exist bands that only measure and not have a screen to display information on. These include for instance the Xiaomi Smart Band 6 or the FitBit Flex, respectively shown in Figure 11.

Figure 11 - Xiaomi Smart Band 6 (Tweakers, 2021) and Fitbit Flex (Fitbit Flex, 2018)

Due to their smaller size, they can be experienced as less notable and have a simpler interface than their larger competitors. While they can still perform similar measurements as the big watches, their battery life is often longer due to compromises on screen size and audio-visual functions. These compromises make them also a lot cheaper compared to the bigger size, around 50-200 euros.

However, the compromises in screen size and interactivity could also result in more difficult interaction. Since they often do not include buttons they rely only on the touch screen for direct interaction, which can be harder for older adults to interact with according to Lewis and colleagues (2017). Besides this decreased interactive aspect the limited on-screen functionality requires more interaction with a smartphone for insight on information. In both examples the band cannot even be used without the connection to a smartphone. Making it less attractive to people who do not have a smartphone or have difficulties interacting with such a device.

An example is the app of Xiaomi. Where the smart watch itself displays the progress of goals such as steps and calories on the screen as seen in figure 11, the app displays more exact measurements and information, for example sleep and intensity of activity. This example can be seen in figure 12.

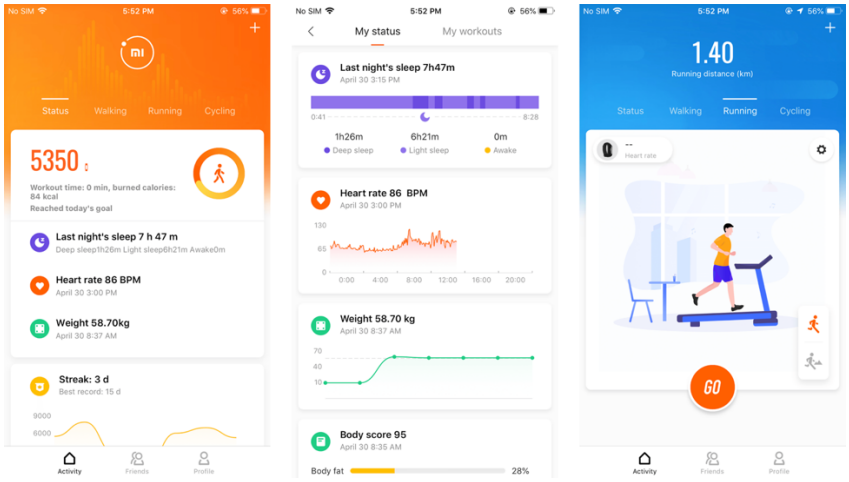

Figure 12 - Xiaomi Mi Fit application (Singh, 2019)

Besides displaying the measured information this application can also guide and assist with varying exercise where it adapts it measurements to the chosen type of physical activity. This way it can measure more clearly what the user did since it knows what the user intends to do.

The application of the Fitbit in figure 13 shows the number of steps in a similar circular way as the Apple Watch. Since the band has no screen, this is the only way to view the measured data. Besides displaying the measured information this application also can give tips for health-related topic in its *Discover* tab. As well as connect to a community where you can interact with friends and family.

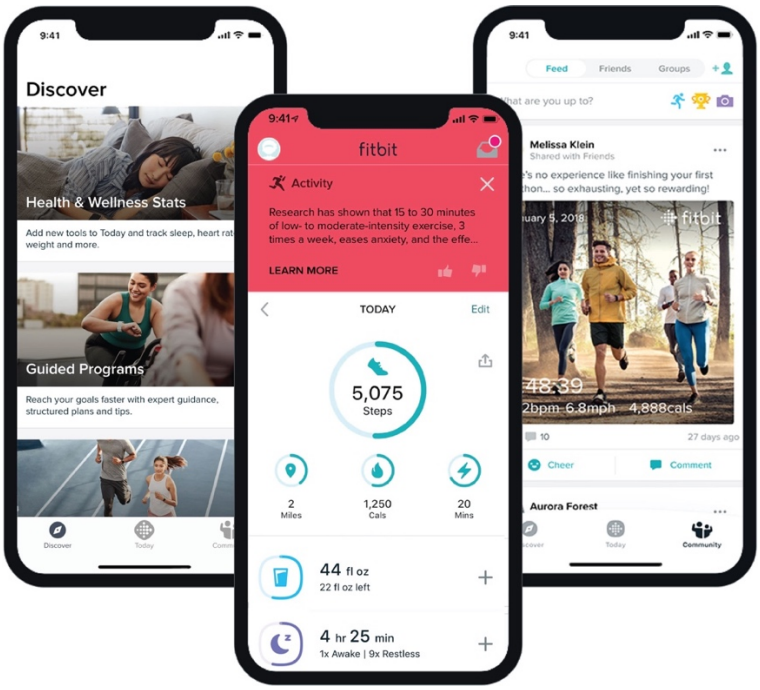

Figure 13 - Fitbit application (Fitbit, 2021)

3.3 Smartphone (application)

A different way to measure the number of steps taken on a day is with only a smartphone. Based on information from the accelerometer or GPS location the number of steps is count and the data is presented to the user in an application. Since this does not require an add-on to measure this data it can be less precise than a smart wearable since you possibly do not always carry your phone with you. An example of such an application is the Pedometer and Stepcounter application by Leap, which can be seen in figure 14.

Figure 14 - Stepcounter and Pedometer app (Bassine, 2019)

The goal to reach is displayed in a circular shape which is filled when the goal is met. The progress from the last few days can be seen and you can earn badges when certain tasks are performed for a few days in a row for example.

Another example can be seen in figure 15 and shows the way the standard application of the iPhone displays its steps health data to the user. While it is informative it lacks the motivating aspect such as earning badges and progress such as the Pedometer app by Leap.

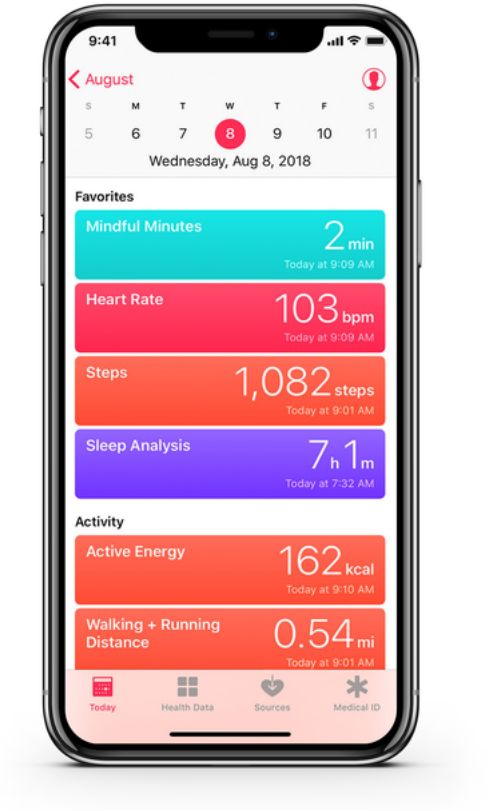

Figure 15 - Standard health application iPhone (Apple, 2022)

3.4 Smart ring (application)

While the Oura ring was already introduced in chapter one it is briefly discussed in this chapter as well to show the interface of the application. In figure 16 the application of the Oura ring can be seen.

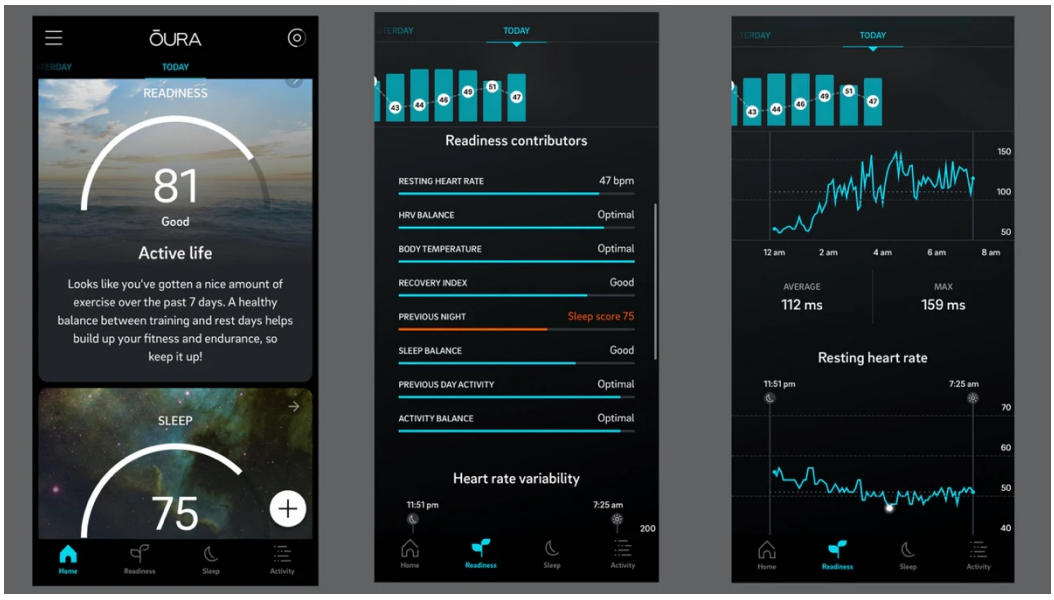

Figure 16 - Oura application (Oura, 2022)

Besides showing the factual data like number of steps and amount of sleep Oura makes use of a calculation of the *readiness score*. This is a score determined by multiple factors such as number of steps on the previous day and current steps, amount of sleep, quality of sleep, etcetera. Based on this it can predict and advice what to do to make you feel better.

Nevertheless, since the Oura ring does not have a screen the insight in this functionality can only be seen in the app, similarly to the FitBit Flex. This makes it less attractive to users who do not have, or have difficulties interacting with a smart phone

3.5 Conclusion

The field of smart wearables that try to stimulate the user is broad. There exist many ways to communicate information to the user. This can be done on screen by smart watches such as the Apple Watch or Xiaomi Smart Band, or in applications like Pedometer by Leap or the application of the Oura ring. Visualisations often include circular progress of a goal or include bar chart to display the intensity and amount of physical activity.

Nevertheless, most of these interactions require a smartphone to fully work, just as the interaction with the Oura ring. While larger watches can display their information on screen, smart bands and smart rings can only display their information in an application. Due to this way of communication, age groups that have difficulties interacting with a smart phone or people who do not own a smartphone in the first place are excluded from usage. Furthermore, doubts could be raised by the rather formal and scientific way of communicating the measured information. While some applications like the Pedometer app by Leap or the Tetris watch by Garmin try to make the interaction more challenging and possibly motivating by gamification, the majority stays behind.

4. Methodology

The main methodology of this research focuses on the process of Creative Technology Design Process as described by Mader and Eggink (2014). Within this process, co-creation will be used to develop a prototype by utilizing the technique of context mapping as described by Sleeswijk-Visser (2005). The next section will first introduce the Creative Technology Design Process and explain how it relates to this study. Second, an overview of the role of co-creation is explained and the different methodologies for ideation and evaluation are explained.

4.1 The Creative Technology Design Process

The Creative Technology Design Process often lies at the basis of a project at Creative Technology and will also be used within the scope of this research. It is a design process that focusses on iterative development and is based on four phases: ideation, specification, realization, and evaluation. Figure 17 shows the different aspects of the process and how they relate towards each other.

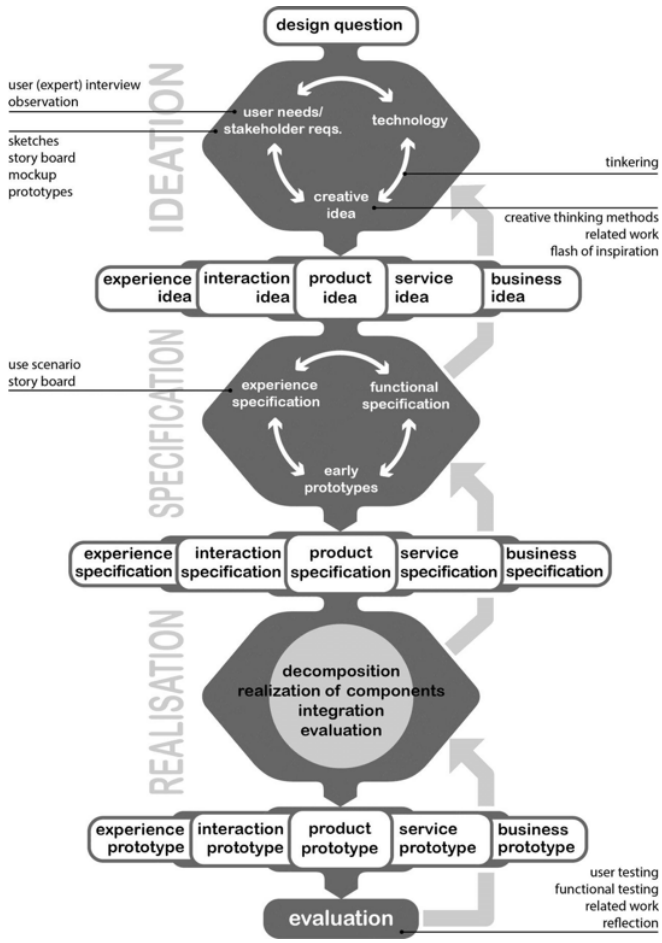

Figure 17 - Creative Technology Design Process by Mader and Eggink (2014)

The Creative Technology Design Process is broad and can function as guideline for the development of a research process. Its fluid but coherent nature allows for own interpretation. For this research a derivative based on the process was created and can be seen in figure 18.

Figure 18 - Development process for this project

4.2 Co-creation

The re-design of the interaction with the Oura ring will focus on the process called *co-creation*. This is a concept where consumers or end-users are active participants in the design and development process (Roberts & Darler, 2017).

It was introduced in academic literature in 2000 by Prahalad and Ramaswamy (2000). While through the years its definition underwent a few modifications, the process of co-creation has shown to be important in the innovation process of products and processes (Fernandes et al. 2016).

The concept can be seen as broad and is therefore interpreted differently across the academic field. Darler and Roberts (2017) mention different synonyms as *value co-creation* (business studies), *experience-based co-design* (design studies), *technology co-design* (computer science) or *participatory research* (community development). However, this study will focus on the field of co-creation in design. Figure 19 illustrates how this process differs from *classical design* as described by Sanders and Stappers (2008). In classical design the user is often observed, and a product is

developed *for* them. Co-design focuses more on the participation and a product is designed *with* them.

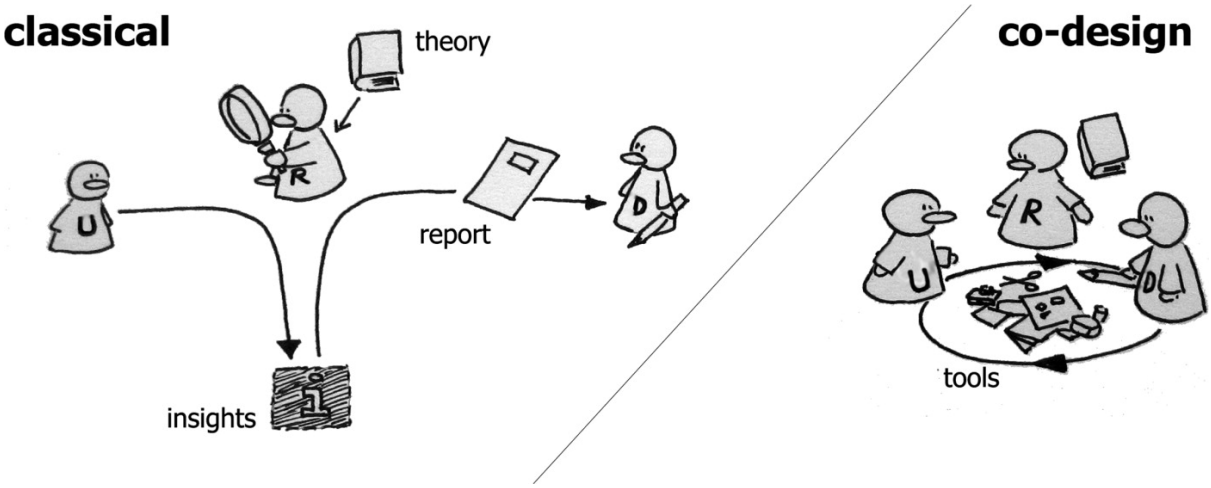

Figure 19 - Co-design versus classical design by Sanders and Stappers (2008)

This circular aspect of testing and iterating strongly deviates the rather linear way of development by classical design. The process is fuzzy and can alter at any given time. An example of this co-creative process can be seen in figure 20. Insight and understanding of the user result in design criteria which eventually converges towards a final product.

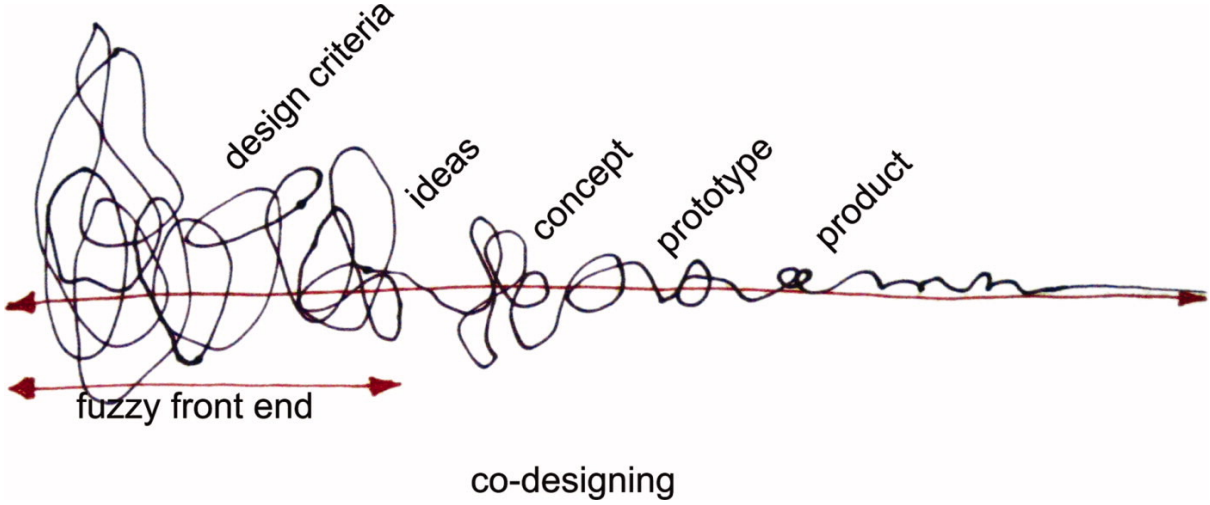

Figure 20 - Co-creation process by Sanders and Stappers (2008)

Numerous studies showed that the usage of co-creation methods can significantly increase the creativity and improve the ideation process. Consumers can generate unique and valuable ideas (Kristensson et al., 2004) and it forces managers to look for more creative and less obvious solutions (Roberts et al. 2005). Sometimes the group of consumers even came up with more creative solutions than the professional design team (Kristensson et al., 2004). With these relevant findings and personal interest of the designer the

method of co-creation was chosen to be the focus in the development of the ideation process as well as evaluation.

4.3 Contextmapping for ideation

However, co-creation is not a stand-alone method. Within the context of co-creation, different techniques exist that can engage with the user and eventually generate ideas of value. One of these techniques is *context mapping* as described by Sleeswijk-Visser (2005).

Contextmapping is centred around the potential user and uses a variety of methods and techniques to evaluate the context of product interactions. It can be used to gain a better understanding of the future user's needs and requirements. Investigating the user's context enables the development of empathy for the user and helps avoid fixation on preconceived concepts about the user or the product.

Given that the target group their age is significantly higher than the researcher's, it is crucial to acquire this knowledge to design an innovation that meets the target group's needs. This technique is a form of empathic design, where the development process does not happen at laboratories or design-rooms but at people their own environments, like their home. The two methods as described by Sleeswijk-Visser and colleagues (2005) that will be used in this research are experience from practise and the experience domain. These different domains are described briefly.

Experience from practise

Experience from practise focuses on techniques that could potentially foster more creative input from the potential user. Where traditional questionnaires or interviews try to gather answers in the moment based on questions, experience from practice introduces an extra layer in the form of generative sessions. These sessions often consist of collage-making or ranking cards in a specific order. The main goal is to visualise the answers people give. This not only is helpful in the thinking process for a participant, but also enables various ways of analysis with the provided data. In figure 21 an overview of the potential output is presented as described by Sleeswijk-Visser and colleagues (2005).

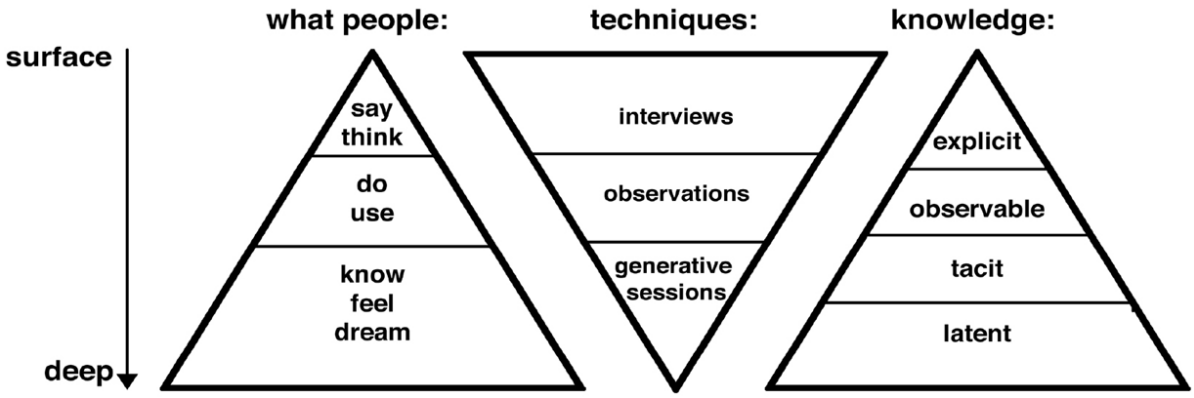

Figure 21 - Experience from design by Sleeswijk-Visser and colleagues (2005)

Experience domain

Another technique as suggested by Sleeswijk-Visser and colleagues (2005) in the experience domain. The experience domain is more focused around actual experiences and actions the participant did, does or want to do, as seen in figure 22. By thinking back on the past and reflecting on the present, one can imagine its future. This could enable the participant to think about its dreams, which happen in the future.

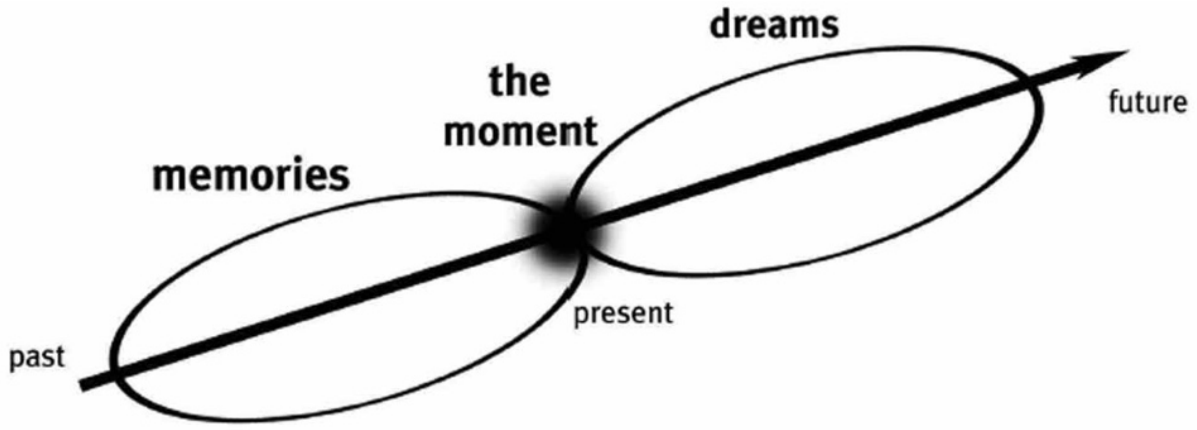

Figure 22 - Experience domain by Sleeswijk-Visser and colleagues (2005)

These techniques will be used to achieve co-creation with the target group. Discussion on how these techniques apply within the scope of this research and elaboration on the different techniques can be found in chapter 4.

4.4 Specification and realization

Based on the input and analysis of the results from the ideation session two sets of requirements are made that gives an indication of the components required for the system to function properly. With these requirements a brainstorm is held which results in a few ideas. The method of brainstorming that is used is mind mapping, as described by Kernan and colleagues (2017). The problem to solve is written down in the middle and based on ideas and

themes the participants of the brainstorm have a connected map is created. Ultimately, this results in multiple ideas. Out of these ideas three ideas are picked and evaluated for feasibility. One idea is chosen and made during realization using rapid prototyping (Dickens, 1995).

4.5 Evaluation

The evaluation will exist out of two parts. First, the results from the ideation session are analysed. Second, the usability and effectiveness of the prototype is tested. The next section will describe and discuss these two evaluation moments.

Evaluation of ideation

The sessions and booklet generate a valuable, varied, but complex set of data. While some of the data is structured according to theme, many of the data is not structured. According to Sleeswijk Visser and colleagues (2005) the analysis of the visual data goes hand in hand with stories the participants talk about the tasks and questions. Most of the information can be distilled from the explanations given by the created artefacts, in this case artefacts being the creative sessions and responses to the questions in the booklet.

To analyse this data which is mainly visual from ground, Sleeswijk-Visser and colleagues (2005) suggest making use of the Grounded Theory approach by Corbin and Strauss (1990). Within this approach, data is studied to discover structures without using pre-set expectations of the data. The Grounded Theory states that potential indicators of a phenomenon are discovered during the analysis, rather than being hypothesized in advance. Sleeswijk-Visser and colleagues (2005) followed the approach of the Grounded Theory and suggested a three-phase structure for the analysis of this generative data:

Phase 1: Fixate on the data

The researcher has already learned about the experiences and explanations of the participant by being present at the session. After the session the researcher should write down thoughts and remarks of the session. While it is a time-consuming task it is important to do because memories will fade after some time.

Phase 2: Search and be surprised

After all the data is collected, it is time to search through the information to find relevant themes and indicators. This works the best if the researcher is surrounded with the different materials of the sessions, like booklets and responses from the creative sessions.

Phase 3: Find patterns and create an overall view

The last phase tries to bundle and organise the different responses and searches for recurring themes but also for striking and remarkable findings. This is done preferably spatial, like a wall with Post-It's for instance. This allows for making connections between multiple responses by quickly reorganising the order.

Prototype evaluation

For this research the evaluation of the prototype consists of a session with user test evaluation and a SUS-score. These different parts are discussed in the next section.

User test evaluation

First, the usability and functionality will be tested with a user test. This test is held with the same participants of the ideation sessions. Questions regarding the effectiveness of improvements will be discussed and the participants are asked to think aloud when they interact with the prototype. To introduce the participants to the prototype a scenario-based discussion will be held followed by a semi-structured interview.

After this session the participants are asked to fill in a questionnaire regarding the usability. This will be the questionnaire as defined by Brooke (1995). It contains 10 questions regarding the usability of a product. The answers are given in a Likert-scale and after calculation will result in the SUS-score between 0 and 100. The score represents the usability of a certain system. The accompanying scores with their interpretation can be seen in figure 23.

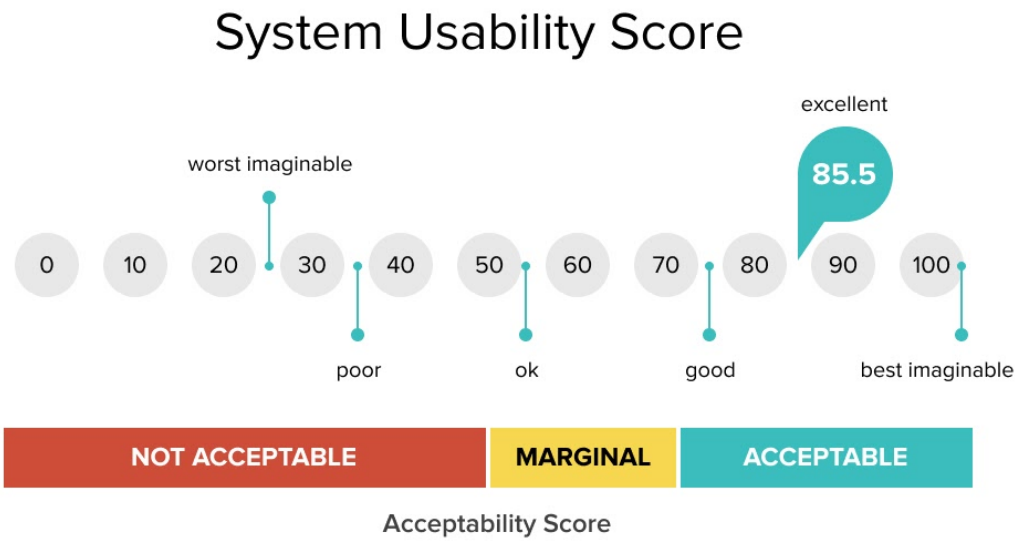

Figure 23 - SUS-score (Adobe XD, 2021)

While there does not exist a validated Dutch translation of this questionnaire the Dutch translation by Jansen and colleagues (2012) is used. The questions can be found in the booklet and in chapter 8.

5. Ideation

This chapter elaborates on the role of contextmapping to the ideation process. The engagement with the end user and their habits are central to the brainstorming process. This not only allows the designer to obtain a better understanding what role physical activity plays in their live, but also helps to gain insight into how people interact with digital technology.

Two components will be used to accomplish this. A sensitizing booklet featuring questions and assignments, as well as a creative session in which the designer converses with the participant about the booklet's questions. In the next section the process of the ideation is described as well as contents of the booklet and creative session. Afterwards the results from the ideation are analysed and discussed.

5.1 Process

The ideation process is divided into three sections, each of which aims to obtain insight into a distinct aspect of the research. The first part focuses on how people engage with digital technology. What kind of interaction with digital technology does the user already have and what the opinion is towards these technologies. The second section discusses which physical activity they perform in their live. This is not only about the quantity but also about the quality and enjoyment. This allows the user to reflect on their active life and discover what motivates them. The third section discusses currently available technologies and how they measure and display physical activity. To what extend is the user already familiar with these technologies and does the user grasp what each one is attempting to communicate.

Even though digital technology, physical activity and smart wearables are the focus of this study and many of the questions revolve around it, participants are free to provide answers that are not related to activity. The interaction with digital technology, for example, does not have to be linked to physical activity.

These ideation sessions are held preferably face to face at the home of the participant. A participant will receive the booklet beforehand and is asked to already fill in the questions. This booklet will be printed on A4, and ring bound. The main language of the booklet is Dutch since the participants are all Dutch. The booklet can be found in appendix A and the contents of this booklet will be discussed in the next section.

5.2 Booklet

The booklet serves mainly as a preparation for the creative session that is held with the user. It allows the user to think about the things they do every day regarding the themes of this study: physical activity and interaction with digital technology. All questions are related to the theme and have their own function. The following section discusses the textual content, visual design choices, and the process of distributing the booklet.

Layout

While the visual design will be discussed later, the textual layout will be discussed briefly down below. An overview of the layout results in the following list:

- Personal introduction
- Explanatory introduction
- Informed consent
- Part 1: Digital Technology
- Part 2: Physical Activity
- Part 3: Existing Technology
- Part 4: Requirements Creative Session

Personal introduction

The personal introduction is a short word from the designer that introduces him with a photo. While this is a rather short introduction it is important for the course of the research since it allows the participant to already create an image of the designer behind the research. This personal *touch* to the process is of great importance when looking at the type of research that is being conducted. As mentioned in the chapter 3, the co-creation can be seen as a form of empathic design. An important factor, as suggested by Kouprie and Sleeswijk-Visser (2009), of empathic design is the willingness of the designer. This includes the personal connection the designer has with the user. Since the designer will experience rather personal contact with the user, it can help to already build this connection from the start and personally introduce the designer towards the user.

Explanatory introduction

The next part in the booklet explains about the research and what the goal of the booklet and the creative session is. It begins with a short introduction on why physical activity is important and what role smart wearables could play in the process of motivating for more physical activity. An example of this page can be seen in figure 24. Besides the *why* the participant is also introduced to the *how*. The different parts of the ideation session are

explained and what is expected from the participant. Furthermore, information what to expect, the confidentiality and privacy of the research, who to contact in case of unclarities, as well as contact info for complaints or comments.

Figure 24 - Explanatory part of the booklet

Informed Consent

After the participant has read the information, they can decide if they would like to participate by filling in the informed consent. This form consists out of confirmation and understanding of the previously read information, permission to collect their data and responses as well as a permission to take anonymous photos. This consent can be found in appendix A. Nonetheless, they are free to choose if they agree that anonymous photos are taken, the creative session can still take place if they indicate not to want that.

Part 1: Digital Technology

After the participant has acquired and agreed to all the information, they are asked to fill in the questions in the booklet. The first part consists out of questions regarding the interaction with digital technology. The different questions are discussed down below with their goal.

Q1: What are your favourite digital technologies and what technology is your least favourite?

Goal: Reflect on the technologies present in their daily live. What does he or she like to use or what is frustrating?

Q2: What digital interaction do you have on a day?

Goal: Reflect and acknowledge the amount and type of interaction with digital technology on a normal day.

While these questions have individual goals for the answers, they both share the goal and purpose to really let the participant think about interactions they have every day.

Often these interactions happen unconsciously because they are part of a use or habit. For example, turning on the television at dinner. The main purpose of these questions is to engage the participant to look at daily habits with a different perspective and to reflect on them. In addition to providing valuable answers that give insights into what the target group thinks, this also serves as a good preparation for the first assignment of the creative session on this theme. If the participant has thought about this theme before, the questions during the creative session will not come out of the blue. An example of this question can be seen in figure 25.

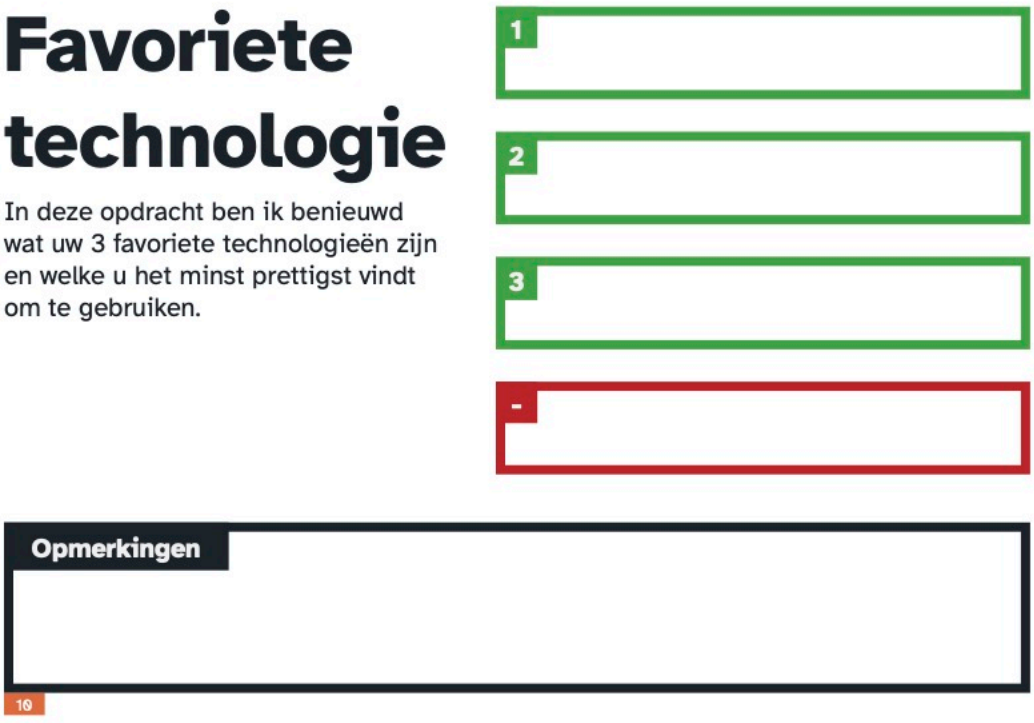

Figure 25 - Question regarding favorite technology

Part 2: Physical Activity

Part two focusses on physical activity and is very similar to part one. The different questions are discussed down below:

Q3: What are your favourite physical activities and what activity is your least favourite?

Goal: Reflect on the physical activity in their daily live.

Q4: What physical activity do you perform in a week?

Goal: Reflect and acknowledge the amount and type of physical activity in a week.

Q5: What place in your house and what things give you energy?

Goal: Physical activity is often linked with energy. Certain aspects, like music for instance, could activate and motivate someone to move. Letting the user think about what them possibly could give them energy could give insight on requirements the interaction technology should have.

Part one and two share many similarities. The main purpose of these questions is also to reflect and acknowledge their habits and routines regarding physical activity. This again also functions as preparation towards the creative session related assignment. An example of these questions can be seen in figure 26.

Figure 26 - Question regarding weekly activity

Part 3: Existing Technologies

Part three is about existing technologies and what the participants think of them. The questions in the booklet are about the physical devices and *how*

they could measure physical activity. It is a preparation for the creative session which focuses on the way these technologies communicate the data, which can be read in section 5.4 about the creative session. The different questions mention three different technologies:

- Smart Watch
- Smart Ring
- (simple) Step counter

It was chosen to use these technologies for multiple reasons. First, the smart watch being a relatively new technology people often already interacted or encountered with. They could already have formed an opinion towards this kind of technology. The aim is to give insight about their opinion towards a known but new technology.

The ring was chosen since this is the technology that is being used for this research and often people have not heard from it before. This has the aim to gather insight if people would incorporate a, for them new, technology in their life.

Lastly, the step counter was chosen since this is a product that is already around for some time and people probably know this product already. This has the goal to gather insight if people actually want to know how much physical activity they perform at all.

The participants are asked about the technologies on the hand of four questions. The first two based on a Likert scale about the following statements:

- I am familiar with this technology
- I would use this technology

Lastly, the participant is asked for reasons to use or not to use the technology. Figure 27 shows an example of these questions.

Figure 27 - Question regarding existing technologies

Part 4: Requirements Creative Session

The last part of the booklet consists out of the material that is required for the Creative Session. The pages can be torn out of the booklet and used in the session. However, this is elaborated on more in section 5.4.

Style of communication

All the information and questions are written in a style which tries to avoid words that could be unknown to the users, such as *smart wearables*. While certain words could be already known be the designer, it could be that older adults never heard of certain terms before. Therefore, English words are avoided and if certain terms could be interpreted differently a concise explanation is given.

5.3 Visual Design

When designing for a certain age group it is important to take their physical and cognitive capabilities in mind, also with textual and visual communication. For this reason, it was chosen to use a physical booklet and not use an online questionnaire. The target group could have more feeling with a visual booklet and therefore be motivated more to answer questions. In the next section the different design choices for the booklet are discussed, as well as examples out of the booklet.

Size and feel

The first decision in the design process was the size of the booklet. To be readable, it should not be too small. Therefore, it was chosen to print the booklet on A4 landscape format. This format is easy to handle and has large pages. The paper weight used for the print is 250 gram per square inch. This is relatively thick in comparison to normal paper which often is 160 gram per square inch. It allows easy handling and page turning for the participant and does not tear apart by mistake. The thickness of the paper also makes it heavier which allows for easy writing. Since the last pages of the booklet are intended for the creative session, the thicker paper also allows for better interaction and grip. The pages are bound in with a ring-band which ensures better page turning since the pages do not fold back for instance. Lastly, a plastic film is bound in at the front and back which makes it more durable and better resistant against liquids.

However, the choice of paper and size does not function merely for better handling and durability. It also has a certain level of professionalism. As described by Sleeswijk-Visser and colleagues (2005), a sensitizing package should be playful and professional at the same time. It should be playful since the participants are asked to perform tasks that encourage them to wonder freely, and it is ought to be a fun exercise. It should be inviting to let the participants come up with their own ideas and experiences. Nevertheless, the playful association with tinkering should be balanced with a certain level of professional appearance. This, so the participants feel that they are taken seriously and feel the need to answer the questions or perform the tasks that the booklet proposes.

Readability and visibility

While the choice of words is important for the reader to understand what is being explained, the size and readability of the words is also crucial. While there exists literature on readability and font-size no specific recommendations are given for the readability in relation to size among older adults. Therefore, it was chosen to use a big enough font-size that often does not require glasses to read of 16 pt.

The font used for the booklet is Atkinson Hyperlegible. A font especially designed for people with visual impairments by The Braille Institute. The font was designed with the letterform distinction in mind to increase character recognition, ultimately improving readability. It was initially designed for people with low vision (Braille Institute Staff, 2020); however, its high legible capabilities make it also suited for people with less vision such as glasses. An example can be seen in figure 28.

Figure 28 - Demonstration of legibility of Atkinson Hyperlegible font (Braille, 2018)

To improve readability and clarity it was also chosen to use strong contrast for the text. Dark blue and white are the main colour scheme together with a striking orange accent colour. The big contrast between the white and blue allows for easy readability. These colours can be seen in figure 29.

Figure 29 - Colours used for the booklet

Lastly, the size of the question boxes is rather big which allows for the users to write in a size to their liking. Additionally, when mistakes are made the big size allows for the correction of errors.

Furthermore, the colours of the different boxes that require an opinion are also coloured accordingly to what type of opinion is asked. For instance, a green box is positive while a red box is negative. Neutral boxes are coloured dark blue.

Distribution

For the sessions to happen, participants had to be found that would like to participate in the research. This was done with the help of a physiotherapist

at *Gezondheidscentrum de Kompas* in Hengelo. Bas Beld, a geriatric physiotherapist, assisted in finding people that were interested and capable in participating in this research. The self-explanatory nature of the booklet allowed the distribution to be limited of time consumption for Bas. He only had to give a small introduction to interested participants and give them a booklet so they could read it at home. Afterwards the participants were called to make an appointment to perform the creative session, which is discussed in the next section.

5.5 Creative Session

The second part of the ideation session consists out of a creative session that is held which each participant individually. As described before, the questions in the booklet serve as preparation for the creative sessions. During the sessions the participants perform small creative tasks together with the designer. While the tasks themselves differ, they all come in the same form. They consist out of images that are provided in part 4 of the booklet. Together with the designer, these images are cut out prior to every task. Eventually these are placed and glued on an A3 paper. The paper contains the task and these different tasks with their relation to the study are described in the next section.

Part 1: Digital Interaction

The relating creative task to part 1 is about what people think about digital technology and what their experience is with this technology. It consists out of a 2D matrix with two different axes.

The y-axis corresponds to the enjoyment a certain technology has to the user: *Like* or *Do not like*. The x-axis corresponds to the perceived difficulty of the technology: *Easy* or *Hard*. This matrix can be seen in figure 30.

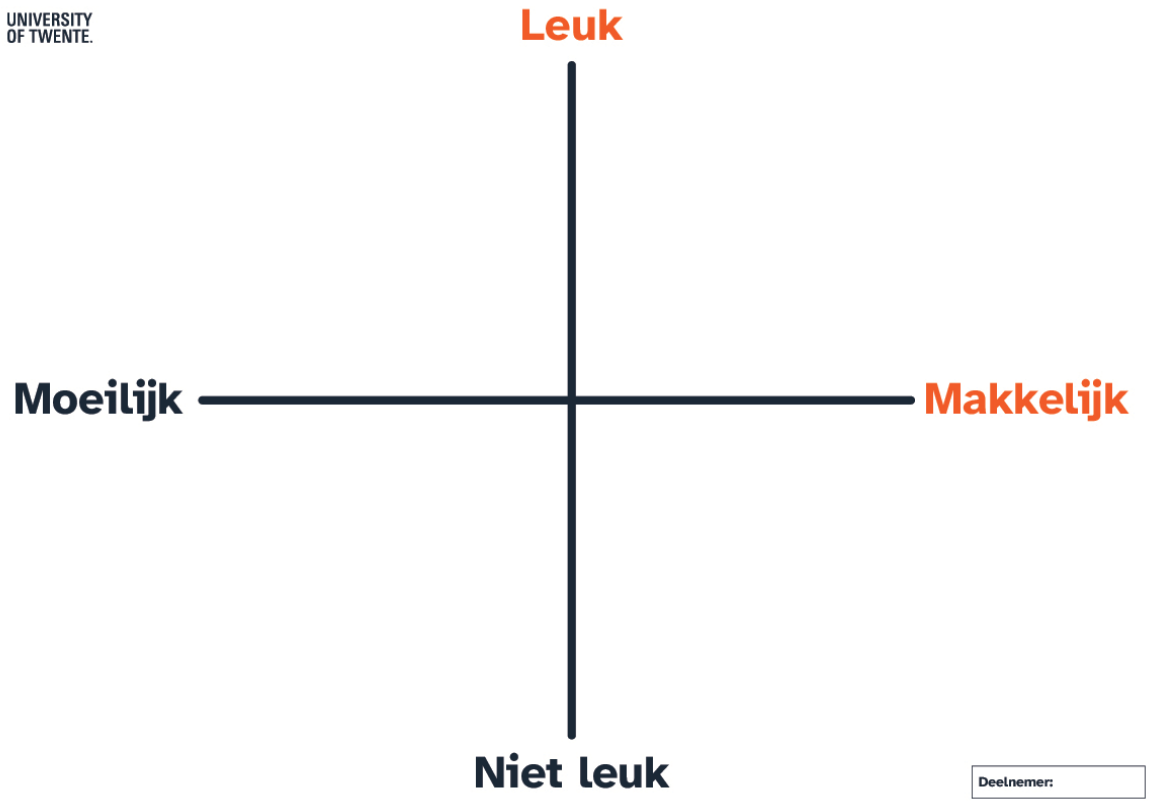

Figure 30 - Creative session task: Digital technologies

Based on what the participant thinks and experiences with the provided technologies they are asked to place them on the paper accordingly. For instance, if a smartphone is very enjoyable to use because it has many features, but it sometimes can be a bit hard to understand or to read because of the small letters, it should be placed towards *Like* but also towards the *Hard* side.

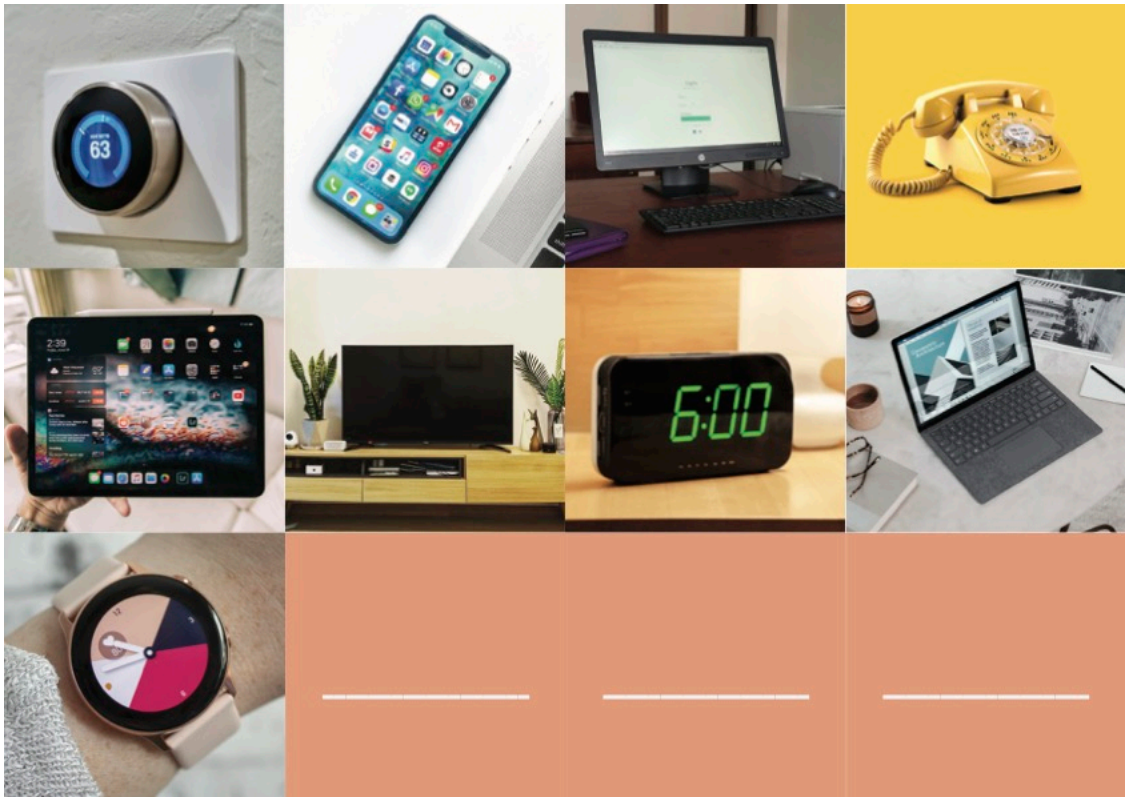

Figure 31 - Examples of technologies for task 1 (Unsplash, 2022)

The different provided technologies can be seen in figure 31. These technologies are from left to right: smart thermostat, smartphone, desktop computer, cable phone, tablet, television, (radio) alarm, laptop, and smartwatch. Besides being a as clear as possible image, the rear side of every image also has the type of technology written out.

If a participant does not use a certain technology, they do not have to place it on the board. Nonetheless, if they for instance think a certain technology is missing, they can write it down on the provided orange cards and place it on the board accordingly. Afterwards the participant is asked to write down why they placed a certain technology on that spot. This can be done on the paper next to the image with a little arrow pointing towards the card.

The main goal of this task is to figure out what types of technology people use and what they think and experience with the technology. The questions in the booklet already let them think about what they like or do not like but now they can really place their opinion and feelings on the board. Not only of technologies they know or use, but also of technologies they have heard about or have little experience with. Additionally, the different images could be perceived as overwhelming, however, it really forces the participant to decide and place what goes where.

As mentioned earlier, the participant is asked to write down their thoughts next to the cards on why they placed it there. However, the task will be held

together with the designer and during the session the participants are also asked to think and talk aloud. This not only helps to resolve questions immediately, but also helps to get a better understanding of the thinking process of the participant. Questions like: 'What is the underlying reasoning to place a technology on that spot?' or: 'Did you had a negative experience with it that made it negative?' function, besides the visual output, also as a good starting point for a discussion afterwards.

Part 2: Physical Activity

Regarding physical activity, the questions in the booklet focused more on the daily habits of physical activity. However, the goal of the creative session is to get a better understanding about the attitude towards physical activity in general. This is done by looking back at the past, reflecting on the present and looking ahead towards the future. The visual layout of the task can be seen in figure 32.

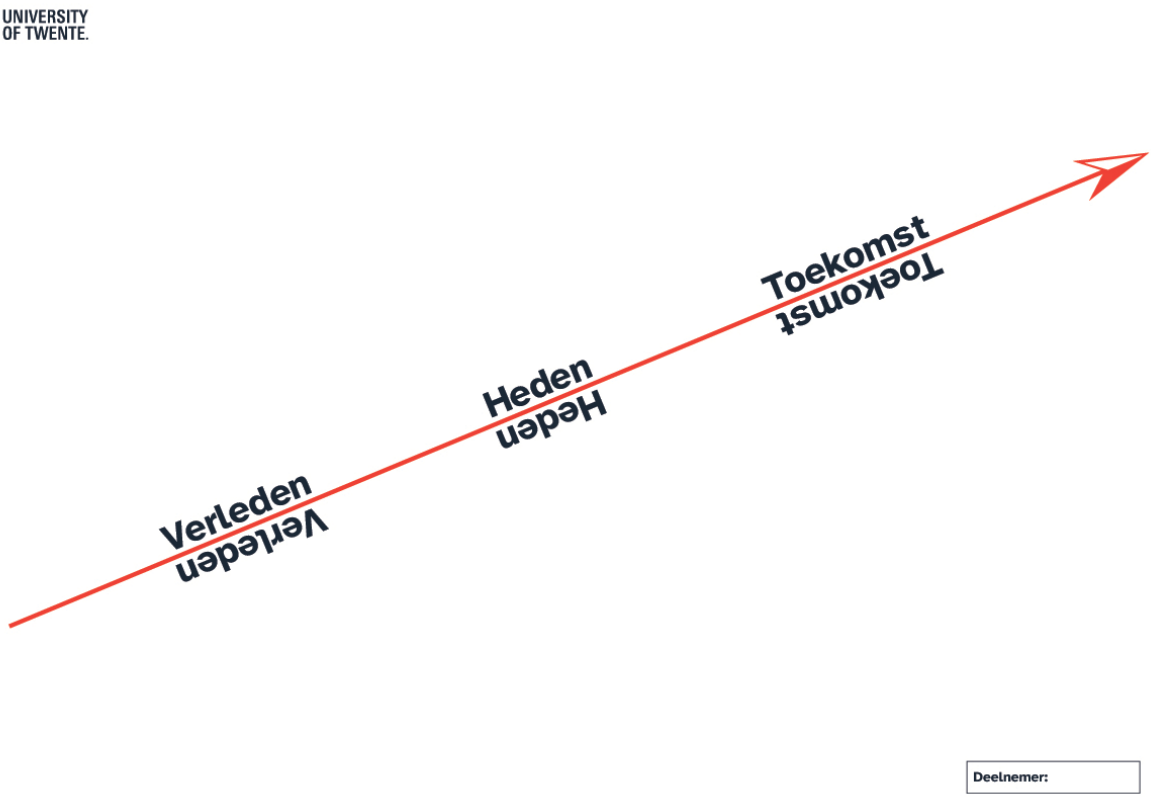

Figure 32 - Creative session task 2: Physical activity

As seen in figure 32, the paper features a long arrow with *Past*, *Present* and *Future*. Based on what type of physical activity people have done, do or want to do, they are asked to cut out and place the activity on the board accordingly.

The different activities are walking or running, cycling, hockey, tennis, basketball, boxing, golf, rowing, sailing, soccer, swimming, volleyball or handball, fitness and taekwondo or another fight sport. It was predicted that the most recurring activity would be walking or running and cycling, so there are three cards of this activity. The rest only has two cards. However, the participant can write down more activities on the paper if a certain activity is missing or if they want to place it in all the three domains. The different cards can be seen in figure 33.

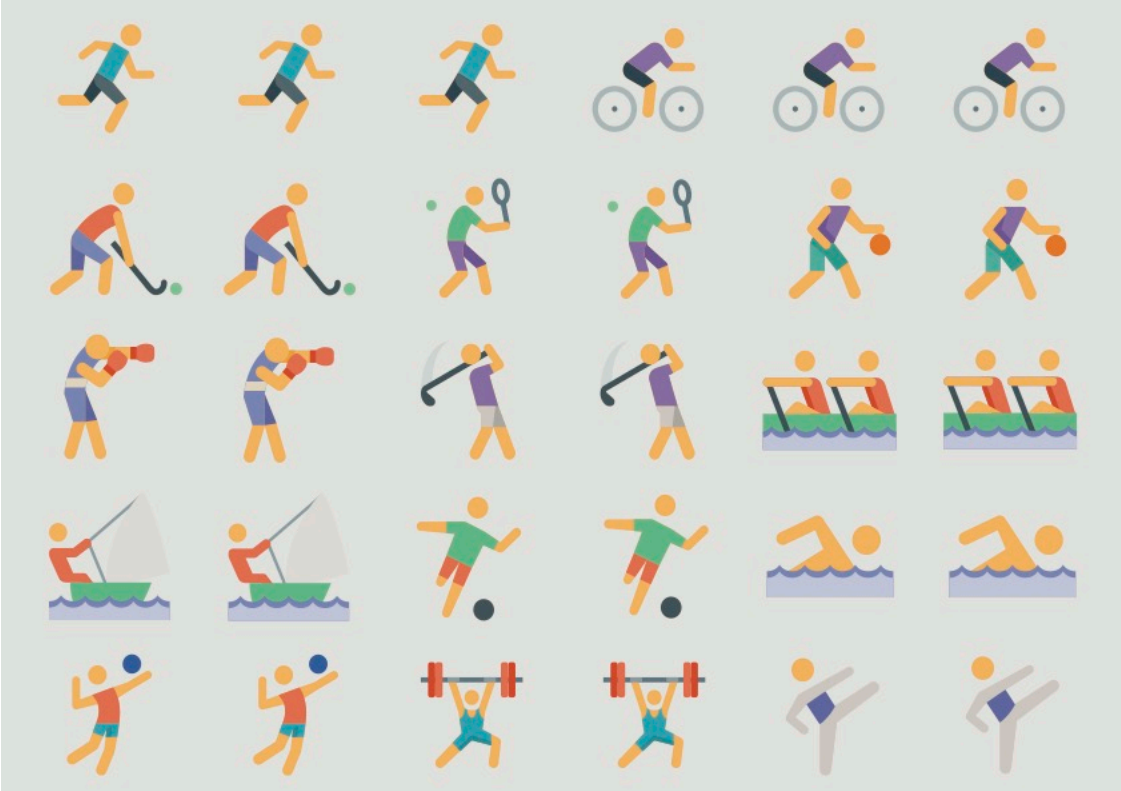

Figure 33 - Different activities for task 2 (ByPeople, 2016)

The main goal of this task is to understand the attitude towards activity and exercise. According to Sleeswijk-Visser and colleagues (2005) it helps to think about the future if we first look at the past and the present. Where Sleeswijk-Visser and colleagues (2005) talk mainly about the future as being dreams, this research interprets the future as motivation or ambition. To what extend are the participants still motivated to perform physical activity? Answering this question could help to understand if the interaction technology that will be developed will be or successful or not. If the user is not motivated intrinsically, an external motivator could be crucial.

Part 3: Existing Technologies

While the preparation questions in the booklet had the focus on how certain technologies can *measure* physical activity, the goal of the creative session is

to get a better understanding about the opinion how this data is *communicated*.

Based on a few popular applications and technologies the participant is asked to express their opinions in a similar way as assignment 1. On the y-axis there is *Motivating* and *Not motivating*. On the x-axis there is *Clear* and *Not clear*. This matrix can be seen in figure 34.

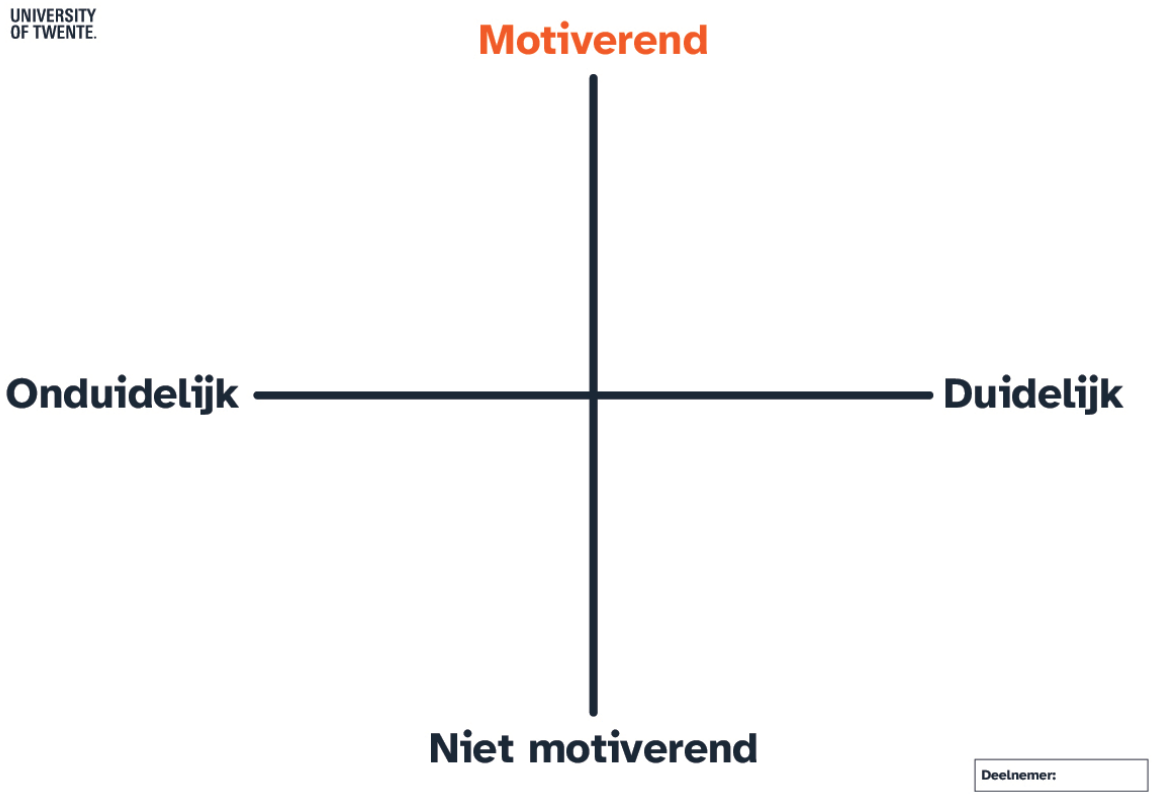

Figure 34 - Creative task 3: existing technologies

There are four different types of technologies provided in the booklet. Two of them feature two images to explain the way of communication better, but the participants do not have to place them on the board, they can choose which one they like.

The first way of communicating is the rings developed by Apple Watch, as described in section 3.1 and seen in figure 6. Based on a predefined goal the rings display the progress throughout the day. The displayed application features three of those rings which can be connected to their own goal. The main goal of this image is to get insight about the opinion towards a circular goal visualisation.

The second type of communicating is with a bar chart. The examples given are the way the Oura Ring presents its activity data in the app as well as a feature on the Apple Watch. The x-axis corresponds to hours on a day and

the y-axis corresponds to the amount of physical activity. Also, the colour of the bars represents the intensity of physical activity.

The third application features a type of ball that gets filled with liquid according to a predefined goal, the Pedometer app by Leap. On this ball also the number of steps is displayed. While it is also based on a predefined goal it is another way of displaying the goal and could give insight on what the participants prefer.

The last technology provided is based on the game Tetris by Garmin. Tetris normally is a game where the player must place shapes in a certain order, and they disappear. This technology caught the idea of Tetris and based on the amount of activity on a day, certain blocks on the watch face disappear. The main goal of this technology is to get insight if people like to translate the goal into a game. Additionally, it has the smallest visualisation of the four, so it is also tested what the opinion towards a rather small size is. The different technologies can be seen in figure 35.

Figure 35 - Different existing visualisations of number of steps for task 3

The main goal of this task is to understand what the participant thinks of the type of visualisation: a circular goal, a bar chart, a visual appealing goal, or a game. Some types could be clear but not motivating for instance. Prior to the session the designer will explain the different techniques and what their intention is. It therefore is not based on intuition; the participant is allowed to already know what the different technologies try to communicate. After the

placement of the cards the participant is also ask why they placed a certain card on that spot.

While the contents of the tasks differ, they all share the same objective: trying to stimulate and engage the participant to get their true opinions and feelings on paper as described by Sleeswijk-Visser and colleagues (2005).

5.6 Results and analysis

As described in chapter 3, the gathered data from the booklet and the creative session will be analysed for recurring or striking themes regarding the questions and responses. The next section will first evaluate the responses and session per question and will finally analyse overarching themes, as described by Sleeswijk-Visser and colleagues (2005). This will be done by looking at the textual and physical responses but also with the use of quotes that were said during the sessions and documented by the researcher.

For the analysis to be in line with the spatial aspect as described by Sleeswijk-Visser and colleagues (2005), the online tool Miro is used. This tool allows for *drag-and-drop* interaction of digital notes and images (Miro, 2021). An example of the analysis can be seen in figure 36. The entire Miro board can be found in appendix B.

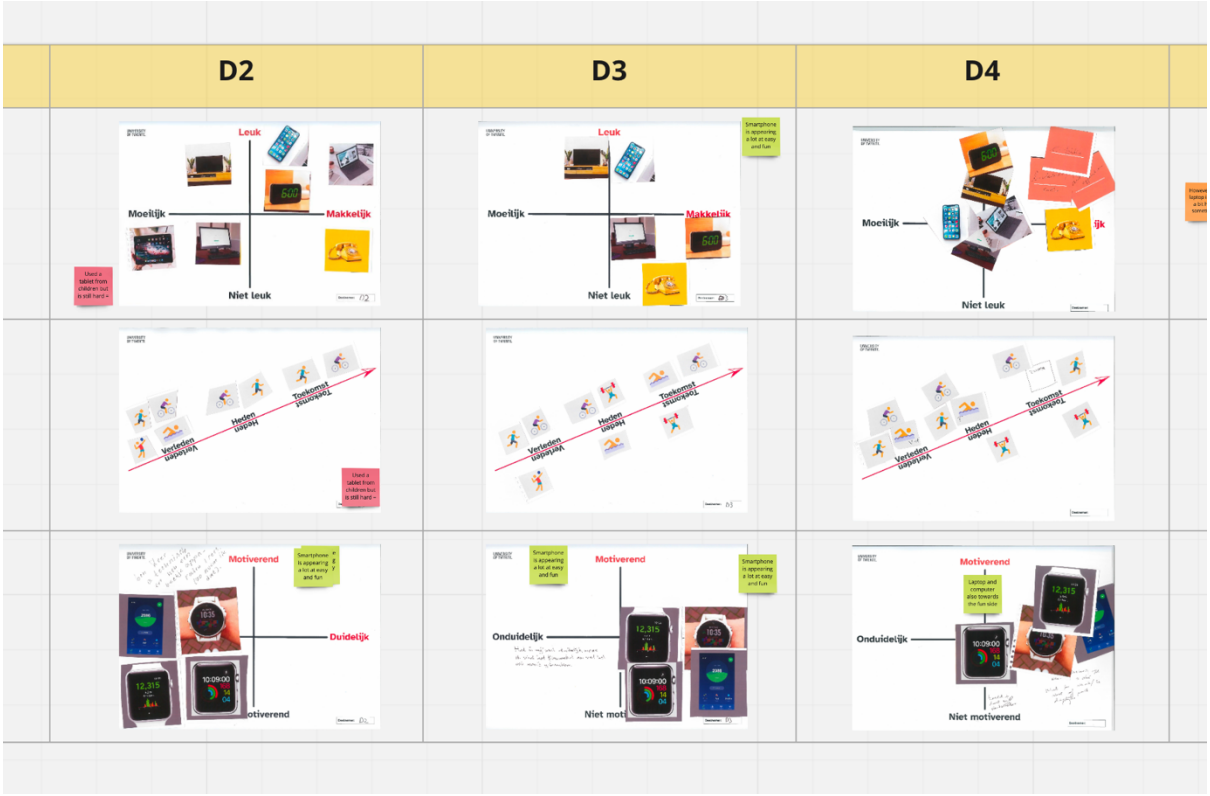

Figure 36 - Example of evaluation in Miro

General discussion

For the ideation sessions seven participants are interviewed. Five of the participants are women and two are men. The first session functioned as a pilot session to test whether the conceived process would be effective or that still some changes were needed. While this led to a few modifications, such as use of language and better explanation, no major improvements had to be made. Therefore, the results of the pilot session were considered with the analysis since the answers were not different from answers of the other sessions.

Overall, the people that participated were interested in the project and already had some knowledge about it by the explanation of the physiotherapist. Even during times of lockdown, they were willing to participate and actively engaged in the different creative sessions as well as have discussions about the topics.

There were no certain outliers in the sense of people that were already very experienced with a certain technology for instance. However, people varied in physical activity. Some participants still did many different activities while others could not perform them anymore for varying reasons. In table 1 an overview of the participants is given.

Table 1 - Overview of participants

Participant	Age	Gender	Current physical activity indication
D1	72	Female	Regularly active
D2	80	Female	Less active
D3	81	Female	Regularly active
D4	78	Female	Regularly active
D5	72	Female	Very active
D6	67	Male	Regularly active
D7	78	Male	Very active

Part 1: Favourite Technology

For the analysis of part 1 the different relevant technologies that emerged from the responses are discussed. This discussion includes the responses from the booklet as well as answers from the accompanying creative session. An example of the creative session can be seen in figure 37. A complete overview of the responses can be found in appendix B.

Figure 37 - Example of response of creative task 1

The smartphone recurred in almost every list of favourite technologies. While two participants listed their smartphones as their favourite piece of technology, the others almost always listed it as second favourite. The enhanced connectivity and easy communication with family and friends is one of the main reasons why it scored so high. Looking at the responses of the creative session, the smartphone is perceived by everyone as being fun and almost always also being easy to use. However, not every participant enjoys the most out of all these functions. According to a participant, apps like Facebook have the threat to be addictive. Therefore, she handled interaction with the smartphone needs to be handled with care. That is also why some participants indicate that they leave their smartphone on the table in the living room and not in the bedroom for instance. They do not want to get interrupted every time a notification makes a sound.

D4: "While it is an amazing piece of technology, it does not have to take over my daily life. I want to use it whenever I want"

When looking at the diaries, the smartphone also is present in most parts of the day. Most of the time people use it after they wake up to check for messages on WhatsApp or e-mail. Later, the same activities happen, and the main usage seems to be for communication purposes.

The computer and laptop are also a favourite to most participants. The great functionality makes it versatile. Not only for fun, but also for work related topics like writing in Word or online communication. For some participants the computer is used daily for this type of communication, like e-mail. Furthermore, the computer is being used by most of the participants for financial necessities as well.

When looking at the responses of the creative sessions, the perceived difficulty of the computer or laptop varies. While people enjoy using it, it is not always that easy in its usage. The computer sometimes tends to get slow and that is a big frustration which withholds people from using it. A quick glance at the diaries confirms this since it is used by some people daily but not as often as other technologies.

Another digital technology that most participants enjoyed using is the television. It is used by almost every participant daily and appeared high on the list of favourite technologies. However, some of the participants found it not an easy technology to use. On a few responses it appeared on the left size of the matrix indicating that it is hard to use. Reasons why are varying but it often had to do with the great amount of functionality.

D7: "I do not have keyboard anxiety, but there are a lot of buttons on my remote."

And:

D2: "I know it is an amazing piece of technology, but I only use so little of it. Last week there was some pop-up in the middle of the screen, and we could not see anything, only hear! At that moment I wish I know more about it."

While not every participant could come up with a technology they did not like, the responses that were given often related to the functioning not being as expected. Screens or connectivity did not work as prescribed which leads to irritation. This is in line with the responses about the computer that worked slowly. It is important to the user that a certain technology does what is expected.

Not only malfunctioning or miscommunication from the technologies themselves can be a problem. The overwhelming number of options and functionalities could give problems with the interaction. This participant complained about the, in his opinion, almost *digital* oven:

D6: "There are just too many sophisticated operational possibilities, I just want to turn it on and set the temperature!"

Nevertheless, when looking at the response of the creative session, the rather old-fashioned cable cell phone is not perceived as difficult by the participants but is not so fun. The participants know how to use it but do not particularly enjoy it. To some extend is the same true for the alarm. However, some participants make use of the radio feature and therefore really enjoy it. Nevertheless, a certain technology can be simple but that does not necessarily mean that is enjoyable to use.

To be conclusive, most of the participants are positive about the smartphone and enjoy the great functionality that comes with it. While it is a tool, they tend to use daily, they are aware of the intrusive role it can have in their lives and therefore try to interact with care. Secondly, the large functionality a computer and laptop have to offer is also appreciated. However, slow interaction or too many options are major turn downs. This is not only true for these types of technologies, but also for others like the television. While it can offer pleasure and information participants can perceive the great functionality as overwhelming and have trouble with the interaction.

Part 2: Physical Activity

The questions relating physical activity mainly had the goal to gather insight about the motivation of the participants. The next section therefore will not necessarily go into detail about the type of physical activity but look with an overview at recurring patterns and how they relate to other activities.

Most of the participants still perform a significant amount of physical activity and get joy out of it. Most of the participants have regular moments in the week where they perform certain exercise such as fitness or swimming. While not everyone enjoys it to the same extend, walking, cycling and fitness are for most of the participants favourite. Some participants try to walk at least once a week for a longer period. Some participants also noted that they try to walk everyday but can catch themselves failing sometimes:

D1: "I try to walk everyday but some days I catch myself in the evening discovering it did not happen."

Cycling was also an activity that was still performed by most. Even when the physical capabilities withheld it:

D2: "I was fallen with my bicycle and while I still enjoy it very much I only cycle in rural areas for a short amount of time nowadays."

Other participants tried to still do it as much as they could:

D7: "I have an electric bicycle but whenever I can, I try to use my manual bike!"

However not everyone enjoys it to the same extend. As mentioned by the second quote the aspect of cycling was sometimes as experienced as dangerous since people had negative experiences with it. Therefore, some participants did not do it anymore. Figure 38 gives an example of what the response could look like. This participant does not actively walk anymore but still wants to perform physical activity in the form of cycling, swimming, and fitness.

Figure 38 - Example of response of creative task 2

Since most of the participants were recruited with the help of a physiotherapist almost all of them performed some sort of fitness once a week. Often this was in collaboration with the physiotherapist. People did not specifically enjoy it because of the activity, but mainly because of the social factor it had. Another participant who still played tennis on a weekly basis said the following regarding the social aspect:

D7: "One of the most important things of playing tennis for me is the social aspect it has and being outside."

This was a recurring theme as a few participants also tried to walk together with friends. The social aspect could motivate them to go outside and perform the activity.

Another activity a few of the participants wrote down was doing chores or housekeeping. Different tasks around the house required quite some energy and were seen as physical activity. While most people did not indicate their opinion, a few people really enjoyed it and wrote it down as being on of their favourite activities. The active aspect of these tasks could motivate them to do it.

D5: "It is more of a necessity than a satisfactory job. However, the active aspect makes up for it!"

Looking at the responses from the creative session it is very clear that all participants still want to perform the activities and sports they perform today. Almost all of them looked back at the past and came up with a few sports and activities they enjoyed. However, most of these activities were not part of their daily lives anymore. Mainly the sports that require significant manoeuvrability occurred mostly in the past. The most recurring physical activities were again walking, cycling and fitness. Almost all participants still see themselves performing these activities in the future as well.

This is line with the findings from the questions in the booklet which suggested that many participants still enjoy these activities so do not see themselves quitting with these soon.

Additionally, the last part of the questions about physical activity focus about what gives people energy. Physical activity and liveliness are often associated with energy. While not every participant had ease with answering this question, a recurring theme of these questions had to do with taking a moment of rest and recharging. This question intentionally was left to be interpreted by the participant of what they defined as what place and things saw as giving energy.

This interpretation mainly led to answers in the form of sitting at a table in the kitchen or living room for instance. After breakfast, listening to radio or drinking a cup of coffee gives the participants energy. However, two participants also got energy from performing activities such as gardening and housekeeping since they experience them as fun.

Part 3: Existing Technology

The last part of the session was experienced differently among the participants. This mainly had to do with the fact that most of the presented technologies were new to them. This was indicated in the booklet as well during the session. During the discussion at the creative session the participants sometimes showed a certain level of resistance towards the technology. This could result in answers that showed little variety and shared a common theme, unfamiliarity.

While some of the participants apologised for this and thought this was not the *right* answer to give, this answer can still be of value. These types of answers really showed the attitude some participants have towards these types of technology. The next part will discuss the responses in the booklet and then look at the recurring themes about the way existing technologies communicate the data to the user.

The questions in the booklet focused on three different types of technology, a smart watch, smart ring, and simple step counter. While the different technologies differ in their form and way of measuring many of the answers where answered the same.

First by looking at the smart watch. Almost every participant had heard about it or seen it in their surroundings. Most of the time children or grandchildren showed it and demonstrated the usability of it. Some of the participants for instance already knew about the step-counting ability of it.

However, almost no one indicated to use it. Only one participant answered the question with a neutral answer. Some participants could come up with reasons what could be a motivation to use it, being it for instance for information and insight. The measurements could be interesting and could give information you normally would not have received. However, most of the participants did not want to use it because it was either complicated or intrusive:

D7: "I do not want to be informed on every moment of the day about all types of businesses."

And,

D2: "The unfamiliarity could make me react nervous towards it."

Almost no one had heard of the smart ring before. However, the attitude towards it was a bit more of acceptance than the smart watch. A reason for this could be the fact that the motivation for participation in the research could be out of interest in the ring.

Nevertheless, it does not mean that the intention to use it was significantly higher than the smart watch. Half of the participants still did not want to use it and still question its usefulness. However, some participants acknowledged the fact that a ring could be less intrusive than a smart watch:

D6: "Less notable at use, no irritating lights"

Participants did show more interest in the ring and think it is a great piece of technology. While this could not be particularly seen in the responses in the booklet, this was mainly observed by the way the participants responded to questions about the ring. They showed interest in its inner and outer working.

The technology that was known to the most people was the normal step counter. Some participants had used it in the past but did not use it anymore. While it was known to more participants, they still did not want to use it. They could see it as a useful tool to measure and get insight in their movement however no one would really want to use it.

D4: "I have used it in the past, but I would rather feel how my own body reacts after 1.5 hours of walking for instance. I do not want to count unnecessary or overperform"

Again, the intrusiveness of the counting is a recurring theme with this technology. The participants see the benefit the technology can have but indicate they do not really want this information.

Where the questions in the booklet focused on the way activity is measured, the creative session focused on the way this information is displayed. The responses were varying. Three participants did not categorise the different technologies and did not think it would motivate them at all:

D2: "I find them all very clear, but it would not motivate me at all."

Or:

D3: "I do not like this technology, so I do not find them clear or motivating"

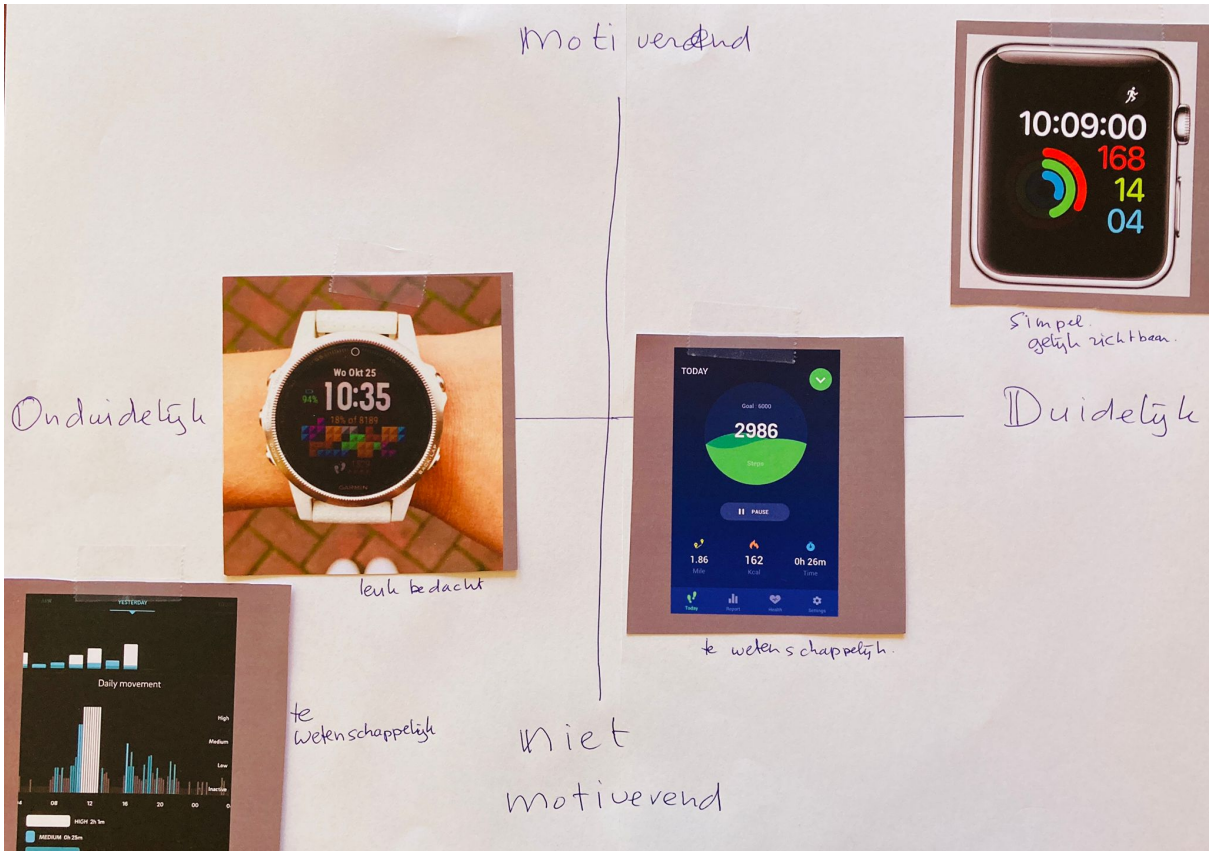

Figure 39 - Example of response creative task 3

These participants often apologised for their, in their opinion, rigorous answers. However, these answers can still be of great value. They are in line with findings of Heinz and colleagues (2013) who suggest that older adults sometimes can show resistance towards a certain technology if they do not see the benefits for themselves. Since this research only gave a short introduction, the technologies could be experienced as redundant, as some of the answers illustrate.

Nevertheless, there also were participants that made a distinction between the different ways the technologies display the amount of activity. An example is given in figure 39. While there was not a single favourite form of display that occurred from the participants the bar-chart was often listed as not motivating and not as clear as other techniques.

D6: "I do not like this one, it is too scientific in my opinion."

The rings on the other hand were indicated to be more motivating:

D1: "Yes, I think that this would motivate me, for instance, in the evening when I see that it is not closed yet, to go outside for a small walk."

While the Tetris-style was purposely chosen to be somewhat unclear and not intuitive at first sight, after explanation most of the participants liked the idea of the game aspect it had.

5.7 Discussion

The main goal of this ideation session was to get a better understanding about the attitude and opinion towards to the different subjects to successfully develop an interaction technology. Therefore, the following themes mainly relate to requirements or functionality this interaction technology should have. These themes form the basis for a brainstorm session and eventually the specification of the requirements for the prototype.

Intrusiveness

The level of intrusiveness a certain technology has in the lives of the participants is an important factor. This theme mainly relates to the presence of a certain technology itself. Most of the participants were still proficient and competent with the interaction of digital technology. However, they want to have the control the amount of time and interaction with these technologies themselves. Notifications that interrupt or are visible all the time can be frustrating and often lead to irritation and a negative attitude towards it. This mainly came forward in the responses about smart wearables and how they interact with people. Due to the inevitable fact that a smart wearable is attached to the body and measures what you do, it seemed to scare the participants. They often did not see the utility of this and prefer to decide for themselves. While this mainly was the case with the smart watch, the smart ring savoured a little bit more acceptance due to its relatively small size.

Individuality

In relation to intrusiveness lies individuality. This not only resonated in the responses in relation to technology but also with the quantity and type of physical activity. To start with physical activity. Most of the participants still were quite active in their daily lives. It was not a hurdle to step out of the door and *do something.* This *something* was interpreted differently throughout the participants. Some saw it as being very active and exercising, others saw it more as being outside and walking, or even gardening. While most of the participants believed they performed enough physical activity, a few felt that they could benefit from more. Even some participants could catch themselves performing too much physical activity and could sometimes use a *brake* in their lifestyle.

Nevertheless, an overarching theme for most participants was the freedom they had to still do and perform these different physical activities. The feeling of having control about the activities to do feels good and could also give them motivation and energy. While the physio-related activities like fitness could feel like an obligation, the social aspect and gained physical functioning could motivate them.

Autonomy

Related to individuality lies autonomy. This individual and autonomic aspect did not only occur in the attitude towards physical activity. Similarly, the interaction with technology shared these relationships. The great functionality and enhanced connectivity are appreciated by every participant. Though, the way and amount of interaction needs to have a certain autonomy for the user. The smart wearable was perceived as taking away the most autonomy since it is believed that it is constantly measuring and displaying the information towards the user. The data could be interesting, and people could gain insight in their health with it. However, because of this constant measurement it felt like the user cannot decide for themselves anymore and that the technology is taking over their life. While not every participant felt this to the same extend, the theme of autonomy in contrast to control was present among all participants.

Utility

Utility is also a theme that came about during the different sessions. This mainly had to do with what a certain technology had to offer and what the benefit towards the user would be. It had to do with the ways existing technologies displayed information about the level of steps towards the user. When a technology was not clear or was not perceived as useful to the user because the information that it provided was not necessary, negativity existed towards it.

Usability

Usability within the scope of this research mainly focused on the ease of use and clarity a certain technology has. For the user this results in the question: “Does the technology that I interact with does what it is supposed to do, and do I understand what it is trying to say?” On the first place this occurred with the interaction with technologies in their daily lives. It could be a major frustration and killer of motivation if a certain technology did not work like it had supposed to do. Slow reaction time or malfunction could lead to frustration and strongly decreased its likeliness. The participants indicated that a certain system should work like it has supposed to do and when it is

has an excessive amount of extra functionality which can cause difficulties, it is not a system they would implement in their lives.

5.8 Conclusion

All in all, the way a technology influences the life of the participant is of great importance. The participants can interact with digital technology and enjoy doing so, however a technology should not be prevalent. These different themes form the basis for what the requirements of the interaction technology should be, and development should take the following into account:

- Mitigate the level of intrusiveness
- Acknowledgement of individuality
- Respect autonomy
- Encompassment of utility
- Entail usability

If a certain technology can meet the criteria and fulfil the needs as described by the participants, it could increase the chance of being successful in the motivation of physical activity. Additionally, these themes form the base for a brainstorm session. It could help form ideas that are already in line with what a user would desire and therefore meet their needs.

6. Specification

To start development, certain requirements are specified. These requirements are tested during the user evaluation and can indicate whether the development was successful. These requirements therefore function as guideline during the realisation phase and as measurements for the evaluation.

First, a set of requirements is specified based on the different themes that arose out of the ideation sessions. These are the user requirements and specify to what the prototype should adhere to be effective. Besides the recurring themes of the ideation sessions, these requirements also utilise design suggestions when designing for older adults, as described by Lewis and colleagues (2017). These different suggestions can be found in appendix C.

Together with the themes and the list of requirements a brainstorm session is held together with two other Creative Technology students that resulted in a few possible solutions. After the brainstorm session one idea was chosen that aligns the best to the specified user requirements. With this idea a prototype is developed.

For this prototype a second list of requirements will be made that covers the system requirements and these specify what the physical prototype should do. Correspondingly, a list of developer requirements is made to specify the resources needed to complete the project.

6.1 User requirements

Based on the ideation session and suggestions as described by Lewis and colleagues (2017) a list of user requirements is made. Based on relevance and occurrence in the session, the different themes are ranked under *must, should* and *could.* For instance, intrusiveness was a common theme among all participants, while information about the benefits or consequences of performing physical activity was not mentioned significantly.

Based on a study by Lewis and colleagues (2017), that suggested design recommendations for the development of smart wearables when designing for older adults, certain requirements that were also mentioned in the ideation sessions are supported by literature. While the suggestions focus on the development of smart wearables, most of the suggestions can still be seen as valuable to consider when designing together with an already existing smart wearable, in this case the Oura ring.

User Requirements
Must
The system must be easy to interact with
The system must not be intrusive
The system must have legible text (Lewis et al., 2017)
The system must not be hard to learn
The system must be clear in message
The system must allow for setting own activity goals
The system must be durable
Should
The system should minimize the steps to complete and allow enough time to process tasks (Lewis et al., 2017)
The system should show the user about the amount of physical activity
The system should motivate to perform more physical activity
The system should allow the user to maintain autonomous
The system should have a place to charge the ring
The system should minimize instances in which multiple tasks overlap in time and compete for attention (Lewis et al., 2017)
The system should provide the status of the steps or goals within broader tasks (Lewis et al. 2017)
The system should not look too scientific
Could
The system could give information about the benefits when performing enough physical activity

The system could show consequences when performing not enough physical activity.
The system could include alert tones that are less vulnerable to age related decline (Lewis et al. 2017)
The system could connect with other systems to feature a social aspect in the stimulation for physical activity.
The system could serve a double-function

6.2 Developer Requirements

To develop the technology, requirements are set for the developer.

Developer Requirements
The project should be concluded in 10 weeks
The project should take the latest COVID-19 measurements into account when interacting with the user
The project should result in a physical prototype
The project should at least have one evaluation session with the user

6.3 Brainstorm

Based on the results of the ideation sessions and the user requirements, a brainstorm was held. This brainstorm was done together with two other students. For this brainstorm session all the different responses of the creative session were categorised on a table and a short summary of the responses in the booklets was made. Together with a short summary of the ideation sessions and a small introduction of the recurring themes the participants of the brainstorm session were informed.

The technique for this brainstorm is the creation of a mind map. It was created on a big piece of paper. Prior to the brainstorm the problem to solve *stimulating older adults into more physical activity* was written in the centre. Connected around it were already some of the themes that came out of the ideation: *intrusiveness, usability, utility, autonomy, and individuality*. It resulted in the following mind map in figure 40:

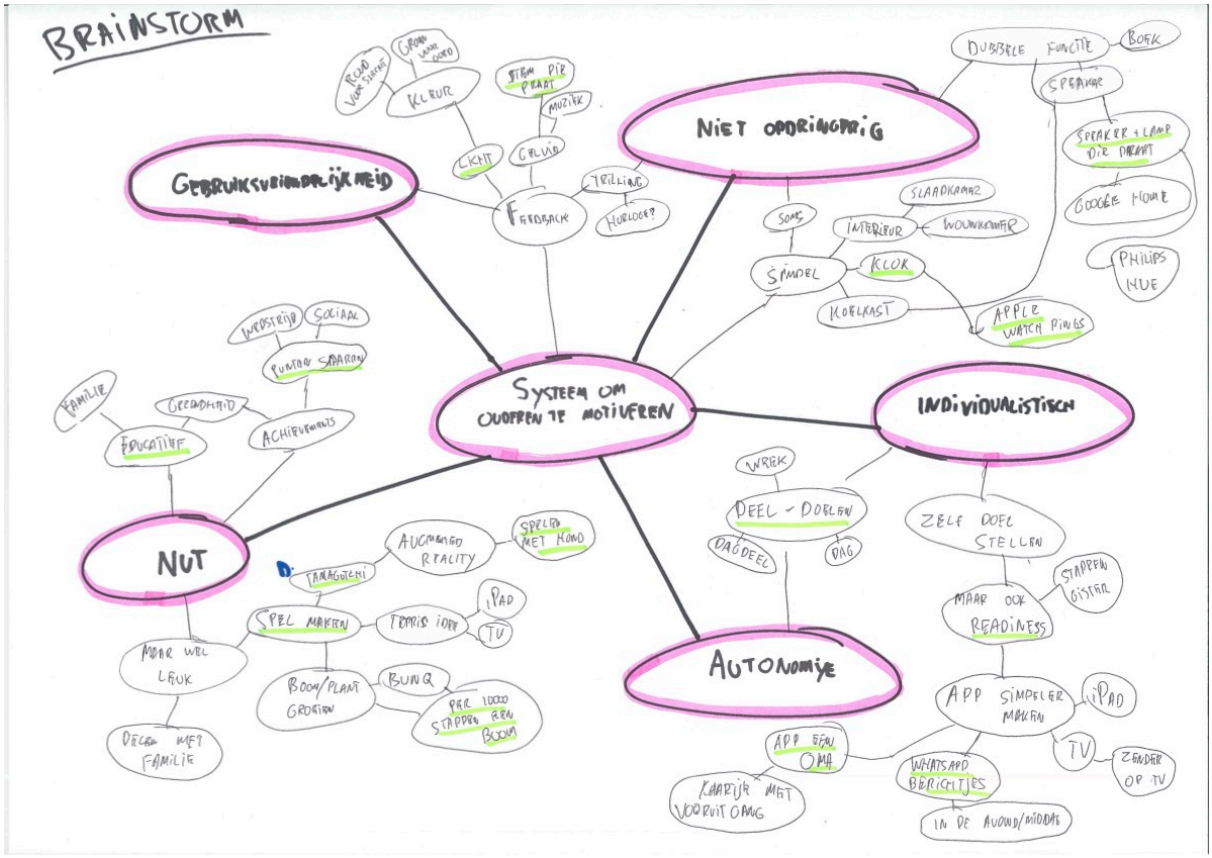

Figure 40 - Brainstorm

Interesting ideas were highlighted and based on discussion afterwards together with the participants and personal interest three ideas were chosen and these are discussed in the next section.

Coaching Tamagotchi

Based on the classic Tamagotchi game where you have care for a certain pet. Based on how much food you give it or how much you play with its happiness is defined. The main idea of this Tamagotchi is that you must walk with a digital dog, instead of a physical one. According to a study by Westgarth and colleagues (2019) dog owners perform more physical activity than non-owners. Translating these findings to the digital world and the user could also feel obligated to perform a walk with their digital dog to keep him happy and healthy.

It is presented to you on a tablet in the living room and the digital dog can bark occasionally to grab your attention. Besides the health of the dog, the dog could also talk to the user and tell facts about what the benefits of physical activity are. This could not only make this idea motivational but also educative.

Motivational Wall clock

Based on the responses of the ideation sessions and personal experience the circular display of a goal seems clear and could be motivating to certain people. While the Apple Watch displays the progress on a day on a watch, this idea displays the rings of progress on a physical wall clock. Besides being a clock, it can also light up and show one or more rings that show some type of goal. It is connected to the Oura ring and every time it makes a connection it lights up and displays the progress of a predefined goal like a circle diagram.

Motiveer een Oma

Based on the idea of *App een Oma*, where you can send a WhatsApp message to your grandparents that gets turned into a card, this idea turns it around and sends text messages to the device of the older adult. Since most of the participants indicated that they use their mobile phone quite often for interaction with friends and family it is a familiar application. They must wear the ring and based on the number of steps they take on a day automated text messages are sent to them that could either be motivating or complimenting based on the progress. It could eventually be extended with weekly status updates sent to the home of the participant in the form of a real card, giving it a physical aspect.

6.4 System requirements

With the user requirements and feasibility of the developer requirements in mind, the different ideas are compared, and a final idea was chosen. Based on this idea a list of system requirements is made. The next section first discusses the different ideas and based on the chosen idea the list of system requirements is made.

While the Tamagotchi-idea allowed for lots of functionality and customizability it could get into conflict with some of the requirements as specified in section 5.1. Constantly caring for a pet could be experienced as intrusive and it could not be immediately clear what the amount of physical activity on a day is. Additionally, it would potentially be displayed on a screen, and this could give problems since the target group could not want another screen in their lives.

The *Motiveer een Oma* idea could work for some of the people from this ideation session. However, there still was too little known about possible consequences the usage of a mobile phone could have to their motivation. It could conflict with some of the specified requirements as well since it still

was a mobile phone and participants indicated that they preferably use their phone with caution.

The final idea that was chosen was the motivational wall clock. This concept matches the requirements the best based on the defined user requirements and seemed feasible based on the developer requirements. It should consist out of a wall clock that incorporated an indication of the progress based on a predefined goal. When the user comes close to the clock and the ring makes connection with the clock it should light up. From this idea a few sketches were made that can be seen in figure 41.

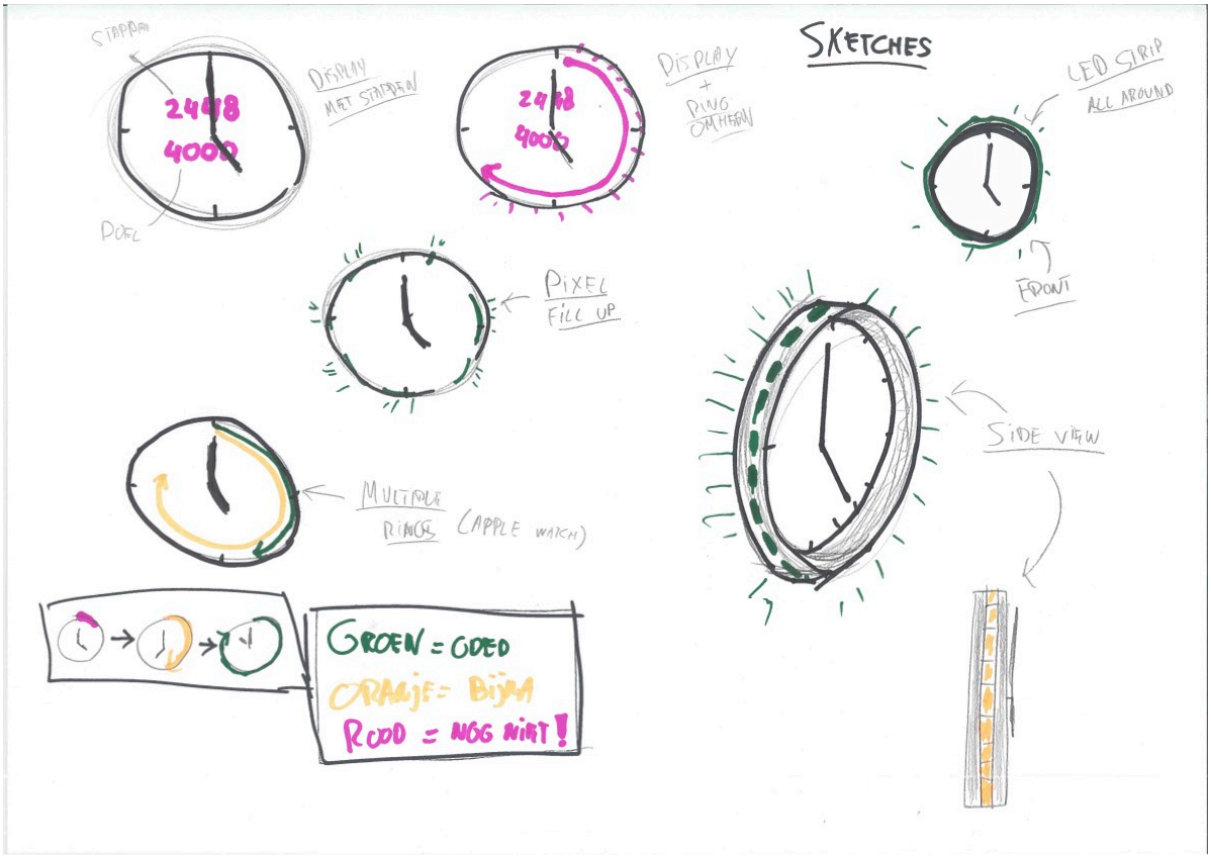

Figure 41 - Sketches for the interactive wall clock

With the idea specified, a list of functional requirements is made. These functional requirements focus mainly on the more physical and tangible aspects of the prototype.

System requirements
Must
The system must be able to hang on the wall
The system must be able to be powered on 230 power supply
The system must connect with the ring automatically
The system must show the progress of the goal
Should
The system should indicate the progress of the goal with colour
The system should be easily programmable
The system should have a place to charge the ring
The system should light up when it connects with the ring
The system should preferably not have a screen
Could
The system could include audio-visual feedback
The system could show a celebration animation when the goal is reached
The system could indicate the progress in a similar way like the Apple Watch

7. Realisation

This chapter will discuss the realisation of the prototype. It elaborates on the specified idea that evolved out of the brainstorm session as described in chapter 5. The next section will discuss how the current prototype was established. This includes an overview of the process and the choices made in the development of the hardware, as well as the software.

While not every part of the software was eventually required at the evaluation session and is not yet incorporated in the current prototype, the workings of the software are still explained as they could serve as a starting point for further development.

7.1 Technical hardware

The prototype was developed at the Design Lab at the University of Twente. The Design Lab is an open workplace for students to build and develop projects for their study. It allows for rapid prototyping because of wood- and metalwork and electronical soldering facilities as well as professional tools such as laser cutters and 3d-printers.

Materials

To build the prototype the following materials were used:

- Ceiling-lamp
- Clockwork with hands
- Poplar plywood, 4, 8 and 10 millimetres
- Vinyl stickering, black
- M2.5, M3 and M4 nuts, washers, and bolts
- WS2811b LED-strip
- Arduino Nano
- DC-DC Buck converter
- Potentiometer
- Breadboards
- Protowires

And to build the prototype the following tools were used:

- Trotec Speedy 500 laser cutter
- Tools from Design Lab (such as drill, dremel, screwdriver and vile)
- Adobe Illustrator
- Java and Arduino IDE

The hardware of the prototype can be divided into three sections: the outer shell, the inner structure, and the electronics. The next section will discuss

and first explain the different sections and their materials. Second, some of the tools are elaborated on more as well as the digital software that was used to laser cut the material.

Outer Shell

The outer shell is made from an already existing ceiling lamp. The inner electronics are removed which results in a flat wall mount and a diffusing cover, respectively outer left and right in figure 42. The diffusing capabilities of the ceiling lamp allowed the clock to be neutral when the lights are not shining. Additionally, the diffusion allows for a more gradual change of the progress of the lamp.

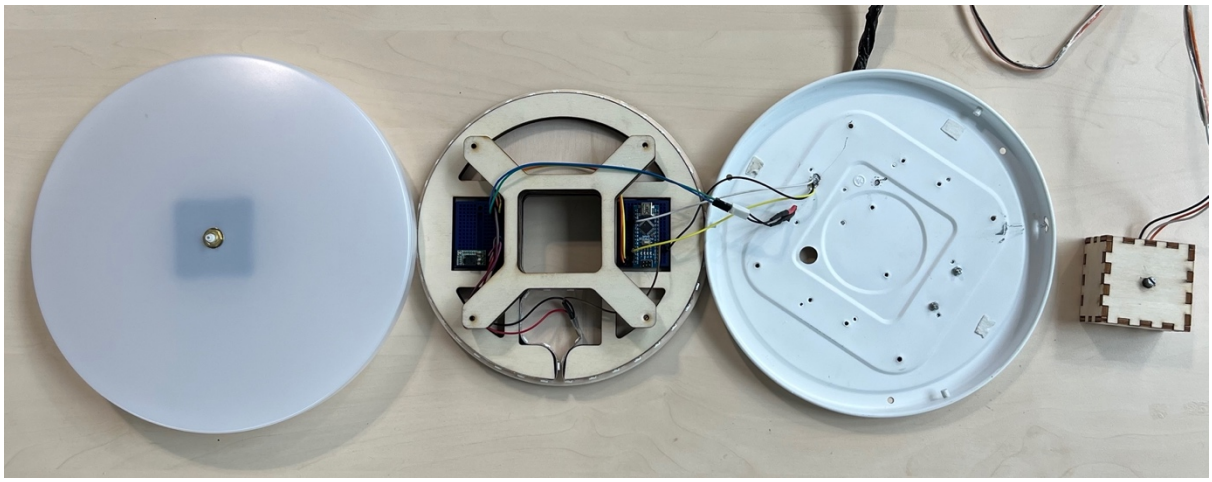

Figure 42 - Overview of inside of the prototype

It was chosen to use this already existing lamp since it is simplistic, and the mounting capabilities of the wall mount allow for easy attachment.

Inner Structure

The inner structure is built up out of multiple wooden laser-cut layers and one black vinyl sticker as seen in figure 43. The stacked layers are exactly high enough to fit inside the outer shell and have mounting holes so it can be screwed to the wall mount as well as to each other. These layers were all laser cut using the laser-cutter. This laser-cutter is controlled by vector-files. The files can be made in Adobe Illustrator and can be found in appendix D.

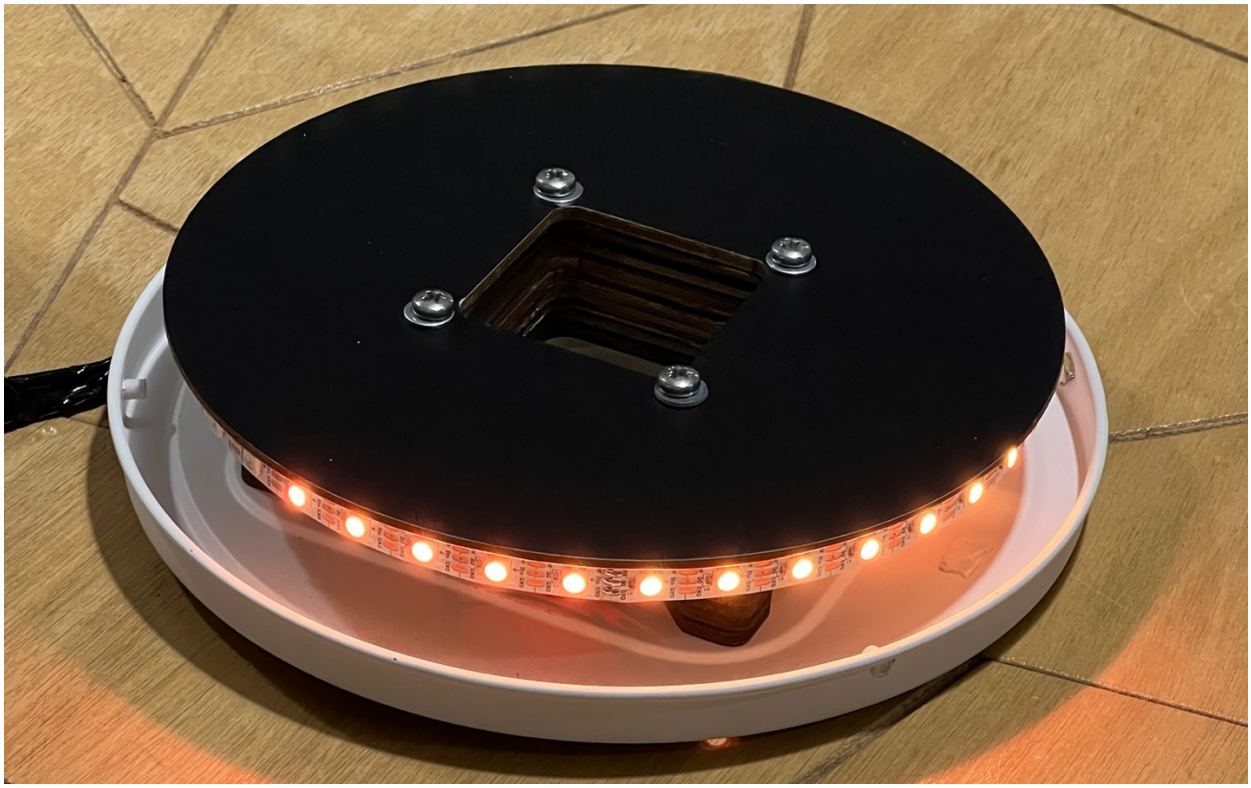

Figure 43 - Structure without the diffuse top

To allow changes to the layers in case of improvements or errors, most of the layers were not glued on top of each other. They are attached with nuts and bolts. However, the attachment of nuts to bolts can be time consuming since the nuts have to be aligned at an exact angle for the bolts to grip in the thread. To counteract this, the nuts are interlocked between certain layers. A cross section of this technique can be seen in figure 44.

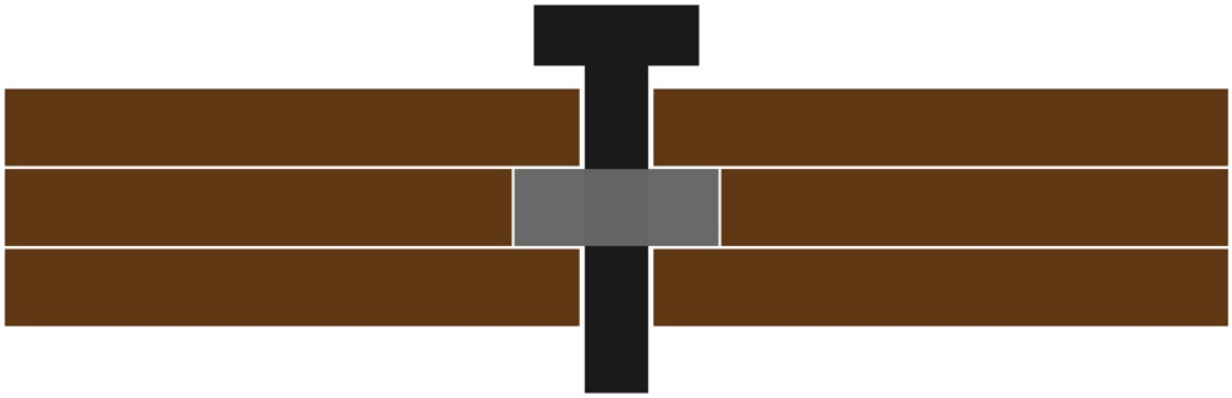

Figure 44 - Sideview interlocking mechanism

The three different layers of wood are glued together which secures the nut in between these layers. This way the bolt can be directly attached to this piece of wood and there is no nut-spanner required.

The top layer consists out of a black vinyl sticker. Since light shines through the top part of the outer shell, the reflection of the rather pale poplar wood could be seen from the outside. To counteract this the top layers is made black with a vinyl sticker that was cut exactly to the dimensions of the layer below. Figure 45 shows this difference.

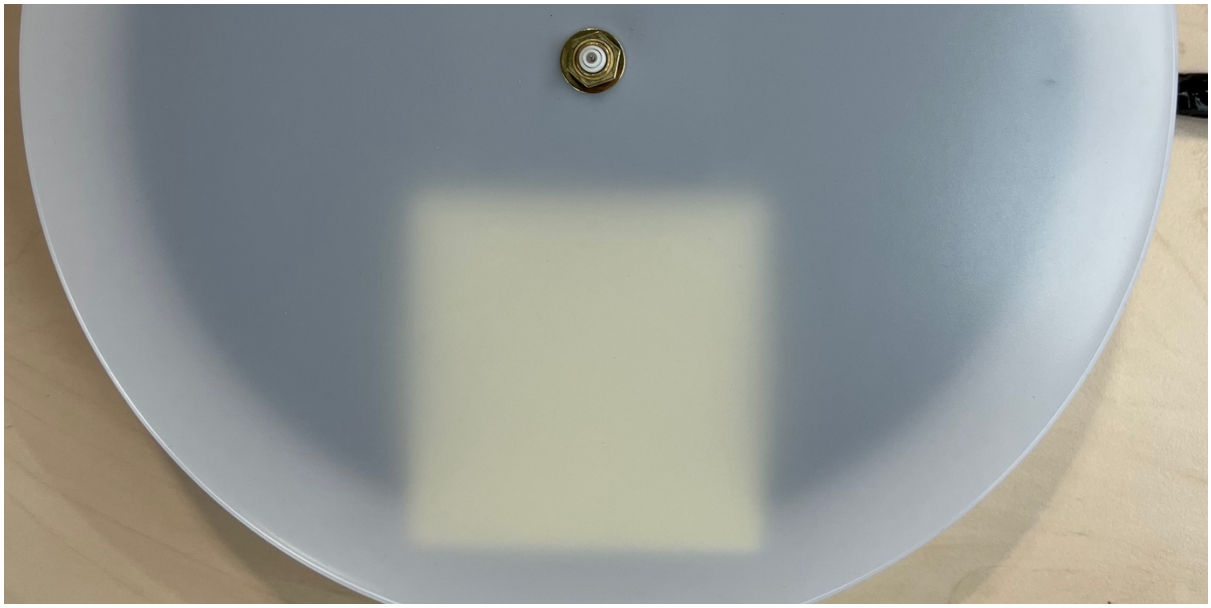

Figure 45 - Difference between light and dark background (light background is a post-It)

The second layer is responsible for directing the light towards the side of the clock. It has a diameter of 210 millimetres which is one centimetre wider than the layer of the LED-strip. It was chosen to add this border around the clock, so it visually created a ring on the outside and light did not bleed towards the front of the clock. In figure 46 the structure with LED-strip can be seen.

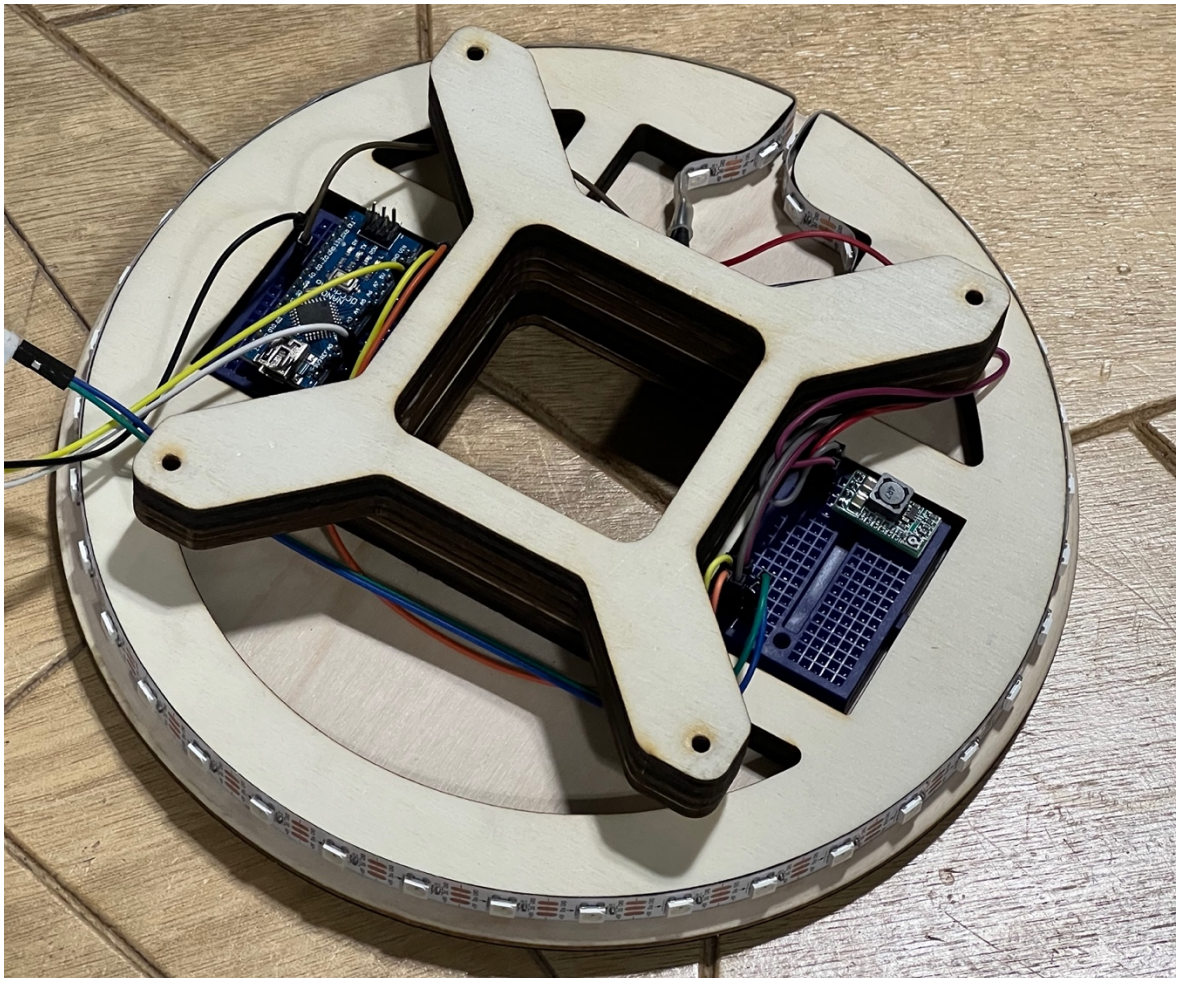

Figure 46 - Inner structure of the prototype with electronics

The third layer is responsible for the mounting of the LED-strip and has cut-outs for the electronics and can be seen in figure 46. It is 10 millimetres thick which is the same as the width of the LED-strip so it can be glued to it. The rounded edges and the hole on the top allow for the electronics to be connected to the Arduino Nano.

To leave space for the electronics to be connected to each other, a spacer of 8 millimetres was placed between the layers. This spacer also is responsible for the mounting of the front layers and has the interlocking nut as aforementioned.

The fourth layer consists out of the mounting to the backplate and is cross-shaped. Since the electronics are below this layer, this cross-shape was required. At the end of the arms the interlocking nuts were implemented so the attachment to the back only required bolts from the back side of the outer shell. The total height of this layer is 16 millimetres and was changed in the development process a few times to align exactly inside the clock.

7.2 Electronical hardware

Arduino Nano

The Arduino Nano can be seen as the computational heart of the prototype. It is a small computer which can be programmed to execute commands based on inputs it gets from actuators. It can be seen in figure 47.

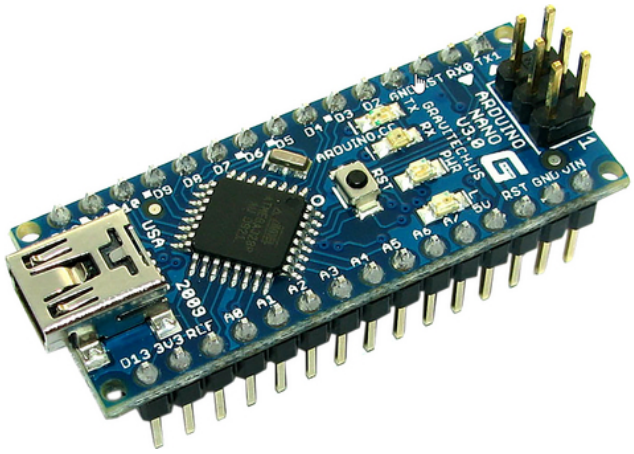

Figure 47 - Arduino Nano (Arduino Nano board, 2022)

It has a USB-port which allows it to be connected to a computer where it can be programmed with the Arduino IDE. Once a certain program is uploaded to the Arduino it does not need to be connected to a computer and only requires power to execute its commands. More about the software and the Arduino can be found in section 7.4.

Breadboard and circuitry

All the electronical parts were mounted on two breadboards and connected with protowires. Figure 48 shows a schematic overview of the entire electronical circuit. The left breadboard is responsible for the Arduino. The right breadboard is responsible for other components, which in this case only was a converter. The breadboards allow for rapid prototyping since they allow for fast plugging and unplugging of the protowires and do not require soldering.

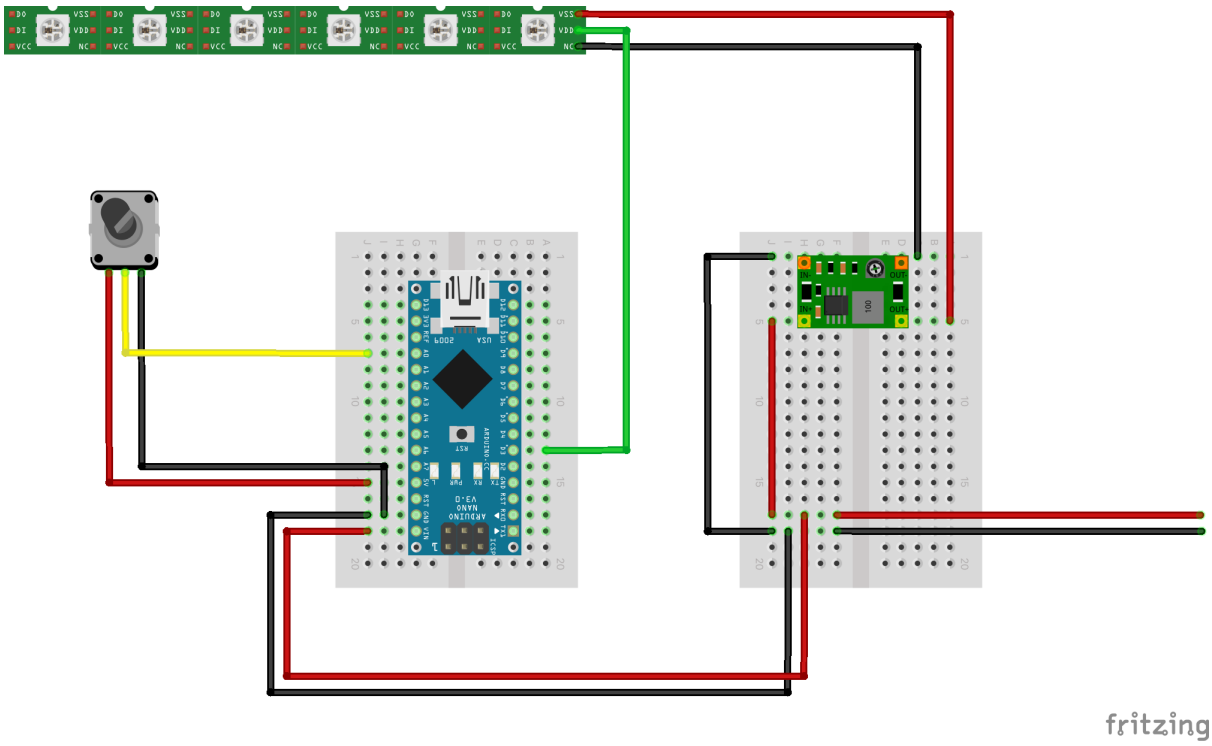

Figure 48 - Overview of electronic circuit

LED-strip

For the lights a WS2811b LED-strip is used. This is an individually programmable RGB led strip. It was chosen to use this LED-strip since it can be programmed together with Arduino and only requires 5 volts of power. This is the same voltage the Arduino can output. A more detailed view of this LEDs can be seen in figure 49.

Figure 49 - Close-up of the LED-strip

Nevertheless, during the process it was discovered that the Arduino itself could not draw enough current for the LED-strip to function properly. This because every light on the LED-strip consists out of three individual LEDs: Red, Green and Blue. These individual LEDs require 20 milli-Ampere for full brightness. Since the prototype should be able to switch between brightness to test which setting would look the best it was decided to assume to upper limit of current. This resulted in the following equation:

$$(0.02 \times 3) \times 40 = 2.4A \text{ of current}$$

At full brightness the prototype would require 2.4 amperes of current. Based on this an external power supply was needed to let all the lights function properly since the Arduino Nano can only output 500 mA. The next section will cover the power supply.

Since the LED-strip can be cut to a desired length it does not have pins like the Arduino and therefore required to be soldered. Three protowires were soldered to each connection and secured with heat shrink, as seen in figure 50.

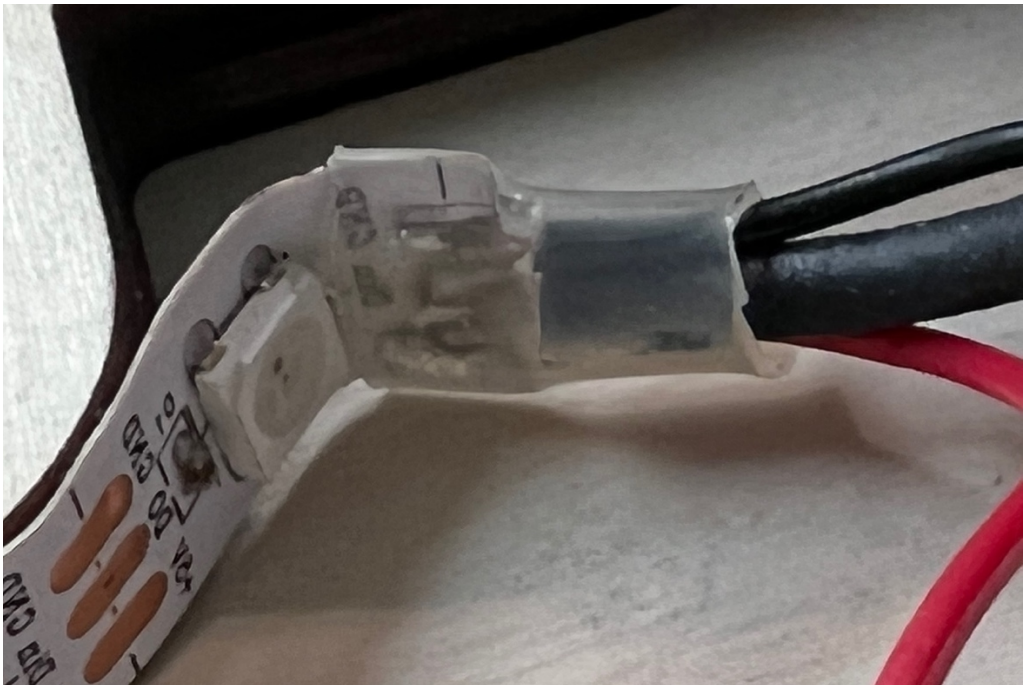

Figure 50 - Soldered LED-strip with heat-shrink to protect

Power supply

For the electronics, and mainly the LED-strip, to function properly, a power supply was attached to the prototype. It was chosen to use a 12V, 1.0A power supply. With this power supply both the Arduino Nano and the LED-strip could be powered. The Arduino Nano can be powered directly from the power supply since it can accept an input ranging from 7V to 12V. For the LED-strip a DC to DC Buck converter was used to convert the 12V input to 5V for the LED-strip to not overheat. This also resulted in the right amount of current for the strip as described in the previous section:

12/5 x 1.0 = 2.4A of current

Additionally, since the LED-strip would almost never require all the provided current, the pins of the power supply could also be used for future components that could require power such as a speaker or a small screen.

Potentiometer

While the prototype can already function on its own with the components mentioned above, for evaluation purposes it was equipped with a potentiometer. This is a turning knob which outputs a voltage between 0V-5V. Based on the degree of the turning knob this value varies. The Arduino Nano can interpret this amount of voltage into a numerical value which can be used in the software. While the eventual product will be connected to a Wi-Fi network and will not require such knob it was chosen to use this knob

for flexibility during the evaluation. The knob including its casing can be seen in figure 51.

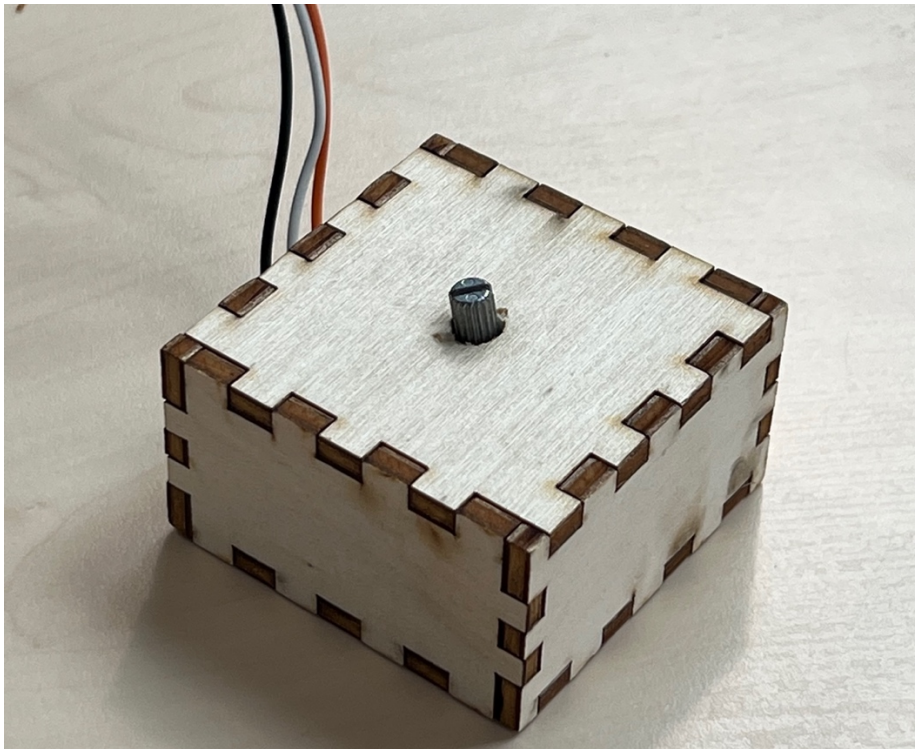

Figure 51 - Potentiometer box for demonstration

Clockwork

The clockwork is a store-bought clockwork with arms. It runs on a battery but could eventually also be attached to the Arduino.

7.3 Software

The elaboration on the software consists out of two sections. First, an exploration and example of the eventual software is considered. Due to time concerns and sharing restrictions from the Oura API, this software could not be integrated into the current prototype. However, the functioning of this software can still be valuable for further research and provides a framework of what the eventual software should look like. Second, the software that was used for the user evaluation and demonstration is discussed.

API connected software

The next section discusses the effort done regarding connecting the actual ring to the prototype. When the ring connects to a mobile phone it sends its data to the application of the phone. This data is stored on a server. However, Oura allows developers to access this data with an Application Programming Interface (API). This technique allows applications to directly interchange information with each other on the internet (Mulesoft, 2022). A client, in this

case the prototype, can request information from a server, in this case Oura. The request is authenticated with a personal token to ensure private access (Oura, 2021). This technique was used in the programming language Java to test before using it with Arduino.

Since Java and C++, the language in which the Arduino is programmed, are quite similar the Arduino can also make these requests. Nevertheless, since the Java code was used to test and experiment, it is rather large and cluttered. Therefore, the code of the entire Java program is not provided but a simpler, but similar, program in the Arduino language is included in appendix E. The output of the Java program can be seen in figure 52 and displays the distance to walk as well as the target distance that is set by the user.

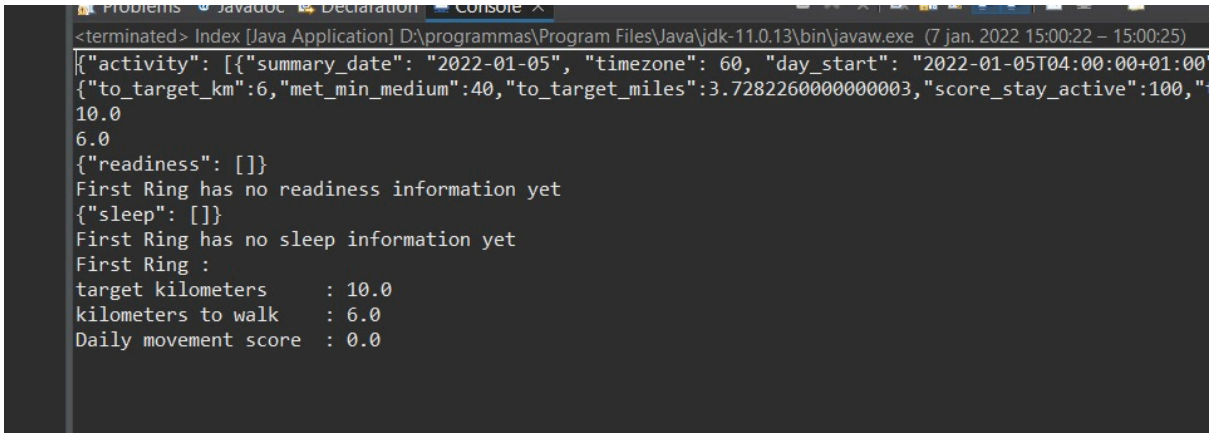

Figure 52 - Snapshot of the output of Java

While the Java program works and can request and output the measured data from the API of Oura, it does not work together with the Arduino. It was planned to use a version of Arduino that can connect with the internet via Wi-Fi. However, when requesting information from the Oura server it gave difficulties and indicated it was not allowed to give this information. While the information and tokens were not different from the example in Java, it still gave this problem. Therefore, it is assumed that Oura only allows identifiable computers to request its information and that this version of Arduino was not sufficient. While there are ways to counteract this problem they were not actively executed since this study focused mainly on the interaction and visual aspect of the prototype. These approaches are shortly mentioned in the recommendations.

Demonstration software

To clearly demonstrate and illustrate the working of the prototype an offline program was written. This program allowed to imitate the progress made on a day by turning on a knob. Based on the angle of the potentiometer the clock would light up, first by being red and gradually turning to green, to

finally display the celebration animation and the static green. This code can be found in appendix E and an overview of its structure can be seen in figure 53.

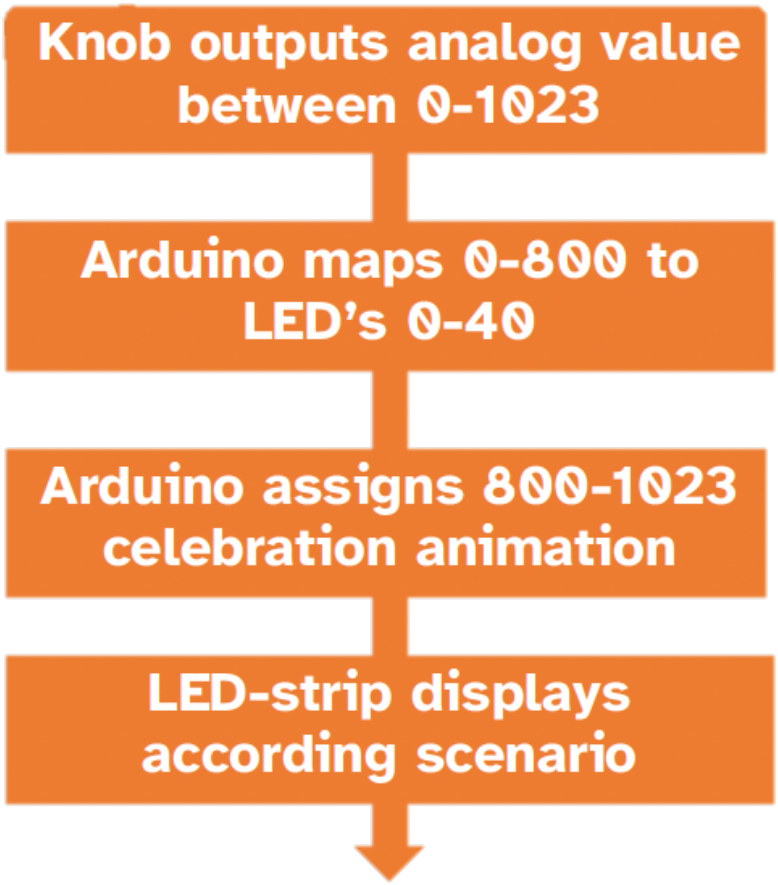

Figure 53 - Scheme of software for demonstration

7.4 Overview

A demonstration of four different scenarios can be seen in figure 54-57. These colours and progress amount would normally light up when the ring connects to the clock and sends its data towards it.

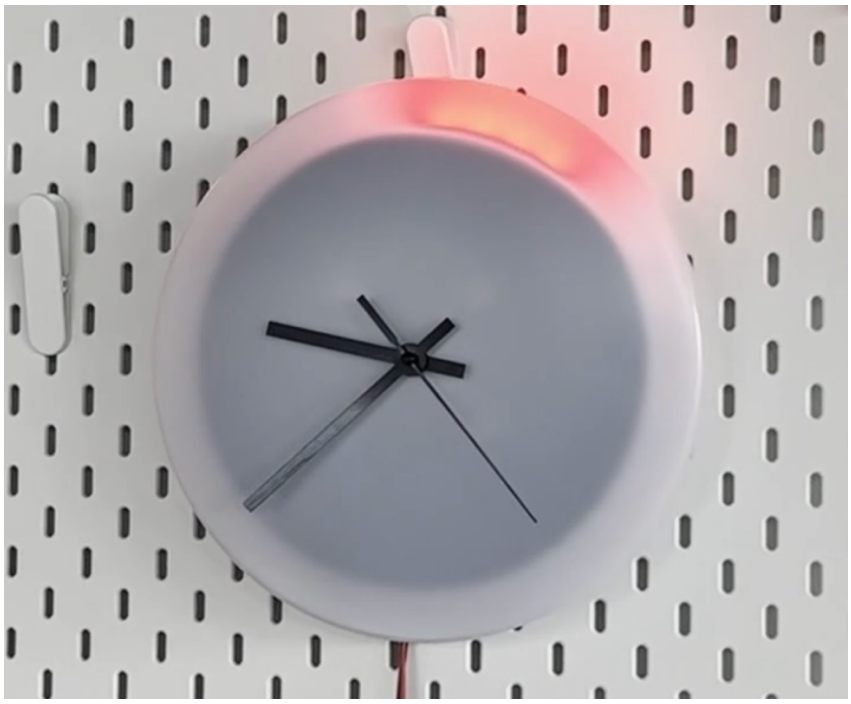

Figure 54 – 15% of goal

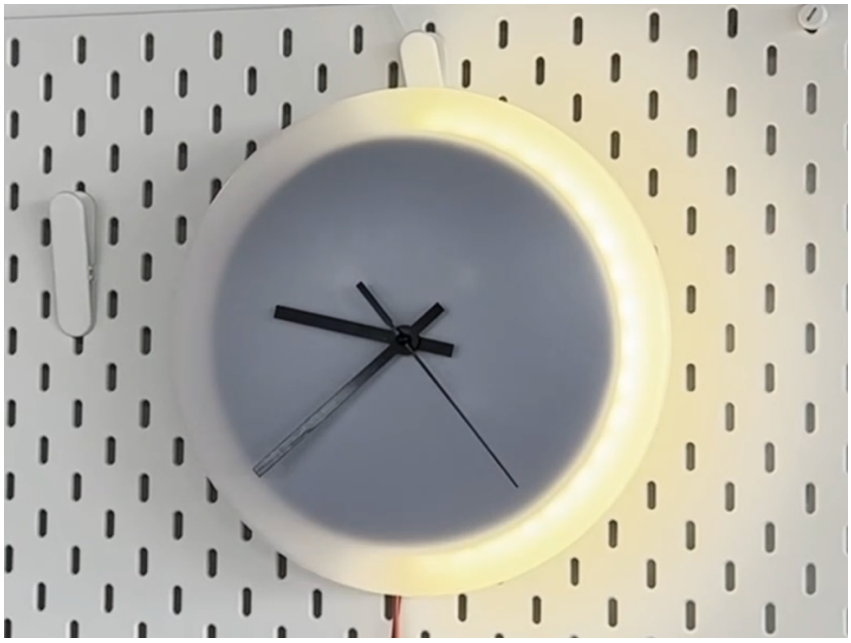

Figure 55 - 50% of goal

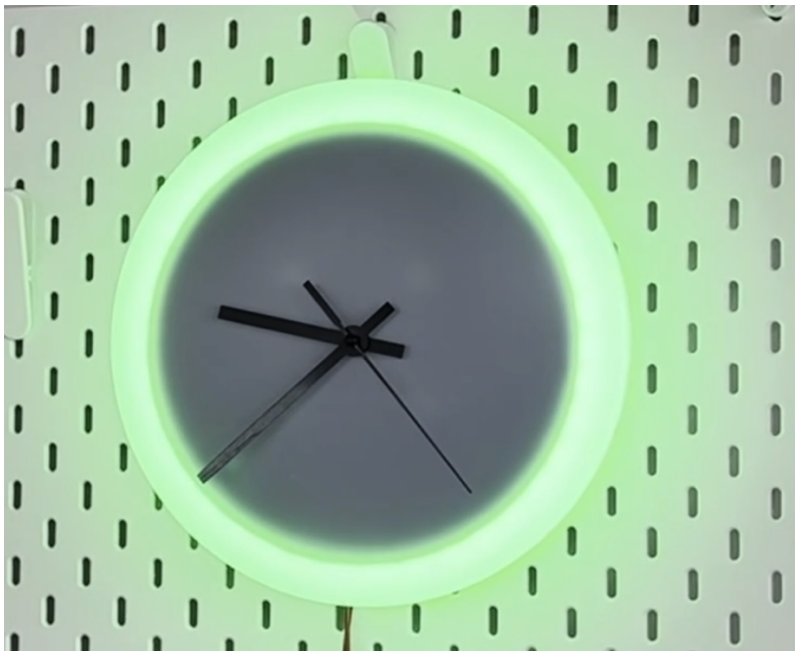

Figure 56 - 100% of goal

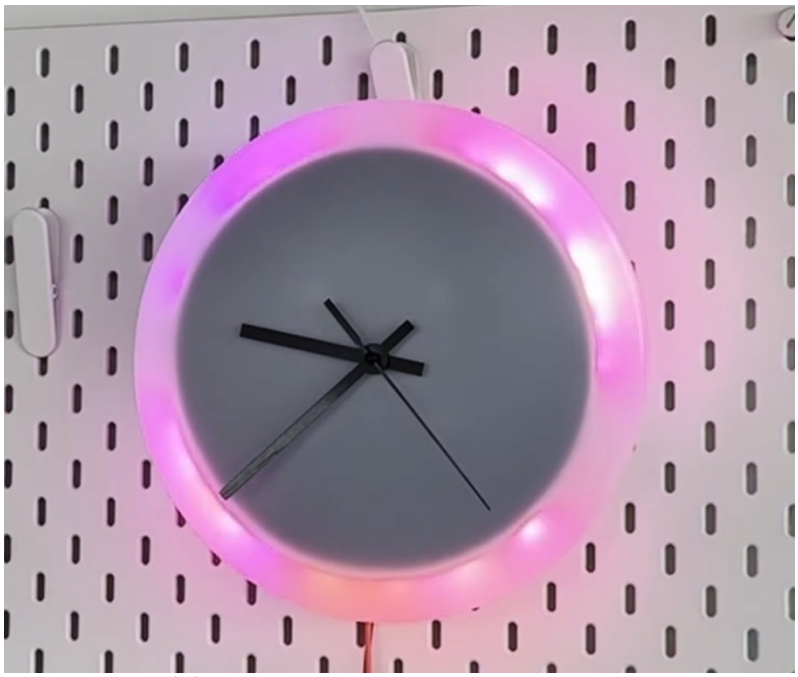

Figure 57 - Celebration animation

8. Evaluation

After the development of the prototype an evaluation session was held. This to gain insight to what extend the developed prototype had achieved its goal and met the requirements as stated in the specification. The user evaluation will be explained and the different questions with their objective will be discussed. The responses will be discussed and analysed on recurring themes. Based on this analysis a recommendation for a second version of the prototype and eventually for further research is given.

8.1 User evaluation

The user evaluation is used to gain insight on the effectiveness and usability of the prototype. It is tested whether the users understand the functionality of the prototype and if certain aspects should be improved. This user test consists out of four parts.

Before the session starts, it is explained to the participant and an informed consent is signed. This consent can be found in appendix A. After consent is given the session will start with testing its clarity and usability based on a few scenarios. The participants are asked to think aloud and describe what they see. Following the shown scenarios, a semi-structured interview is held with questions regarding the scenarios and what aspects could for instance be improved. After this discussion the participants are asked to fill in a questionnaire regarding the SUS-score of the prototype.

Part 1: Intuition

To test the clarity and intuitiveness of the prototype the following scenarios are shown:

- 25 % of circular goal
- 65 % of circular goal
- 100 % of circular goal
- 100 % celebration animation
- Goal achieved idle mode

Before these scenarios are shown only limited explanation is given. The ring is handed over to the participants and they are told that when they would come close to the clock with the ring, it would light up and show a certain scenario. The participants are asked to think aloud. Their thoughts and responses are written down.

After the scenarios the full explanation is given of the prototype and the workings if it would be an already existing product. This to help the user in

imagining that it is already an existing product. There is also room for them to ask questions for further explanation.

The main goal of this part is to test whether the participants already understand what the prototype wants to show, based on intuition of the lights and colours. However, it should be noted that the participants already know a little bit about the topic and the study so they could have an idea that it is about motivating physical activity. Therefore, this part is only short and will take a few minutes, it functions as an icebreaker for the rest of the session and allows for a short discussion and introduction to the actual explanation.

Part 2: Clarity and motivational capabilities

After the introduction and explanation, a semi-structured interview is held. The interview covers the clarity of the message the clock wants to tell and the perceived motivational capabilities of the prototype. To start the discussion multiple questions are prepared to serve as guideline for the conversation, However, it should be noted that these questions merely serve as guideline and the participants are free to interrupt or ask for elaboration on certain topics. The questions leave room for own interpretation due to the informal and qualitative nature of the evaluation. This first part of the semi-structured interview focuses on the clarity and motivational capabilities of the prototype and the questions are discussed down below.

Q1: Do you understand what the prototype wants to tell? Clarities/Unclarities?

Goal: Get a better understanding if the participants understand what the prototype is showing and what aspects are clear or which aspects are not clear. Note that this question is asked after the explanation and possible guesses of what is shown are already covered in part 1.

Q2: Would it motivate you to perform more physical activity? Why/why not?

Goal: Understand if the prototype would motivate the user to perform more physical activity and what aspect of the prototype would be responsible for it or why not.

Q3: What should be improved to motivate you/motivate more?

Goal: In the case of no motivation at the previous question ask for improvements and in the case of motivation ask what aspects could make it even better in motivating.

Q4: Would insight about the consequences of performing too little physical activity motivate you to perform more physical activity?

Goal: The clock in its current form only displays personal status and not any other information. Information, like benefits or consequences, could lead to more motivation, but could also be experienced as intrusive based on the responses of the ideation sessions. Therefore, this question solely focuses on the consequential aspect and display and if a feature like that would be helpful for the user.

Nonetheless, it should be noted that responses later in the interview can still be written down at the corresponding questions. As aforementioned, the questions function as guideline for the interview and do not necessarily need to be answered in order.

Part 3: Usage and implementation

The next part of the semi-structured interview focuses on the usage and implementation of the product. While the questions in the session have the intention to blend seamlessly into each other, the analysis afterwards separates it into two different parts.

Q5: Would you use this product? In case of yes, where would you use it?

Goal: To get a better understanding if people would use it and where they would place it. The exact place is not particularly relevant, rather if they would hang the clock at a place where they see it often, like the living room for instance.

Q6: Do you think that there is still something missing at the product?

Goal: To get insight in if the prototype in its current form has enough functionality or that there are still certain things missing.

Q7: What would you be willing to pay for the product?

Goal: Get insight in the financial value to the participants. It is important to note that it applies for the whole integrated system, so also a ring that is connected to the clock. This not necessarily needs to be the Oura ring but can also be another, simplified ring, that only measures movement. This question applies only to the current state of the product which is the clock and a ring that measures movement.

Q8: If you bought/use this product, what would you expect of the implementation?

Goal: On the one hand get an understanding if people understand the working of the product or if they still need explanation and on the other hand get insight in the preferred way of learning when they buy a new product.

Besides room for questions, the form that is to be filled in by the researcher also has enough space for additional notes that could for instance elaborate on missing functions or suggestions.

Part 4: System Usability Scale score (SUS-score)

After the interview the participants are asked to fill in the questionnaire regarding the usability of the system as described in chapter 3. For this interview the Dutch translation by Jansen and colleagues (2012) is used:

1. *Ik denk dat ik dit product frequent zou willen gebruiken.*
2. *Ik vond het onnodig ingewikkeld.*
3. *Ik vond het product makkelijk te gebruiken.*
4. *Ik denk dat ik technische support nodig heb om het product te gebruiken.*
5. *Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.*
6. *Ik vond dat er te veel tegenstrijdigheden in het product zaten.*
7. *Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.*
8. *Ik vond het product omslachtig in gebruik.*
9. *Ik voelde me zelfverzekerd tijdens het gebruik van het product.*
10. *Ik moest veel over het product leren voordat ik het goed kon gebruiken*

8.2 Process

The evaluation session is held with six participants, and they all participated in the ideation sessions. These participants are already introduced earlier and can be found in chapter 4. Out of these participants, only participant D5 could not attend the user evaluation.

Overall, the participants enjoyed the evaluation session. They were very interested in the prototype and had a positive and pro-active attitude towards the prototype. There were no certain difficulties during the session.

The evaluation session was held at *Gezondheidscentrum de Kompas*. While the initial plan was that it would be held at the homes of the participants, it was chosen to switch to a room at *De Kompas*. This because the prototype requires a wall to represent its working effectively and truly. When a participant would not have such wall with mounting options it would conflict with the realism of the scenarios. While the participants would

possibly not feel at home anymore, the predicted disadvantages weighed heavier than the gained advantage. Besides, since most of the participants visited *De Kompas* weekly this would not lead to any logistical difficulties, that could for instance have happened with a room at the campus. The set-up of the session can be seen in figure 58.

Figure 58 - Impression of set-up at De Kompas

The session was held on Saturday the 22nd of January. While *De Kompas* is opened on a Saturday there are no consultation hours so there was free choice of the rooms. It was held from 09:00 till 12:00 and there was half an hour reserved for every participant.

In addition to note taking, the different sessions were recorded when consent was given. This to possibly recall answers if the participants responded elaborately. The different answers were also written down on a prepared and printed form. This booklet of six pages also included the informed consent form and the usability test. This booklet can be found in appendix A.

8.3 Results and analysis

In the next section the process and responses of the evaluation session will be discussed and analysed. This will be done by first reflecting on the different questions individually and draw conclusions based on recurring themes and answers. These conclusions are input for further development and form the basis for future recommendations. In the next section the responses will be discussed based on the categories as defined in section 7.1.

Part 1: Intuition

Although the first part of the session functioned mainly as icebreaker and introduction to the prototype, the responses of the first part were still valuable to get a better understanding about the clarity of the product. Most of the participants did understand the idea of the circular goal display. However, the first scenario was interpreted differently among multiple participants. Some thought it was indication of being on or standby while others experienced the red colour as negative. After the second scenario it was clear for all the participants that a certain goal was increasing, and it was working towards completion. While all the participants understood the 100% green goal meant that the goal was met, not everyone understood the celebration animation afterwards. Nevertheless, the explanation afterwards was clear for every participant and these responses will be discussed in the next section.

Part 2: Clarity and motivational capabilities

After explanation of the complete interaction and meaning of the different scenarios all participants understood what the prototype wanted to show and tell them. The circular visualisation was experienced as clear, and the participants understood that the angle of the circle corresponded to the number of steps taken and the remainder stood for the number of steps that were needed to complete the goal.

D7: "I really like the quick insight."

Besides the circular aspect the different colours throughout the different scenarios are also understood by every participant. Besides that, the switch in colour together with the intended message of red; negative and goal not met yet, to green; positive and goal met, was clear. Two participants responded the following:

D7: "I find it particularly clear that the colours go from red to green, just like a traffic light."

And:

D4: "I get a lot of positive energy from the green light; it feels good to me."

The opinion towards the motivational capabilities varies between the participants. While there is agreement between all the participants that it eventually and potentially could motivate, some questioned the motivational capabilities for themselves. This mainly had to do with personal and intrinsic motivation:

D2: "I am quite stubborn and if I want to do something it really has to come from myself. It could eventually motivate me, but I really need to try it first."

Or:

D7: "No, it would not motivate me, I already have enough motivation from myself! However, when more physical activity is required due to medical reasons for instance, such a tool could help me."

However there also were participants that did saw the added value for themselves:

D6: "Yes, I want it! It would definitely help me to move more. Maybe not the goal necessarily but just the insight could be enough."

However, not only the motivational capabilities would help, one participant also noted that the limiting factor could also be helpful:

D4: "Could it also give a small alert when the goal is reached? So I know that I've done enough for the day. I would also really like that."

And while the colour of the lights and the completion of the circle was clear to all participants, some indicated that it could be even more alerting when the goal was not reached yet:

D1: "It may get even more bright red at the end of the day indicating that I did not take all my steps yet."

Another participant shared this thought but indicated that it should only flash if a certain lower limit was not met yet:

D6: "It could flash when a very low goal, a lower limit of not too many steps for instance, is not reached yet. This would motivate me to at least get that goal."

Another addition suggested by two participants is to play a sound when the goal is reached to make the completion of the goal even more fun.

However, these rather intrusive actions were not acknowledged by everyone. As improvement a participant would like to decide for themselves when the clock would light up and not light up every time the ring makes the connection.

D4: "It could get busy for me when it constantly lights up, I would prefer to choose it for myself."

The question regarding insight in the consequences of performing not enough physical activities was answered diverse. While some participants indicated that it would help to motivate them even more, others said it did not help them:

D2: "I already know the consequences, so the clock does not have to emphasise this even more."

However, none of the participants came up with a specific idea in what way the clock should display these consequences. Nonetheless, one participant did mention motivational text that he would like to see on the clock:

D7: "A text like 'moderate' or 'good job' could be even more motivational. I think that could definitely help people even more."

To conclude, the participants saw some improvements regarding the intensity of the lights, being too much or too little. Insight regarding the effects of too little physical activity would not directly make a great difference since a lot of the participants already knew the consequences.

Part 3: Usage and implementation

The next questions are mainly about the actual usage and implementation of the prototype and required the participants to imagine that they would use and buy the clock together with the ring.

The first question is about visibility, where they would hang the clock. There was consensus among the participants. They would hang the clock on a place where it was visible. Places like the living room and kitchen, rooms where the participants indicated they came a lot during the day, were favourite:

D1: "I have a clock in my living room which is not that dear to me. I think I would replace it and hang it there. That way I can see it throughout the day."

And:

D2: "Besides the functionality regarding the activity it is also just a clock which displays the time."

However, as mentioned before, some of the participants did say that it should be a little bit less present to their taste and that they would like to control the amount of light.

Following the question regarding missing aspects of the prototype was asked. Many of the participants did not particularly miss something in its current form and the question often led to a conversation of the further development of the prototype. Since the participants did not always knew exactly what things the ring could measure this was often explained. This resulted in multiple features that participants would like to see.

D1: "I would like to see my blood pressure, heartrate and sleep-rhythm"

And:

D6: "I would like to see extra functionalities like heartrate, oxygen level and sleep and then the sleep should be displayed in purple!"

Other participants also indicated features they would like to see that did not particularly had something to do with the measurements of the ring:

D4: "Can it also measure my mental health? (...) I would like to see extra features like when I need to take a break or use it as a cooking timer and I think it would be fun to see other people on the clock as well, for instance my friend who I walk with every week. (...) It could also be helpful as a reminder for people who take medication."

The answers regarding the question what people would be willing to pay for it contain some uncertainty. During this question it was not specified whether the participants see the investment as extension if they already had the Oura ring or see the purchase as an integrated system with ring and clock. Therefore, it is assumed that the responded prices are for a ring and the prototype.

While not every participant indicated that they needed the prototype they could all come up with a price. The prices in euros, from lowest to highest, are:

D2: 40-50, D6: 49,75, D4: 80, D1 & D3: 100, D7: a few hundred.

However, it should be noted that D7 indicated that he would be willing to pay a few hundred euros for it if it would really help to perform more physical activity. He saw it as a preventive factor against diseases related to insufficient activity and could potentially see insurance companies play a role in the reimbursement.

Since a lot of the participants understood the workings of the prototype together with the ring quick, there were no major expected prerequisites regarding the implementation process. There however was consensus about the fact that none of the participants want a booklet that explains the working. Most of the participants indicated a short explanation would suffice. It was indicated that this should preferably be done together with someone who already understood the clock. Another participant mentioned that a short video would also be enough. One participant also mentioned that they would like to have contact with someone in case of technical difficulties, but this would only be occasional.

Part 4: SUS-score

The questionnaire about the usability of the prototype gave the following results:

Table 2 - Overview of SUS-score

	q1	q2	q3	q4	q5	q6	q7	q8	q9	q10	SUS-Score
D1	1	1	5	1	3	1	5	1	1	1	75,0
D2	4	1	4	5	4	1	5	1	4	2	77,5
D3	5	1	5	1	5	1	4	1	5	1	97,5
D4	4	1	5	1	5	1	5	1	5	3	92,5
D6	3	2	4	1	5	1	4	1	5	1	87,5
D7	5	1	5	1	5	1	4	1	4	2	92,5
Average											87,1

Based on the average score of the participants the usability of the prototype can be interpreted as *excellent*, as described by Brooke (1986).

8.4 Conclusion

The main goal of this evaluation was to get a better understanding of the clarity and usability of the developed prototype. This was done by showing different scenarios the prototype could show when a user comes close to it while wearing the Oura ring.

Based on the semi-structured interview and the questionnaire insight was gained regarding its clarity, motivational capabilities, possible improvements,

usage, expectations of implementation and usability. In the next section these different insights are described briefly.

Clarity

While the intuitive interpretation of the scenarios differed among the participants, after explanation every participant understood the message, the clock wanted to convey. According to the participants the circular goal indication together with the contrasting colours that faded from red to green, clearly indicated the current progress and the remaining steps to be taken.

The celebration animation however, required some more explanation, and it was indicated by some participants that the celebratory aspect could be improved by using sound.

Motivational capabilities

There was diversity among the perceived motivational capabilities of the prototype. This mainly had to do with the intrinsic motivational character of the participant. While most of the participants indicated that the clock would motivate them to move more, two participants said it would not particularly motivate them since they were motivated from themselves.

One of the main reasons indicated for this motivation was the change of colour as the green colour was experienced by most participants as pleasant and positive.

Insight regarding the consequences of not performing enough physical was indicated by a few participants to help. However, three participants said that they were already aware of these consequences and the clock did not have to display that as well.

Possible improvements

Two participants indicated that they would like the clock to be more present and warning when the goal was not achieved yet. Another participant indicated that motivational text could help to motivate more. While not every participant indicated about the intensity or time the clock was illuminated, a few participants indicated that they would want to have more control then only when the ring is connected. They would like to choose for themselves when the clock illuminates.

There arose no other major improvements and the discussion was mainly about the expansion of functionality regarding information such as sleep, heartrate, blood pressure or mental health.

Usage

All the participants indicated that, if they would use the prototype, they would mount it on a place where it was visible. The two places indicated are the kitchen and the living room. The participants could not come up with certain aspects that they still missed about the prototype besides the improvements.

Expectations of implementation

The participants were willing to pay different amount of prices for the product, but the average is around 80 euros. Since the question was not specifically asked only about the clock, this price applies to the integrated system of clock and ring.

Since the prototype was clear to all the participants, they only expected some verbal explanation that could either be explained when the clock was installed or shown in a video. It could also be helpful for one participant to call for help on the occasion of unclarities.

Usability

The overall usability based on the System Usability Scale was experienced as excellent with a score of 87,1.

9. Discussion

In the next section the results are briefly summarized and discussed, limitations and recommendations are mentioned, and a conclusion is given.

9.1 Summary of the findings

The goal of this project was to re-design the interaction technology with a smart ring to motivate older adults to increase physical activity. As populations continue to live longer, it is more important than ever to spend the additional years in good health and support a high health-related quality of life. Performing 150 minutes of moderate intense physical activity and two strength and balance practises per week can contribute to the healthy ageing process

Literature revealed that e-Health and smart wearables can play a significant role in the process of motivating and increasing physical activity. However, the current adoption of smart wearables among older adults is low due to perceived difficulties and the lack of assessment of their intended utility.

Evaluation of existing technologies that aim to motivate the user to be physically active, showed that these technologies often require a smartphone to function properly. While their measured health information can be of added value to the user, concerns are raised by the motivational capabilities of their accompanying digital applications and visualisations for older adults.

The co-creative technique of contextmapping as described by Sleeswijk-Visser and colleagues (2005) was applied with seven older adults to gather insight regarding their attitude and opinion about the interaction with digital technologies and physical activity. Analysis of the responses resulted in five themes that affect the interaction with digital technology: the level of intrusiveness, acknowledgement of individuality, respect of autonomy, encompassment of utility and overall usability. These themes, together with relevant literature regarding design suggestions for older adults formed the bases for an effective interactive system.

As an effort to re-design the interaction with the Oura ring, an interactive wall clock was developed. Its double function encompassed utility and made it less intrusive. The straightforward but undemanding insight of a user set predefined goal allowed the user to maintain its individuality and autonomy. The clear and colourful visuals mitigated misunderstanding and left little chance of errors and therefore could be experienced as highly usable.

To test to what extend the effort of this re-design was effective and complied to the suggested themes, the prototype was evaluated with six of the seven participants that participated in the ideation session. This evaluation focused on intuition, clarity and motivational capabilities, usage and implementation, and usability. This evaluation showed that the participants had a positive attitude towards the prototype. While improvements and recommendations were noted it was experienced as clear, potentially motivating to most of the participants and excellently usable with a SUS-score of 87,1.

9.2 Limitations and recommendations

Nevertheless, the conducted research does come with its limitations and therefore recommendations for future work. The next section will first discuss limitations regarding the process of the research and secondly describe limitations to the prototype and tools used.

Process

The interaction with the potential user, in this case the participants in the ideation and evaluation sessions, was short. While the ideation sessions produced results that were in line with current literature, the evaluation of the prototype only allowed for short interaction. It required imagination of the participants, like where they would hang the clock it in their own home without actually experiencing it. Doubts are raised by the validity of these type of responses since the participants did not actually have these types of experiences and the conversation was mainly hypothetical.

Future research should expand the experience with the prototype to result in more realistic answers. This could take away the hypothetical aspect of the conversation since people can really experience the prototype. Evaluation could also extend the time of evaluation by placing the prototype in the personal living space of the participant. This way the experience becomes even more real and true to realism.

Time concerns and limited options due to the COVID-19 restrictions resulted that most of the recruitment of participants was done with the help of a geriatric physiotherapist. While this resulted in willing and enthusiastic participants, most of them already performed reasonable or enough physical activity. Therefore, discussion regarding the motivational capabilities of the prototype with these participants was less valuable. The purpose of this research is to motivate in more physical activity and since some participants indicated that they already performed enough of it made the implementation of the clock obsolete. Responses regarding the motivational

capabilities of the clock were also of hypothetical nature and the responses come with an annotation.

Future research should ideate and evaluate with a larger and more diverse user group. This could result in answers that better represent the entire population since the current participants already performed enough physical activity.

While a co-creative process has proven to produce valuable responses by literature, the responses in this research could be biased. First, since the people that participated voluntarily accepted to participate in this research, out of personal interest for instance, they are interested in the topic. They could for instance already have knowledge regarding the topic or health in general plays an important role in their lives. Second, the result driven nature of the research could result in answers that are in favour of the research. While the personal connection between researcher and participant is important in the co-creation process since it can give more intimate and in-depth answers, it also has a downside. The participants knew that this research was for the graduation of Creative Technology. They could feel bad if they answer with responses that they could perceive as irrelevant or not useful for the research. They could see the research as doing a favour and could take a stance of being the perfect participant. This effect could even be reinforced due to the age difference between participant and the researcher. Experience with grandchildren that also had conducted research before for instance could lead to even more compassion and empathy towards the research.

Future research should evaluate if the gain of in-depth knowledge outweighs the possible biased results. The research could be made more anonymous from the designing side or made less informal with a more structured research architecture.

Prototype

While the evaluation yielded positive responses regarding clarity and motivational capabilities the prototype could not be tested to its full capability. It was chosen to only develop and evaluate the visual and communicative aspect of the clock. This not only was due to the short time span of the research but also since the servers of Oura did not allow for data access with the Arduino.

Further development of the prototype should cover more about the connectivity and interaction with the prototype. Elements such as range, illumination time or sound should be implemented and tested with the user. Personalisation options such as changing the colour or intensity could

be discussed in future co-creating sessions and evaluations. The actual placement of the clock and interaction with a remote control for instance. Additionally, extra functionality such as displaying sleep data or heartrate should be developed and tested as well. A possibility for displaying certain values more specifically could include a small screen or illumination numbers on the clock. The numbers could for instance indicate the heartrate of the user since the circular aspect does not allow numerical display.

The smart wearable used in this research is the Oura ring. While it is tested and compared to activity trackers that are well established (Henriksen et al. 2020), the average age of the participants was 33 years old.

Since the focus of this research is on older adults it is important to also compare the Oura Ring with the established trackers with older adults. It could be that older adults perform a different amount and type of physical what the Oura ring could interpret differently. Nonetheless, for this research the analytical data from the Oura ring was not used for the development and the Oura ring functioned merely as demonstrative element and uncertainties in measurement can be neglected for this study, but future research should take this into account.

9.3 Conclusion

To conclude, the research question is stated once again:

How should the interaction with a smart ring be designed to motivate older adults to perform more physical activity?

By implementing the co-creative method of contextmapping as described by Sleeswijk-Visser and colleagues (2005), insight regarding the attitude and opinion about the interaction with digital technologies and physical activity of seven older adults was obtained.

This resulted in five themes that affect the older adults' interaction with digital technology: intrusiveness, individuality, autonomy, utility, and usability. These themes, together with relevant literature regarding design suggestions for older adults, formed the bases for what a system should align to allow effective interaction.

An interactive wall clock was developed that showed the progress of the number of steps of a predefined goal in a circular way by using an LED-strip.

The double function of clock and motivator encompassed utility and made it non-intrusive. The straightforward but undemanding insight of a user-defined goal allowed the user to maintain its individuality and

acknowledged autonomy. The clear and colourful visuals mitigated misunderstanding and left little chance of errors and therefore could be experienced as highly usable.

To test whether this effort of the re-design of the interaction with the Oura ring was successful, a user-evaluation was held with six of the seven participants. While improvements and recommendations were indicated, it was experienced as clear, potentially motivating to most of the participants and excellently usable with a SUS-score of 87.1.

Therefore, it is suggested that by using the co-creative method of contextmapping, an effective and motivating interaction with the Oura ring can be designed.

Nevertheless, future research should continue the evaluation of the prototype with a larger and more diverse user group and should test added functionality that could increase motivational capabilities.

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Appendix A

Overview of the entire booklet for the ideation sessions in figure 59-65.

Kom in beweging met de Oura Ring

Onderzoeksboekje Bachelor Creative Technology
Afstudeeropdracht Sam Hengeveld

Inhoud

Woord vooraf

Wat leuk dat u mee wilt doen aan mijn onderzoek! Ik ben Sam Hengeveld, 22 jaar en student van de studie Creative Technology aan de Universiteit van Twente.

Voor mijn afstudeeropdracht doe ik onderzoek naar hoe de interactie met een slimme ring ouderen kan stimuleren om meer te bewegen. Ik vertel u graag meer over het onderzoek!

Inleiding

Zoals u misschien wel eens heeft voorbij zien komen op televisie of in de krant is bewegen goed voor jong en oud. Het draagt bij aan het voorkomen van verschillende ziektes en houdt het lichaam en geest fit. Toch doen we het allemaal maar erg weinig. De gemiddelde Nederlander zit namelijk 9 uur per dag! Onderzoek laat zien dat een klein ommetje, gewoon even de buitenlucht in, al heel veel positieve effecten kan hebben, voornamelijk voor de oudere generatie.

Een mogelijkheid om meer te bewegen is door het gebruik van smart wearables. Misschien heeft u er zelf een of kent u mensen in uw omgeving met een slim horloge, zoals de Apple Watch. Deze kan uw hartslag en beweging meten met sensoren en op basis daarvan feedback geven over hoeveel u beweegt. Door feedback te geven kan de drager ervan gestimuleerd worden om toch nog even een blokje om te maken.

De smart wearable in dit onderzoek is de Oura Ring. Een slimme ring die net als een smartwatch door middel van sensoren beweging kan meten. Op de afbeeldingen hiernaast is deze te zien met de app waarmee de ring komt.

Echter zijn deze slimme wearables voornamelijk populair bij jongeren en sporters. Onderzoek laat zien dat ouderen soms wat meer moeite kunnen ervaren met het in gebruik nemen van nieuwe technologieën en daarom wat terughoudender zijn in het gebruik ervan.

Figure 59 - Page 1-4 of booklet

Een gemiste kans, want deze smart wearables kunnen ook voor de oudere generatie van hartstikke gezond belang zijn!

Het doel van dit onderzoek is om op basis van informatie uit twee sessies met u, een mogelijke toekomstige gebruiker, tot een interactieve technologie te komen die kan stimuleren om meer te bewegen. Simpel gezegd, om tot een andere oplossing te komen dan de smartphone voor het geven van informatie over de dagelijkse beweging. In de onderzoekswereld heet dit ook wel co-creatie.

Afbeelding 1: Oura Ring gedragen om de vinger

Afbeelding 2: Impressie van de app waar de Oura Ring mee komt

worden nageleefd en zal ik een zelftest doen van tevoren, anderhalve meter afstand houden en een mondkapje dragen tijdens het onderzoek. Mocht u om wat voor reden dan ook het niet prettig vinden dat dit bij u thuis plaatsvindt kunt u dit aangeven en zal er worden gezocht naar een passende oplossing.

Alle verzamelde informatie (zoals bijvoorbeeld uw naam, leeftijd, antwoorden op enquêtevragen, etc.) zal vertrouwelijk worden bewaard en niet worden geassocieerd met uw naam in het verslag. De informatie zal alleen gebruikt worden voor dit onderzoek en naderhand (medio februari 2022) worden verwijderd.

Wanneer u om wat voor reden dan ook tijdens het onderzoek zich niet prettig voelt bent u vrij om dit aan te geven en het onderzoek te stoppen. U hoeft daarvoor geen reden te geven, en het heeft geen negatieve consequenties voor u. Zoals eerder genoemd bestaat dit onderzoek uit twee korte sessies van 30-45 minuten en ben ik ten alle tijde aanwezig. Wanneer u vragen heeft kunt u deze altijd stellen

Naderhand zal u de resultaten van het onderzoek ontvangen, tenzij u heeft aangegeven dat niet te willen.

Mocht u vragen hebben in de aanloop of na afloop van het onderzoek? Dan kunt u mij mailen op s.hengeveld@student.utwente.nl of bellen op 06 19476688.

Ook kunt u te allen tijde contact opnemen met de opdracht begeleider Femke Nijboer op femke.nijboer@utwente.nl of voor onafhankelijk advies en/of klachten met de Ethics Committee op ethicscommittee-cis@utwente.nl

Maar waarom heeft u dan dit boekje? Dit boekje dient als voorbereiding op het eerste deel waar ik graag even wat meer over vertel.

Het eerste deel van dit onderzoek is er namelijk om inzicht te krijgen naar uw omgang en interactie met digitale technologie, wat voor fysieke beweging u door de dag heen doet en wat uw blik is op bestaande technologieën. Dit zal plaatsvinden door middel van een creatieve sessie (30-45 minuten) waarin we samen vragen zullen behandelen door middel van kleine opdrachtjes, zoals een collage maken. Uiteraard is er dan ook de ruimte voor een gesprek. De vragen in dit boekje laten u alvast even nadenken over deze thema's.

Het uiteindelijke doel van deze sessie is om meer inzicht te krijgen in uw omgang met technologie en beweging om zo een zo goed mogelijk prototype te kunnen ontwerpen.

Het tweede deel bestaat namelijk uit een korte evaluatie van het ontworpen prototype. Hierin kunt u uw mening geven en beschrijven wat u ervaart. Dit zal een paar weken na de eerste afspraak zijn. In deze evaluatie (30 minuten) zal ik langskomen met het prototype en vragen stellen op basis van geschetste situaties, gevolgd door een kleine vragenlijst over wat uw ervaring was met het prototype. Het doel van deze evaluatie is om inzicht te krijgen naar de effectiviteit van het prototype en feedback te verzamelen voor verdere ontwikkeling.

Deelname aan het onderzoek zal dus bestaan uit twee afspraken van 30-45 minuten. De voorkeur heeft dat dit bij u thuis kan plaatsvinden. Uiteraard zullen de dan geldende regels omtrent corona

Geinformeerde toestemming

Onderstaand ziet u verschillende punten waarvan ik u wil vragen het goed door te lezen en mee akkoord te gaan. U bent vrij aan te geven of u akkoord gaat met het maken van de foto's. Wanneer u dit liever niet heeft kan het onderzoek nog steeds plaatsvinden, echter zal ik dan geen foto's maken.

- o Bij deze verklaar ik dat ik voorgaande tekst gelezen heb en weet dat deelname aan dit onderzoek volledig vrijwillig is. Ik ben ervan op de hoogte dat ik de deelname aan dit onderzoek mag beëindigen wanneer ik wil en dit geen negatieve consequenties heeft voor mij.
- o Ik geef toestemming voor de verzameling van mijn gegevens ten behoeve van het onderzoek. Ik weet dat mijn gegevens/antwoorden niet zijn te herleiden naar mijn naam, vertrouwelijk bewaard zullen worden en worden verwijderd na afloop van het onderzoek
- o Ik geef toestemming dat de onderzoeker anonieme foto's van mij mag maken, zoals de interactie met het prototype, ter illustratie in het verslag.

Handtekening deelnemer

Handtekening Sam Hengeveld

Figure 60 - Page 5-8 of booklet

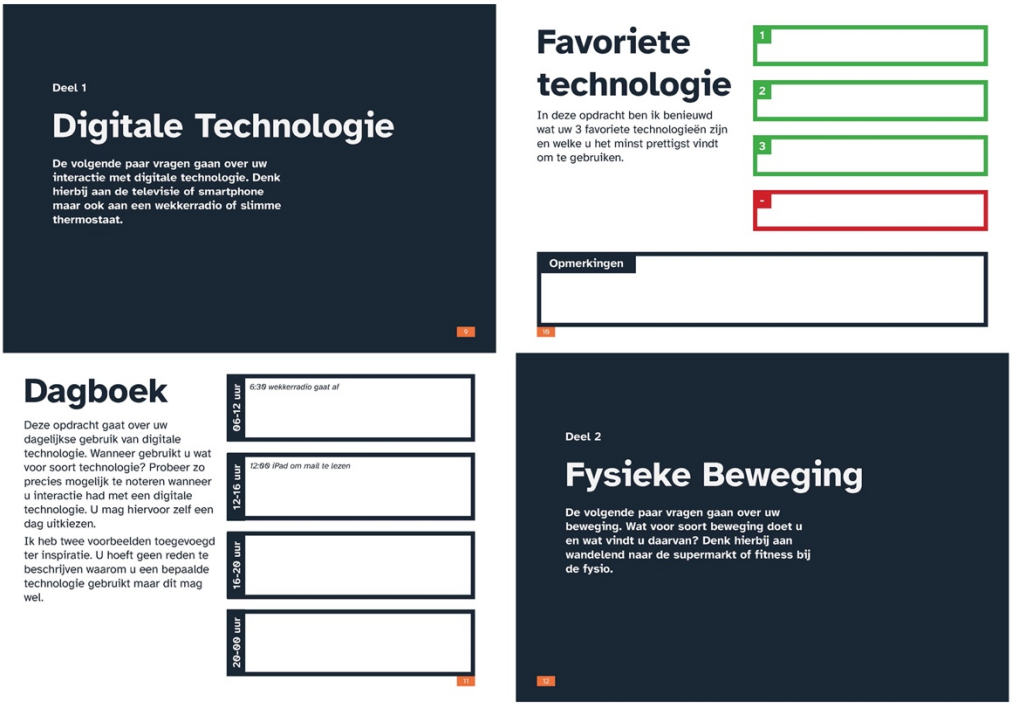

Figure 61 - Page 9-12 of booklet

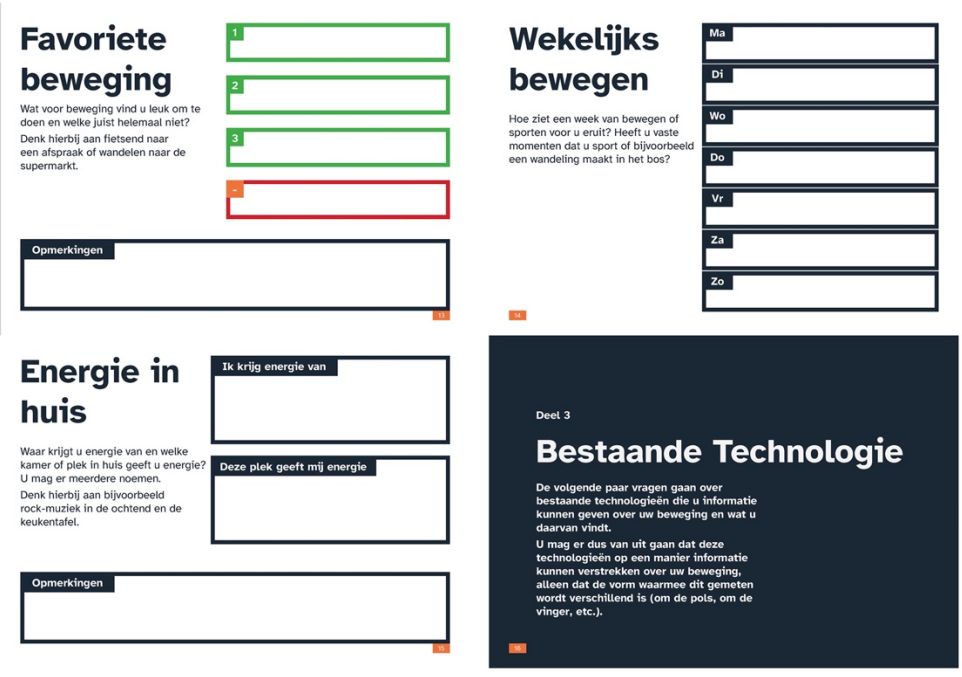

Figure 62 - Page 13-16 of booklet

Figure 63 - Page 17-20 of booklet

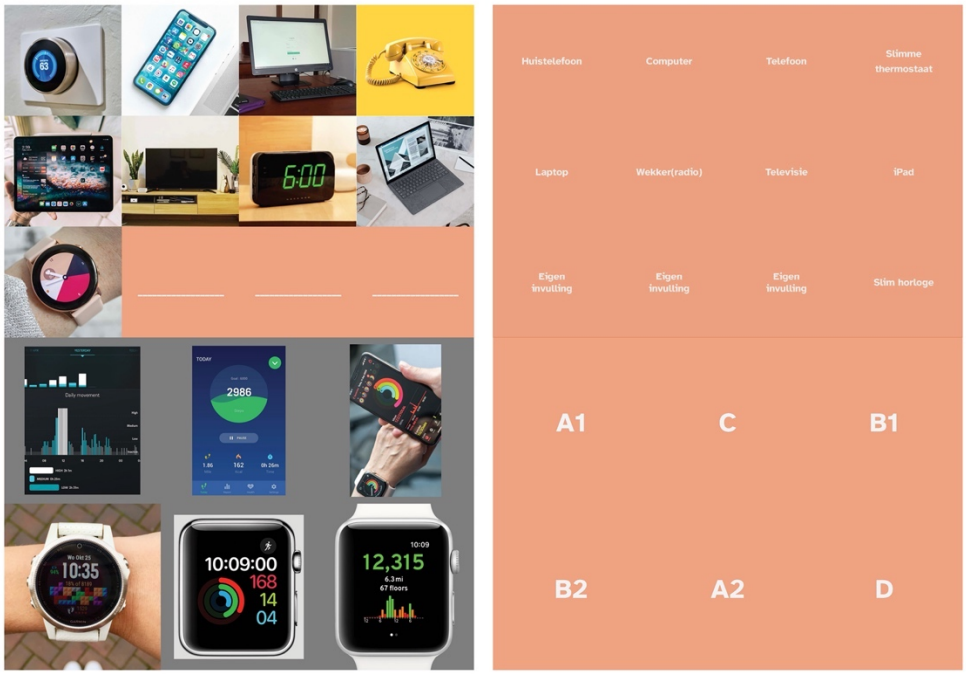

Figure 64 - Page 21-24 of booklet

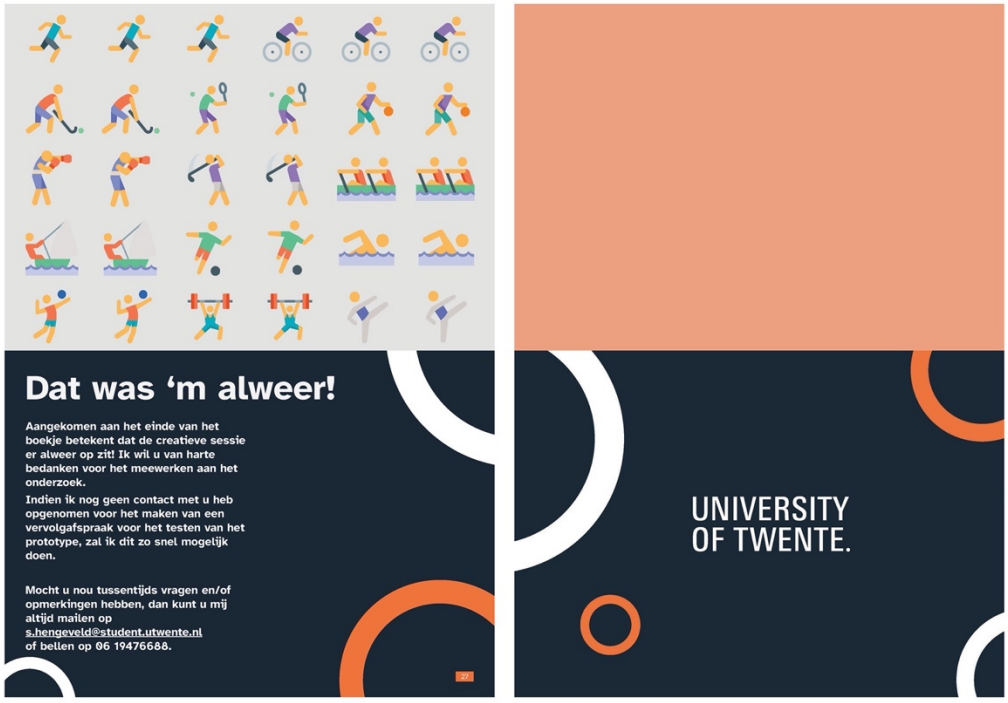

Figure 65 - Page 25-28 of booklet

User evaluation snippets from informed consent and usability form in figure 66 and 67:

Geïnformeerde Toestemming

Dit is het tweede deel van het onderzoek over de Oura Ring. In dit deel wordt u naar uw mening gevraagd over het ontworpen prototype. Het doel van deze evaluatie is om inzicht te krijgen naar de effectiviteit van het prototype en feedback te verzamelen voor verdere ontwikkeling. Deze sessie zal niet langer dan 30 minuten duren.

Alle verzamelde informatie zal vertrouwelijk worden bewaard en niet worden geassocieerd met uw naam. Van het gesprek wordt, tenzij u aangeeft dat niet te willen, een audio-opname gemaakt zodat ik dit later kan terug luisteren ter geheugensteun. De informatie zal alleen gebruikt worden voor dit onderzoek en naderhand (medio februari 2022) worden verwijderd.

Wanneer u om wat voor reden dan ook tijdens het onderzoek zich niet prettig voelt bent u vrij om dit aan te geven en het onderzoek te stoppen. U hoeft daarvoor geen reden te geven, en het heeft geen negatieve consequenties voor u. Ik zal ten alle tijde aanwezig en wanneer u vragen heeft kunt u deze altijd stellen.

☐ Ik geef toestemming voor de verzameling van mijn gegevens ten behoeve van het onderzoek. Ik weet dat mijn gegevens/ antwoorden niet zijn te herleiden naar mijn naam, vertrouwelijk bewaard zullen worden en worden verwijderd na afloop van het onderzoek.

☐ Ik geef toestemming voor het maken van een audio-opname en weet dat deze opname naderhand wordt verwijderd en alleen wordt gebruikt voor dit onderzoek.

_____ _____

Handtekening deelnemer Handtekening Sam Hengeveld

Figure 66 - Informed consent user evaluation

Gebruiksvriendelijkheidstest

Ik denk dat ik dit product frequent zou gebruiken.						
Mee Oneens						Mee Eens
Ik vond het onnodig ingewikkeld.						
Mee Oneens						Mee Eens
Ik vond het product makkelijk te gebruiken.						
Mee Oneens						Mee Eens
Ik denk dat ik technische hulp nodig heb om het product te gebruiken.						
Mee Oneens						Mee Eens
Ik vond de verschillende functies van het product goed met elkaar geïntegreerd.						
Mee Oneens						Mee Eens
Ik vond dat er te veel tegenstrijdigheden in het product zaten.						
Mee Oneens						Mee Eens
Ik kan me voorstellen dat de meeste mensen snel met het product overweg kunnen.						
Mee Oneens						Mee Eens
Ik vond het product omslachtig in gebruik.						
Mee Oneens						Mee Eens
Ik voelde me zelfverzekerd tijdens het gebruik van het product						
Mee Oneens						Mee Eens
Ik moest veel over het product leren voordat ik het goed kon gebruiken.						
Mee Oneens						Mee Eens

Figure 67 - SUS-score form user evaluation

Appendix B

Overview of analysis in Miro board in figure 68-71:

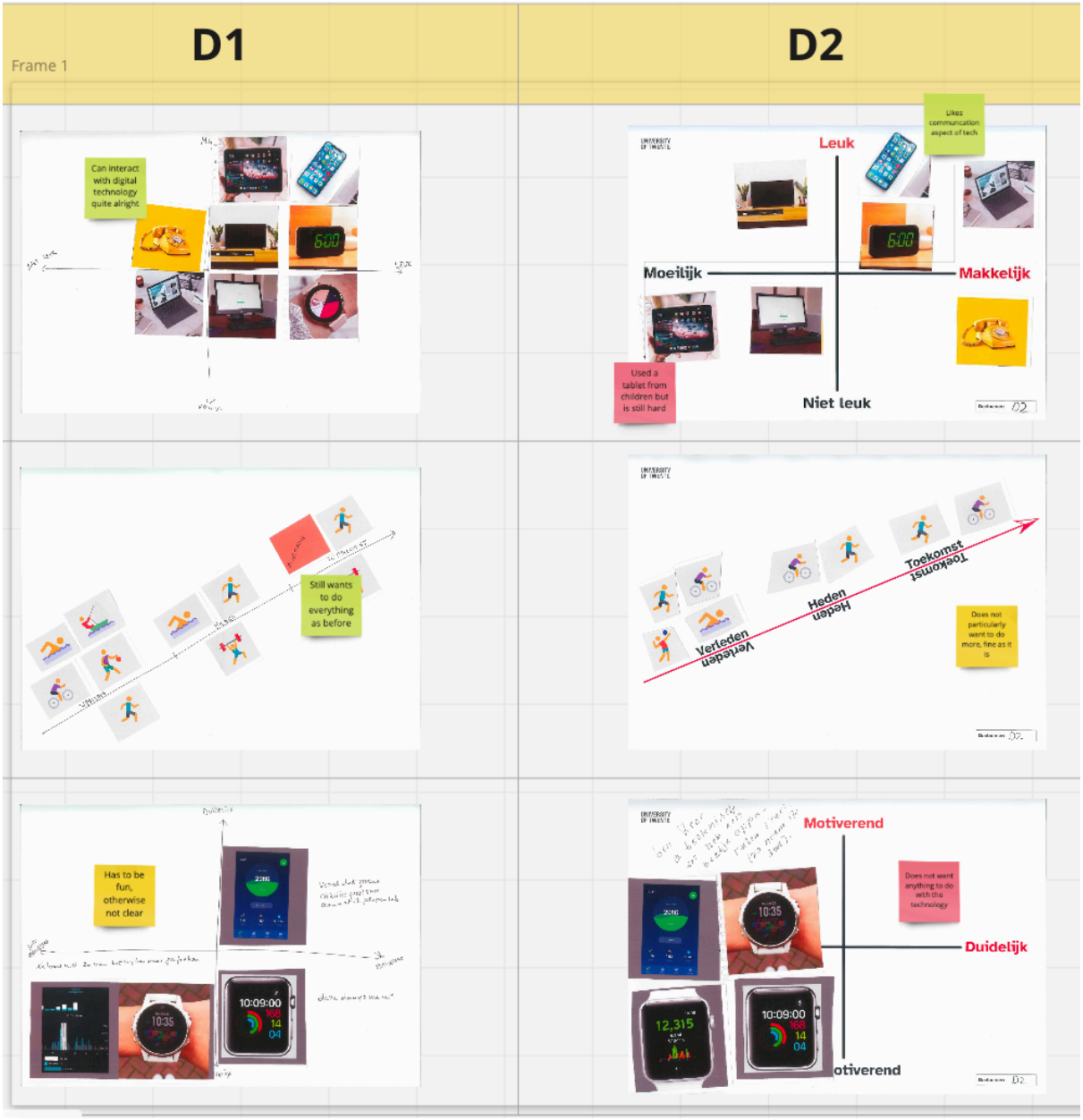

Figure 68 - D1 and D2 responses

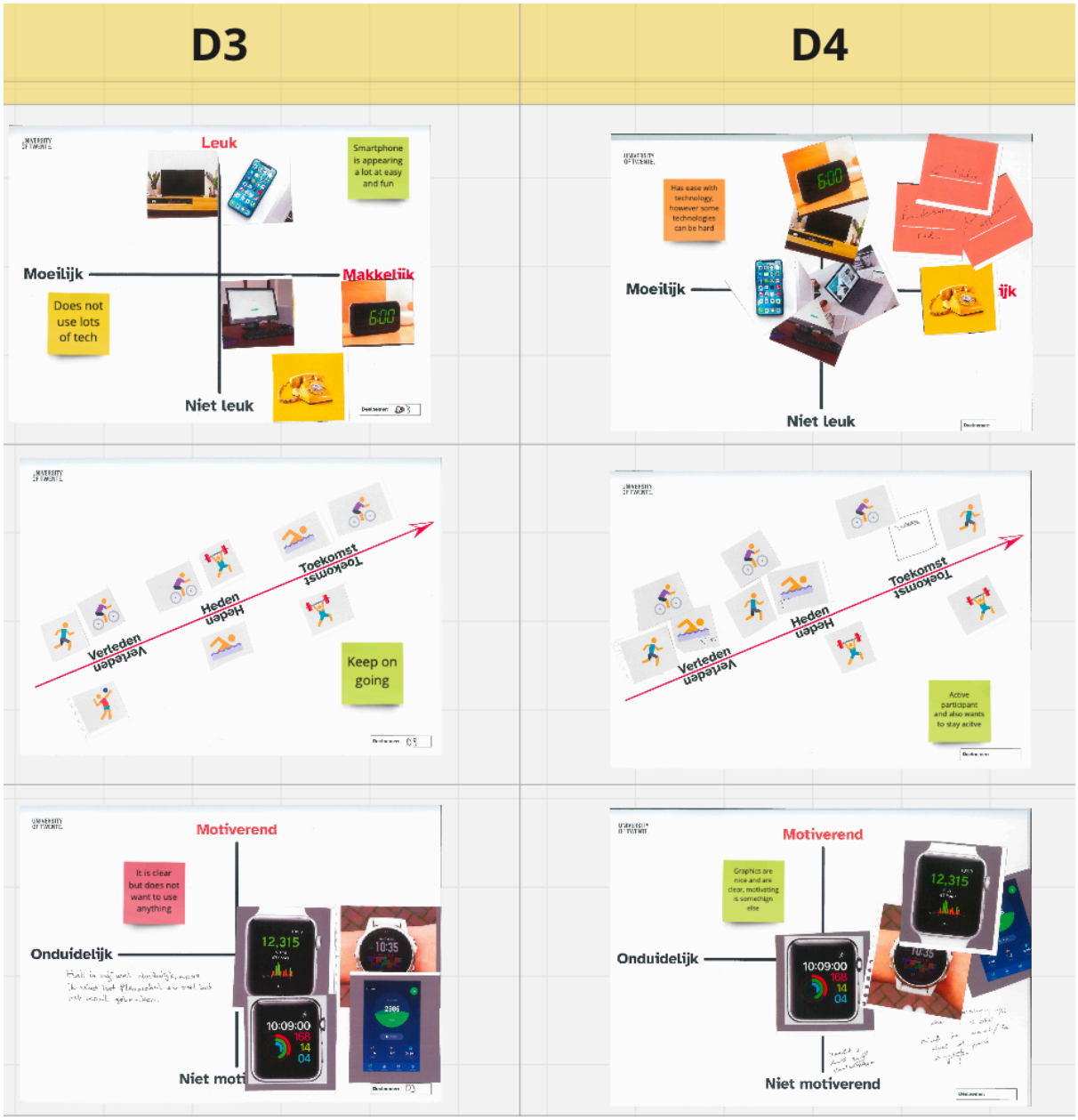

Figure 69 - D3 and D4 responses

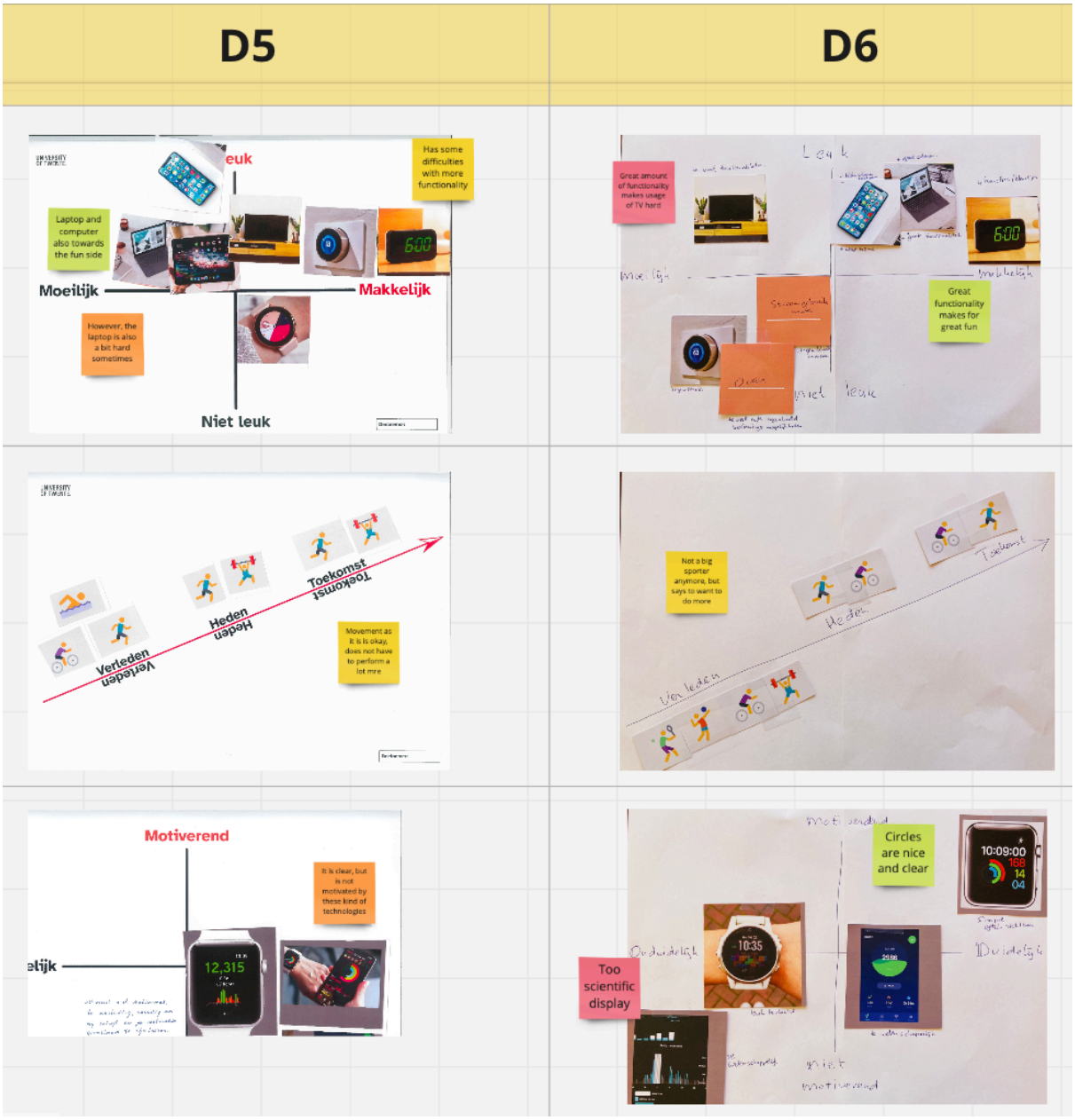

Figure 70 - D5 and D6 responses

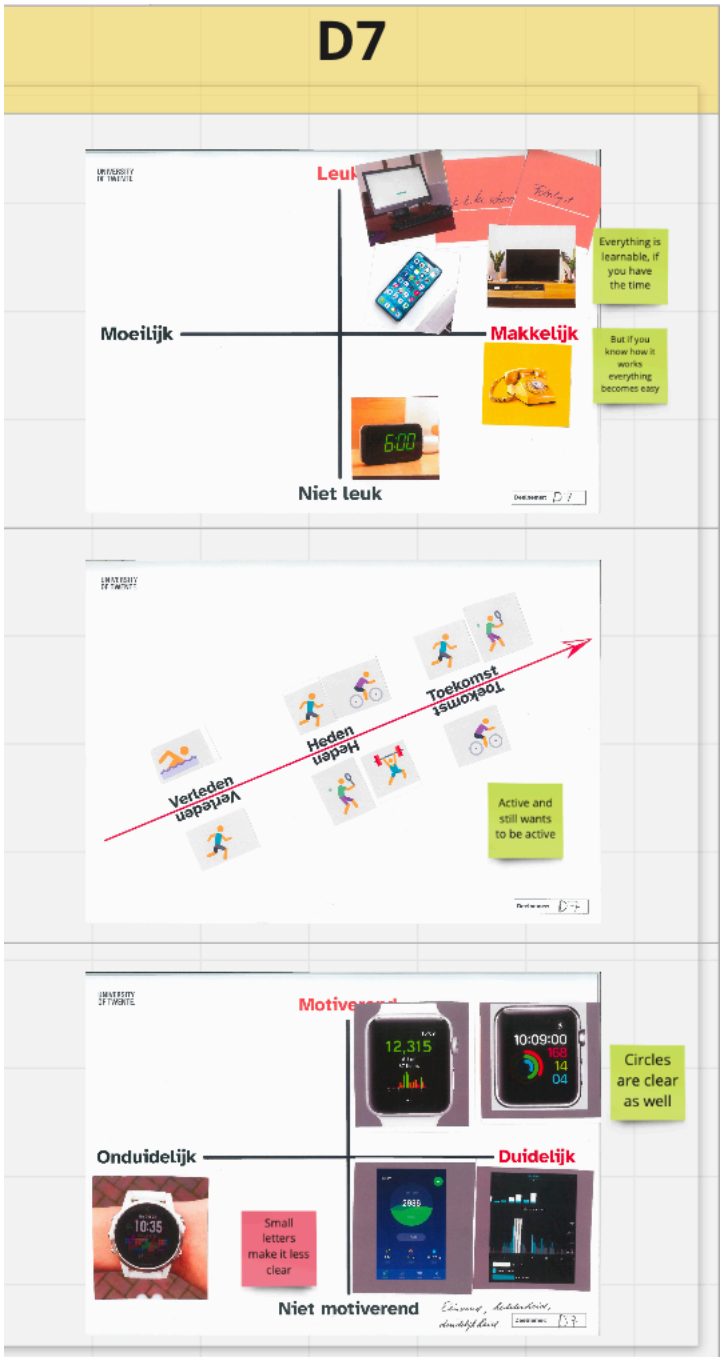

Figure 71 - D7 response

Appendix C

Design recommendation for older adults in figure 72:

Table 1. Technology Design Recommendations for Wearables Intended for an Older Population

Consideration	Limitations	Suggestions
Motor	Diminished fine-motor control	Increase the size of buttons and icons. Controls should be easily adjusted with minimal force. Tasks requiring fine-motor control should allow for easy recovery from errors. Guard against activation of nontarget controls.
	Tactile sensitivity	Limit need for tactile feedback in device interactions.
Vision	Acuity	Text should be easily legible with minimal correction. Text size should be modifiable. Provide a text-to-speech option for small text size.
	Periphery	Reduce the need to rely on cues in the periphery; use alternative sensory inputs (e.g., auditory or tactile). Adjust content/text size according to eccentricity from the center of the screen. Minimize time on task.
Eyeglasses	Visual occlusion	Make devices and displays adaptable to the user (e.g., adjustable display location).
	Discomfort	Design devices that accommodate eyeglasses.
Hearing	Frequency, vocals	Use alert tones at frequencies that are less vulnerable to age-related decline. Provide customizable volume, particularly for speech or other high frequencies. Allow for calibration of volume at specific frequencies.
Executive function	Complex tasks/functions Working memory	Minimize the steps required to complete a given action. Provide the user with the status of the steps or goals within broader tasks, such as showing the user the next action.
	Distraction	Minimize instances in which multiple tasks overlap in time and compete for attention. Keep task-irrelevant information to a minimum.
	Processing speed	Older adults need extra time to perform various tasks or no time constraints at all.
Memory	Explicit memory decline	Offer cue information needed to execute a task, and make future tasks event based and not time based. Minimize the number of steps (recall) needed for a task.

Figure 72 - Design recommendation by Lewis and colleagues (2017)

Appendix D

Overview of the layers of the inner structure that were lasercut in figure 72:

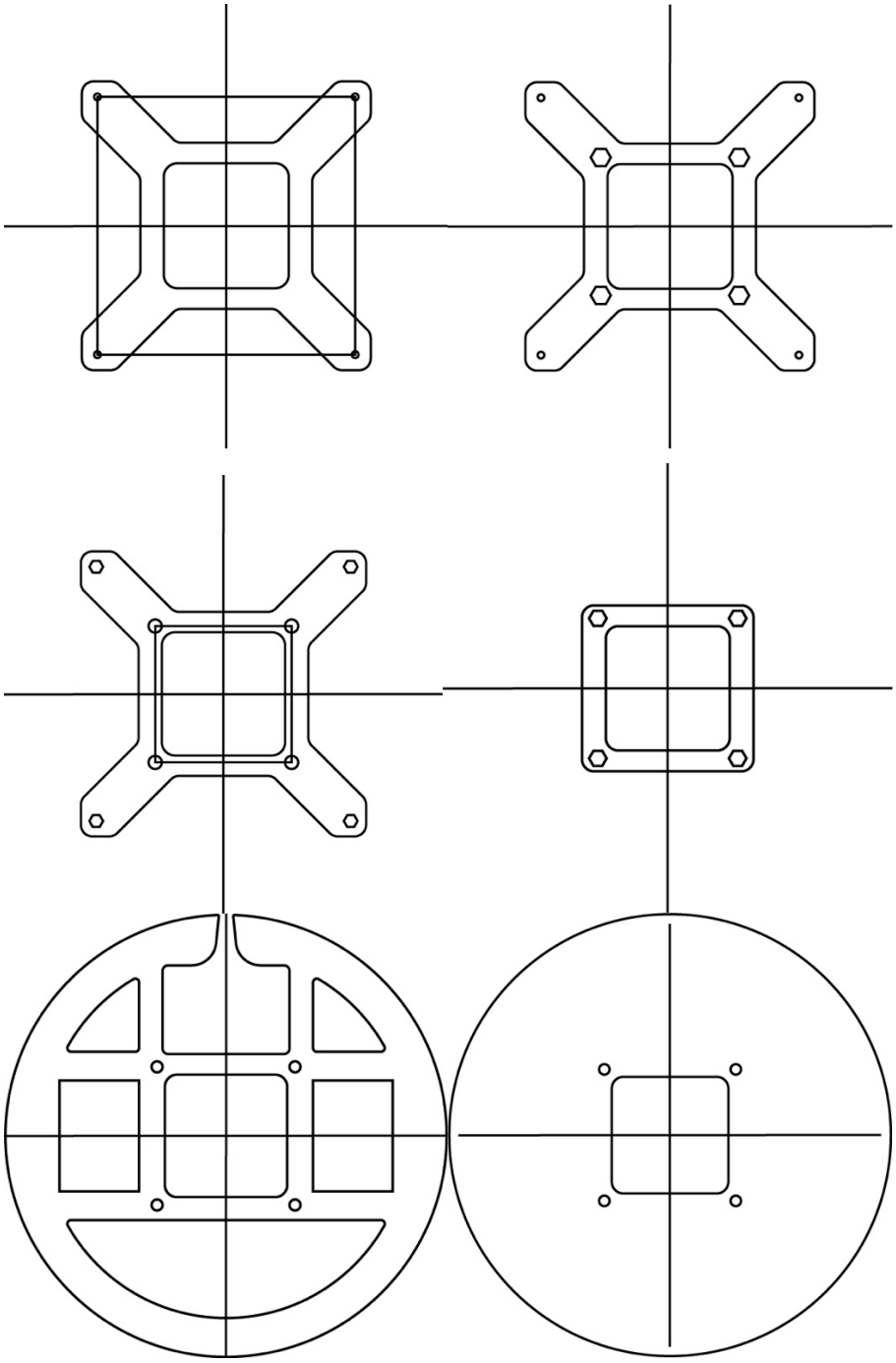

Figure 73 - Overview of the layers that were designed in Adobe Illustrator

Appendix E

Overview of the code for connecting with Oura API:

```
#include <ESP8266WiFi.h>
#define SendKey 0  //Button to send data Flash BTN on NodeMCU
int port = 8888;  //Port number
WiFiServer server(port);
float targetkm;
float toTarget;
//Server connect to WiFi Network
const char *ssid = "Questo Wireless 3.0";  //Enter your wifi SSID
const char *password = "Hoogstraat16";  //Enter your wifi Password
int count=0;
//=====================================================================
//                    Power on setup
//=====================================================================
void setup()
{
  Serial.begin(115200);
  pinMode(SendKey,INPUT_PULLUP);  //Btn to send data
  Serial.println();
  WiFi.mode(WIFI_STA);
  WiFi.begin(ssid, password); //Connect to wifi
  // Wait for connection
  Serial.println("Connecting to Wifi");
  while (WiFi.status() != WL_CONNECTED) {
    delay(500);
    Serial.print(".");
    delay(500);
  }
  Serial.println("");
  Serial.print("Connected to ");
  Serial.println(ssid);
  Serial.print("IP address: ");
  Serial.println(WiFi.localIP());
  server.begin();
  Serial.print("Connect laptop with the wemos");
  Serial.print(WiFi.localIP());
```

```
  Serial.print(" on port ");
  Serial.println(port);
}
//=========================================================================
//                  Loop
//=========================================================================
void loop()
{
  WiFiClient client = server.available();
  if (client) {
    if(client.connected())
    {
      Serial.println("Client Connected");
    }
    while(client.connected())
      while(client.available()>0){
        // read data from the connected client
        Serial.write(client.read());
      }
      //Send Data to connected client
      while(Serial.available()>0)
      {
//        client.write(Serial.read());
        client.write("answer");
      }
    }
    client.stop();
    Serial.println("Client disconnected");
  }
}
```

Example of the code used for demonstration:

```
#include "FastLED.h"

#define PIN_SLIDE_POT_A A0 // input pin of the slide pot

#define MAX_SLIDE_POT_ANALGOG_READ_VALUE 1000 // maximum voltage as analog-to-digital converted value, depends on the voltage level of the VCC pin. Examples: 5V = 1023; 3.3V ~700

#define DATA_PIN    3

#define LED_TYPE    WS2812

#define COLOR_ORDER GRB
```

```
#define NUM_LEDS    46
CRGB leds[NUM_LEDS];
#define BRIGHTNESS         127
#define FRAMES_PER_SECOND  120
uint8_t gHue = 0;
void setup() {
  pinMode(PIN_SLIDE_POT_A, INPUT);
  FastLED.addLeds<LED_TYPE, DATA_PIN, COLOR_ORDER>(leds,
NUM_LEDS).setCorrection(TypicalLEDStrip);
  FastLED.setBrightness(BRIGHTNESS);
}
void loop() {
  int slide = analogRead(PIN_SLIDE_POT_A);
  int switchedon = map(slide, 0, MAX_SLIDE_POT_ANALGOG_READ_VALUE, 2, NUM_LEDS);
  int green = map(slide, 0, MAX_SLIDE_POT_ANALGOG_READ_VALUE, 0, 255);
  int red = map(slide, 0, MAX_SLIDE_POT_ANALGOG_READ_VALUE, 255, 0);
  if (slide > 920 && slide < 980) {
    EVERY_N_MILLISECONDS( 10 ) { gHue++; }
    fadeToBlackBy( leds, NUM_LEDS, 10);
    int pos = random16(NUM_LEDS);
    leds[pos] += CHSV( gHue + random8(64), 200, 255);
    FastLED.delay(20);
  }
  else if (slide > 980){
    for (int i = 0; i < switchedon; ++i) {
      leds[i] = CRGB(0, 25, 0);
    }
    }
  else {
    // 3) Light up the LEDs
    // Only LEDs are switched on which correspond to the area left of the slide knob
    for (int i = 0; i < switchedon; ++i) {
      leds[i] = CRGB(red, green, 0);
    }
    // LEDs are switched off which correspond to the area right of the slide knob
    for (int i = switchedon; i < NUM_LEDS; ++i) {
      leds[i] = CRGB::Black;
    }
  }
```

```
  FastLED.show();
}
```