

# Increasing the Physical Activity of Older Adults through Interactive Buttons

Bachelor of Science Thesis Creative Technology

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## Abstract

This thesis aimed to develop a technological intervention using interactive buttons to assist older adults over the age of 60 with a low socioeconomic status. This group was chosen because they experience a more challenging ageing process, including higher chances of depression, faster onset of health problems, and signs of ageing such as cognitive and physical decline.

The intervention utilised interactive buttons that could be connected on a network, remain connected over a distance, and use LEDs and a speaker. Three input methods were possible: a single press, double press, and long press. These features were used to create a version of the Memory game with a musical twist. Additionally, the ability to freely play music fragments was added. Instructions were provided to the target group in both written and verbal form. The buttons were placed on movable pillars to encourage walking, with the secondary goal of promoting dancing.

The intervention was evaluated by observing the target group and recruiting them to participate in the research. Findings suggest potential in such interventions with participants appreciating the initiative and stating to find it an effective way of getting those who require more physical activity to be more active. However, more research has to be conducted on how to attract the target group in such a way that they autonomously want to use the intervention.

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## Chapter 1 – Introduction

The World Health Organisation (WHO) states in a report from 2022 that a quarter of the global population does not engage in a sufficient amount of physical activity (PA) [1]. In the same report, they share that high-income countries have double the levels of inactivity compared to low-income countries [1]. PA is important for the human body, especially for older adults as they are in the later stages of life as it can reduce health risks, such as depression, a decay in cognitive ability, a decrease in mobility, and an early demise [1] [2]. Concerns about this group have been rising throughout the years as they might not engage in enough PA. The Dutch Ministry of Movement of Health, Welfare and Sports has created PA guidelines for its citizens based on recommendations from WHO. The Ministry states that, although people are aware of the health benefits of PA, they still do not meet the guidelines. The guidelines recommend moderately intensive movement for 2,5 hours weekly, fulfilling at least two muscle and/or bone-strengthening activities, and working on balance [3]. An activity is considered moderately intensive when breathing quickens, but the ability to speak remains. In 2022, 44,3% of the Dutch inhabitants above the age of four fulfilled the recommendation [3]. In addition, a report from 2021 by the Ministry states that too much time is spent sitting down, which can lead to up to 9 hours per day [3].

This thesis will shed light on this problem through a design project which attempts to assist older adults to engage in more PA. A successful intervention can lead to significant benefits, such as an increase in their quality of life and the duration of their life. The Ministry states that the health gain is the biggest for those that go from low to some movement [1]. Enabling older adults to have more PA in their lives can lead to a more active lifestyle, allowing them to remain in their social circles and do what they deem important [2]. Callari et al. [4] suggest that an active lifestyle also allows older adults to slow down the decay of their cognitive and physical abilities as they practice them often with such a lifestyle. However, older adults must be willing to make this behavioural change happen to reach this.

The focus will be an area in the Netherlands with a low socio-economic status (SES), the southern area of Enschede—research by Steptoe et al. [5] suggests that this is a vulnerable demographic as a low SES can be linked to ageing at a faster pace than people with a high SES. McPhee et al. [6] state that PA is low in the overall older adult demographic, however, it is more severe for those living in low SES areas.

Furthermore, the citizen organisation “Outside Sports” has expressed their concern about the lack of PA performed by the older adults in South Enschede. The organisation would like the citizens to be more active and out and about in the neighbourhood than what is currently happening. An example of a desired activity that the demographic can do is walking. Moreover, WHO states that walking is a form of PA that is accessible and safe for all [1]. Technology will be used as a medium to reach this aspiration. Technology has the potential to provide meaningful interactions that can have more impact on its users as it opens up a gateway for new experiences [7]. According to Carta et al. [8], developing a safe and effective intervention for older adults in a community can positively impact their independence and decaying cognitive state. Therefore, interactive technology is used in this thesis as it enables possibilities that greatly benefit this target group. In addition, the interactions can be designed in a way that encourages new or already established social relationships. The challenges that will arise in the development of this intervention will include finding the right kind of PA for the target group, the implementation in the environment of South Enschede, and changing the PA behaviour of the target group.

### 1.1 Research Questions

The goal of this thesis is to achieve a change in the PA of older adults by providing them with an interactive intervention that uses smart buttons with available features such as LEDs and a speaker. To

accomplish this goal, interactions have to be designed to encourage older adults to participate in PA. Therefore, research questions were established to determine how to reach the goal. The main research question (RQ) of this thesis is the following:

**How can interactive technology be used to encourage physical activity among older adults in an outdoor setting?**

Three categories were established for sub-questions that will aid in answering the RQ.

### 1.1.1 Sub-questions – Design

The first category will focus on design with the following questions:

**SQ 1.1 How to design technological products for older adults?**

**SQ 1.2 What impact does the neighbourhood have on the physical activity levels of older adults?**

**SQ 1.3 How can an intervention meant for the improvement of the physical activity of older adults be evaluated?**

These will be answered by carrying out literature research and by evaluating the concept. The literature research will delve into topics such as design guidelines, limits of the target group, preferences, and the role of the environment on the target group. Eventually, knowledge gained from the literature research is implemented in the ideation phase.

### 1.1.2 Sub-questions – Behaviour

The second category will be related to behaviour with the question being:

**SQ 2.1 How to encourage older adults to increase their physical activity?**

Answering this question will require conducting interviews with the target group to find out their stance on the topic. In addition, literature research related to behaviour will be conducted, with topics such as the acceptance of technology.

### 1.1.3 Sub-questions – Needs

The third category focuses on the human needs of the target group with the following question:

**SQ 3.1 How important is having a social aspect for a successful technological intervention?**

Research will be done in the form of literature research and multiple interviews. The topics that will be explored are how social needs are currently met and to what extent they can motivate older adults.

## 1.2 Report Outline

This thesis will outline the development process of a technological intervention designed to promote PA among older adults. It will consist of 6 chapters. Chapter 2 will delve into background research, including an exploration of the field's current state, interviews with the target demographic, neighbourhood observations, and an analysis of media representations. Chapter 3 will cover the methodology, establishing the methods used during the ideation phase. Following this, Chapter 4 will elaborate on the methods mentioned, leading to a final concept. This final concept will be further detailed in Chapter 5, where the requirements will be outlined. Using the findings from Chapters 4 and 5, the concept will be brought to life in Chapter 6, which will focus on the realisation of the concept. Chapter 7 will discuss how the concept was evaluated with the target group. The results will be discussed, and the overall process will be reflected on in Chapter 8. Finally, Chapter 9 will present the conclusion.

## Chapter 2 – Background Research

This chapter delves into the knowledge gained through background research, including literature research, interviews with the target group, an analysis of the state of the art, and a media analysis. Background research is a crucial step in making informed decisions down the line. Therefore, the more areas covered in this chapter, the better the decisions made can be supported as the backbone of this thesis.

### 2.1 Literature Research

The start of this thesis consisted of conducting literature research. The findings provided a foundation of knowledge and understanding to tackle the problem and answer the questions stated in Chapter 1. The findings of this research were used as supporting material for deciding how to approach the target group and the design process. The upcoming sections of this chapter will delve deeper into the literature findings of each relevant topic.

#### 2.1.1 Effects of Ageing

This section focuses on what happens to the human body when ageing. Effects of ageing can influence reaction time, learning new motor skills, and being in control of one's body. Frolov et al. [9] conducted a study on these effects and found that the brain of older adults reacts differently to handling motor actions compared to young adults. The part of the brain responsible for movement shows that older adults require more time to move their hands than younger adults. This means that a lower reaction time will occur. This finding highlights that an intervention based on reaction time might not be the way to go.

In research by Domingos et al. [10] they state that one of the biggest challenges of ageing lies with declining cognitive health and functioning, reducing the quality of life. They state that it is key to implement a way to keep the brain from ageing, which can be reached by increasing PA. McPhee et al. [6] support this statement as they find that PA affects physical and cognitive functions and grants older adults the ability to remain both mobile and independent. A different effect they noticed that is affected by ageing but lessened by PA is the reduction of muscle mass. A common symptom of low muscle mass is the reduction of mobility [6].

An interesting finding by Löckenhoff and Carstensen [11] is that the interest in improving health has reduced greatly for older adults, with their focus being towards retaining their current state. This means that the intervention should not attempt to improve the abilities of older adults, but to assist in retaining them. This can make PA more attractive for them, possibly reducing the mentioned effects of ageing. Having an intervention involving cognitive abilities might be helpful for them as well to lower potential decay in that field.

#### 2.1.2 Effects of Physical Activities

Sun et al. [12] state that even though there is a worldwide concern for the PA levels of older adults, there is still a lack of research conducted on what type of activities this demographic enjoys. Nevertheless, research has found evidence supporting low to moderate-intensity activities such as walking and dancing.

In a study by Duijvestijn et al. [13], the researchers explored the inactivity of Dutch citizens over a 17-year period. They found that most people who met the PA guidelines did so by engaging in activities at work, participating in sports, and going on walks. Since older adults may not be employed and might not be able to participate in sports, walking could be a good PA to encourage. The study also revealed that although older adults have become more active over the years, their PA levels remain low compared to other age groups. This indicates an actual improvement in the activity of the target group. Chou et al.

[14] discovered that moderate-intensity aerobic exercises, such as walking, can reduce mortality by at least 30%. Research also suggests that older adults who prefer a more social experience tend to opt for group activities, such as group walks. Additionally, a study by Domingos et al. [10] shows a positive relationship between engaging in PA and the parts of the brain responsible for memory, learning, and decision-making. Regarding walking, the duration and frequency were found to be associated with a larger hippocampus, which is crucial for memory and learning. However, this finding is specific to females and does not apply to men. Overall, these findings underscore the importance of maintaining regular walks.

Both Esmail et al. [15] and Liu et al. [16] explored the effects of dance. The latter found that older adults who participated in a dance intervention had better endurance, flexibility, and physical health than those who did not. This occurs as the amount of oxygen usable during PA increases because the heart and lungs are trained. In the trial conducted by Esmail et al., a decrease was found in the anxiety of the participating groups, however, no changes in their lifestyle were found after the trial was concluded. In the research of Paterson et al. [17] it was mentioned that the improvement of endurance can lead older adults to give activities that used to be overexerting for them, another chance.

McPhee et al. [6] and Paterson et al. [17] point out that the intensity of PA should align with the individual's capabilities, which can change over time. Therefore, it may be advantageous for an intervention to adopt an incremental approach to encouragement [17], allowing individuals to control the difficulty level and develop themselves while using the same technology.

These sources provide guidance on the type of PA the target group should participate in when using the intervention. Both walking and dancing offer significant physical and social benefits, making them ideal choices as the minimum level of PA users will be encouraged to engage.

### 2.1.3 Behaviour and Its Influential Factors

Older adults often maintain their established behaviour patterns for various psychological and practical reasons. Lee et al. [18] state two beliefs related to this, firstly, some older adults believe PA interventions are not targeted towards them but younger people, and secondly, they believe their physical limitations prevent them from participating. Another obstacle found is the potential lack of willpower of older adults, hindering their willingness to engage in PA. Additionally, older adults with health issues may feel less confident in trying new forms of exercise, contributing to their reluctance to participate.

Older adults, especially those in low SES environments, can also struggle to find suitable sources of PA, as they do not know what is available to them due to a lack of information. The delayed satisfaction after engaging in PA often leads to dwindling motivation. Overcoming these barriers requires addressing psychological factors such as confidence and enjoyment of PA [18]. Self-efficacy theory emerges as a valuable framework for this purpose. McPhee et al. [6] state that group-based activities and raising self-efficacy are crucial for getting older adults to engage in PA. Not only that but they can lead to long-term participation and a community can help people turn their motivation into actual actions since they might be unaware of how to meet their desire for PA [17].

Bandura's [19] self-efficacy theory emphasises individuals' confidence in their ability to perform specific actions, which is crucial for initiating and maintaining active behaviour. Bandura states that self-efficacy has four information sources: performance accomplishments, vicarious learning, verbal encouragement, and physiological and affective states. An example of performance accomplishments is reflecting on a positive experience, making older adults feel capable [18]. Vicarious learning is about witnessing other people perform the actions and gaining confidence from that, as people can get the sense of being capable of those actions [18]. Having someone as a role model figure can be someone with a similar background or lifestyle; engaging in specific behaviour is also a form of vicarious

learning. With verbal encouragement, credibility is essential because when praise is seen as not credible, confidence levels are lower [18]. An example of a physiological state that can impact behaviour is stress; a high level of this is demotivating for behaviour change [18]. This can be tackled by preparing older adults for the outcome of their actions, as they can prepare themselves for it and might reduce the negative emotions linked to PA. For example, being told that certain body parts will feel a certain way due to exercise can reduce the chances of discouragement, knowing that it is normal. Implementing these four self-efficacy sources is vital for adopting behaviour changes. Understanding the interplay between self-efficacy and outcome expectations is essential [18]. Both are related to the extent to which someone participates [18].

Aiming to change behaviour can be more impactful and long-lasting when allowing people to plan their activities with motivational factors, beliefs, and expectations according to Lachman et al. [20]. In addition, implementing personal aspects, such as age, personality, socioeconomic status, and environment, also helps in behaviour adoption. Setting goals, adjusting negative mindsets and attitudes, and having social support are expected to increase self-efficacy. Besides the increase in self-efficacy, older adults are expected to maintain their goals better and get more joy from having an active lifestyle. The influence of a social aspect should not be underestimated. Having a partner can assist people in staying on track with their goals and maintaining behavioural changes [20]. Interestingly, Carstensen et al.'s [21] socio-emotional selectivity theory suggests older adults interact with individuals they already know as they experience them as rewarding and satisfying. Thus, pre-established relationships seem to be preferred over new ones.

It seems like narrowing down the target group, as done in this thesis by focusing on low SES and their environment, is a good approach. Research also suggests that for long-term changes, a method that can be used to reach that is the usage of technology, which is happening in this thesis. In addition, conducting interventions in community settings where older adults live and receive health services can increase the reach of the interventions.

Noticeably, Paterson et al. [17] pointed out challenges in creating PA interventions for older adults in a low SES area. From their knowledge, such interventions usually do not manage to reach the demographic, and when it does happen it is difficult to determine whether the intervention was effective enough for a behavioural change to occur. This shows how crucial it is to look into what could make this change happen.

Devereux-Fitzgerald et al. [22] find that the perceived value that older adults have surrounding PA, will play a crucial role in them accepting such activities. When viewing PA as something that will bring them negative consequences, such as exhaustion, they will be hesitant to participate. Not only that but when perceiving it as unnecessary it also greatly decreases the motivation. Experiences are important for the perceived value as they can make or break it by heavily influencing it. For example, having a negative perceived value can be changed to a positive one through a positive experience with PA. In the same research, it was found that a positive perceived value can be a stronger motivator than enjoyment and psychosocial benefits. Informing users on how their progress can also have a motivating effect.

While analysing motivational factors for PA, multiple sources mentioned the social aspect. This indicates that the social aspect plays an influential role in achieving a goal. Chaudhury et al. [23] state that older adults who are part of an active community, like a recreational organisation, are more likely to meet the PA requirements. Older adults might find encouragement in their social circles [6]. Carta et al. [8] suggest that interventions for groups seem more effective than those for individuals. Additionally, low costs and a high return on enjoyment are also favourable [6] [22].

Research by Morgan et al. [24] suggests that intervention may be more successful when PA is not the focus but how it can contribute to a purposeful and fulfilling life. Highlighting the broader benefits of PA, beyond health outcomes, may resonate more strongly with older adults. Addressing issues related to self-worth and identity is pivotal for encouraging greater participation in PA.

In conclusion, interventions promoting PA among older adults should address both practical barriers and psychological factors. By leveraging self-efficacy theory and tailoring interventions accordingly, a more active and fulfilling lifestyle can be fostered among older adults [12] [18].

#### 2.1.4 Influence of The Neighbourhood

The built environment is a significant factor when discussing the influences of health behaviour [23]. Older adults with a low SES background could be relying more on the neighbourhood and what is available there within reach than others in their age group [25]. The environment can influence the autonomy of older adults; for example, a walkable outdoor environment can mobilise older adults, allowing for more PA [23]. Moreover, 76,5% of the PA happens near the homes of the older adults [22] [23] [26]. Devereux-Fitzgerald et al. [22] state that the closer to home, the higher the acceptance rate. This is why it is essential to analyse what Enschede South looks like, as the intervention is supposed to aid older adults in that area. Ideally, the intervention should be placed in a public setting, as research [4] indicates that installations not requiring money in such a setting can make older adults more interested in it. The social aspect and built state can influence PA [23].

When looking at the effects that a neighbourhood could have on its residents, it is found by Loo et al. [26] that low SES areas are more likely to show symptoms related to depression, thus a lower quality of life can be found here. Engel et al. [25] assert that the layout of a neighbourhood is intricately linked to social cohesion, a crucial aspect to consider given that social interactions conducted by older adults primarily occur within their neighbourhoods. Van Dyck et al.'s [27] finding supports this further, suggesting that older adults could engage in more PA if they find the built and social environment of their neighbourhood enjoyable, thereby emphasising the potential of the neighbourhood in promoting the PA of older adults.

Having something in the environment that has a stimulating effect is crucial, especially something challenging can lead to active use [28]. A statement made by Strohmeier [28] that can be used for further ideation, is that innovative interventions can be used to encourage walking, motivating individuals to be more active, and make public spaces in general more enjoyable and inviting.

Research indicates that older adults prefer passive activities that are not demanding, for example, reading or observing. A popular activity among them that is more active is walking by themselves or with pets. Having parks nearby for older adults can be essential as they enjoy being there. Onose et al. [29] state that older adults are regular visitors to parks, finding that 92% of older adults visit the park weekly. In a questionnaire, they found that the needs of older adults and other demographic groups are vastly different in what they prefer in the park. Older adults seem to appreciate nature, silence, and cleanliness the most in a park. The same research found that older adults would like more activities to be placed in the park, such as workout areas or chess tables. They were also open to attending events at the park. The park's size is unimportant, as needs can also be fulfilled at small ones. Older adults spend more time in parks than other demographics, so they notice the decrease in the environment and ecosystem services the most.

Older adults are open to trying out diverse physical activities. Parks could play a role in this as work-out areas, or playgrounds can be installed there. A concern expressed by Onose et al. [29] regarding playgrounds for older adults is that they often prioritise function over aesthetics and social interactions. This is something that can be looked into for this thesis.

When creating spaces for older adults, such as parks, it is crucial to involve them in the process, as this can help make the spaces more friendly for them [29]. Their input is invaluable in ensuring the spaces meet their unique needs and preferences, enhancing their overall well-being.

### 2.1.5 Socio-Economic Status

The target group is from a low SES area, so to understand them better it is essential to know what the effects of such an area or status can be. The definition of socio-economic status used in this thesis was based on the research by Steptoe et al. [5], Svendsen et al. [30], and Sasaki et al. [31], which includes measures such as wealth, education, living environment, occupation, and migration background.

Older adults with lower SES tend to experience significant changes in physical capabilities, physiological function, sensory function (especially vision), cognitive performance (specifically memory and processing speed), emotional well-being (such as enjoyment in life and depressive symptoms), and social function (such as the number of close friends and cultural engagement) [30]. Rawal et al. [32] state that people with a low SES status in general have poorer health than those with a high SES status—research by Onose et al. [5] found they experience accelerated ageing compared to other groups.

Research indicates that older adults with higher SES tend to engage in more PA. For instance, during the COVID-19 pandemic, a study connected men's health with declining household income. Additionally, McPhee et al. [6] state that older adults with a low SES background are less likely to maintain being active compared to those with a high SES background.

SES serves as an indicator of overall life situations for older people. Individuals with low SES have limited access to resources and activities that promote health. On the other hand, higher SES individuals have better access to healthcare, reducing stress and enhancing overall well-being as they age [5].

To summarise the findings, there is a significant correlation between lower SES and accelerated decline in various age-related aspects. This underscores the importance of this thesis, especially considering the target group's low SES, emphasising the study's relevance and significance.

### 2.1.6 Designing technological products for older adults

This section was part of my assignment for the Academic Writing course, as part of Module 11. To begin designing technology for older adults, it is essential to understand how to design appropriately for this target group. Demirebilek and Demirkan [33] recommend implementing the Usability, Safety, Attractiveness Participatory (USAP) Model, which involves five stages where older adults are involved in the design process by giving proposals that the designer builds on further. Involving older adults in the process of developing technology is crucial to ensure that their specific needs are met. Ignoring their needs may result in lower rates of technology adoption, as they may not recognise the necessity. This method, alongside other sources, states the importance of conducting thorough evaluations of product requirements and carrying out user tests [33, 34, 35, 36, 37, 38, 39].

Multiple design guidelines such as those of Peine et al. [35], Leonardi et al. [38], and Hsu [39] suggest that physical and cognitive attributes should be considered, as they tend to decline with age. According to Hsu [39] this can be achieved by keeping information and instructions concise, having a simple interface, and not demanding memorisation. Paterson et al. [17] also found it to be key to inform older adults about their progress and how far they are from the goal.

As the buttons used for this thesis have built-in LEDs, the implementation was explored. Davis et al. [40] state that when using LEDs, designers should prevent overwhelming users by avoiding frequent

changes in brightness or hue. This issue should be further explored with users as the concept from this thesis will be used in an outdoor setting, where reactions to LEDs might differ. In this research, they state that lighting parameters can be used to enhance social connectedness. The strength of colours comes into play here, with colours capable of provoking emotions from passive to active. For example, red can be used when high activity is required, blue for low activity, and green for a passive state. This is valuable knowledge that can be used in the project.

Not only did Davis et al. inspect the reaction to colours, but also the reaction to changes in the LEDs themselves, such as changes in brightness or hue. As mentioned before, frequent changes should be avoided, but small ones as well. For example, if an LED changes brightness incrementally, then users might struggle to recognise the change. By changing colours, users are notified of a change in activity.

The most common design guidelines are the involvement of older adults, adopting familiarity, and taking anecdotes of their lives [33, 34, 35, 36, 37, 38], implementing these can increase the chances of older adults adopting the technology into their lives according to Davis et al. Designers need to understand the existing knowledge and experiences of older adults to create technology that caters to their requirements. Familiarity and anecdotes are related concepts that can help designers gain insight into what older adults are already familiar with. According to Leonardi et al. [38], using familiarity is crucial as it can make the older adults perceive the technological intervention as fitting in their surroundings, which increases acceptance.

#### *2.1.6.1 Challenges faced by older adults when using technology*

When designing technological interventions for older adults, next to design guidelines, it is crucial to consider the challenges that they may face when adopting technology. The decline in both motor skills and cognitive abilities [4] [40] can significantly impact the effectiveness of technological interventions. The most common key barriers found were learning complexities, convenience, usability, and the fear of unwanted consequences [34, 35, 36, 37, 38] [41]. However, Voelcker-Rehage [42] states that even though older adults have decayed physical abilities, they are still able to learn things and achieve results.

The barrier of having a high learning curve, thus a complex technology or interaction for older adults, is a reason to stay away from technology [36, 37, 38]. Peine et al. state that older adults use their experiences to assume the functions the technology can offer, so bringing in familiarity might reduce the learning curve. According to Wandke et al. [43] Older adults feel discouraged when simple technology is replaced by more advanced versions of it. The findings of the literature research clarified that older individuals are interested in incorporating technology into their daily routines to improve their quality of life [34], showing that they will not always shy away from technological interventions. This can be seen back in the barriers of usability and convenience. Leonardi et al [38] point out that the level of usability strongly influences the experience, with a highly negative experience resulting in rejecting technology. It appears that older adults feel encouraged to use technology when recognise the necessity, and the required resources, such as time and money, are low [43]. The target group generally prefers technology that does not require them to learn new skill sets or to undergo a steep learning curve [36] [38] [43]. If they cannot see how technology will improve their life, it is unlikely that older adults will deem it worth it to invest their resources into it.

The fear of unwanted consequences stems from some older adults carrying the belief that they have passed the age to be a user of high-tech products, potentially damaging the product in the process, which results in them being reluctant to adopt new technologies [39]. This can be avoided by designing for them and not the younger generation due to the difference in cognitive abilities [38] [39] [43]. Overall, it seems like these barriers are connected and show that designers must keep the potential for cognitive and physical overload in mind and strive for simplicity.



### 2.1.7 User Acceptance from Older Adults

Encouraging older adults to increase their bodily movements requires a multifaceted approach tailored to their unique needs and social dynamics. Transitioning into incorporating technology into motor and cognitive training can be effective, particularly when older adults perceive the training as valuable and the technology as user-friendly, fostering sustained engagement [4]. Overcoming initial apprehensions about technology use through familiarisation and assurance can strengthen acceptance [12]. Personalisation and gamification elements can further enhance engagement and effectiveness [12].

Integrating PA into the routines of older adults, such as incorporating movement into errands like grocery shopping, can result in long-term adoption [20]. Moreover, dispelling negative beliefs about PA and providing social support, feedback, and incentives are crucial for fostering participation [20] [17]. Cultivating a sense of community and belonging through PA can also enhance older adults' willingness to participate in interventions [24] [44]. Research suggests that older adults who live alone gain motivation and satisfaction from spending time with others [45], making it worthwhile to invest in group-based interventions. Additionally, participation in these interventions tends to drop less than in home-based interventions [45].

Allowing older adults to have a hand in the intensity of PA can help them be more engaged, as they prioritise preserving their health and functional abilities [12]. Additionally, the intrinsic joy that can come from activities or interacting with others doing the same activity can assist [12]. Leveraging group dynamics and cohesion tactics can significantly enhance the longevity of participation in exercise programs [6]. Furthermore, interventions should strengthen self-efficacy through tangible achievements, observational learning, positive reinforcement, and addressing psychological barriers [1].

Group-based interventions are particularly effective in promoting moderate activity levels and sustaining engagement over time compared to solitary endeavours [45]. Nevertheless, developing interventions that drive substantial changes in older adults' PA behaviour remains challenging [44]. Emphasising social interactions within activity settings can amplify motivation and benefits [17]. Short-term intervention programs have demonstrated high initial engagement rates and short-term efficacy in boosting PA levels [17]. Older adults are aware of the benefits of PA yet is hard to persuade them to participate. Once they engage in a more active lifestyle, some are prone to return to their old behaviour after the intervention participation is over [17].

Research shows that to get older adults to participate in a bodily movement-related intervention, they must raise their confidence to overcome barriers they have created for themselves [45]. The older adult should not be alone in this; as the saying goes, "It takes a village to raise a child" to have successful participation of older adults; not only are intrinsic factors needed, but extrinsic factors as well [45]. Reducing negative beliefs that older adults might have about their ability to exercise, such as their age not being beneficial or harmful, can lead to increased PA [20]. Interventions that implement behavioural strategies seem more successful than interventions that prioritise education [18]. So, to get older adults to increase their bodily movement behaviour, factors such as their confidence, beliefs, and attitudes should be addressed, as doing this will give the intervention higher chances of success [18].

When creating an intervention that aims to increase PA, such as this thesis does, the outcome should focus on what PA can bring the users and not just weight loss [46]. Devereux-Fitzgerald et al. [22] suggest that the low PA of older adults can be linked to them not feeling like their wants and needs are integrated into the intervention. People are more inclined to engage with the intervention when they recognise that it will bring them enjoyment and interactions with others [22]. Rawal et al. [32] found that interventions aiming at improving the PA of older adults had little effect but this could be linked to the design. Highlighting once again the importance of a community needed

to be involved. Promoting PA is a good approach but can only go so far, combining it with a social aspect, can lead to more success.

## 2.2 Interviews with Target Group

It was crucial to gain a better understanding of the needs of older adults to provide an effective solution for them. One effective method for gaining such knowledge was conducting interviews. Moreover, previous research demonstrates the importance of involving older adults in the design process, as they are the ones who will ultimately use the intervention. Thus, giving them a platform to express their voices is vital. For this study, 6 older adults were interviewed, ranging in age from 63 to 83. Four were from a low socio-economic background, and the others were from a high one. They were asked questions related to their past life, current life, PA engagement then and now, and questions regarding the gamification possible with the buttons. Whilst getting to know these groups, comparisons can also be made. However, it is essential to remember that these participants do not represent the entire population of older adults. Although they may share similarities with others in the target group in similar settings, their experiences and opinions may not be representative of everyone in their demographic. This section will focus on the answers to the background research, while Chapter 4 will discuss the answers related to ideation.

Two of the older adults with a low socio-economic background were still employed and stated that the majority of their PA takes place at work. Furthermore, they claimed they did not have enough time for PA as they had a job and were too exhausted afterwards, leaving no opportunities to engage in PA. This could mean the intervention should be short for this group to join. This would also mean that it is unsure whether these participants will actually be more active after retiring or whether they just claim time to be their most significant barrier.

These older adults also stated that currently, nothing around them motivates them enough to participate in PA. However, if something would be nearby, they would go there even if it were not on their route. This can mean the want is there, but they do not know how to fulfil it as they do not recognise their environment as helpful.

The two retired older adults with a low SES had a different view of their neighbourhood. They were satisfied with their surroundings even though they spent most of their time at home. One of them was severely ill, so their physical ability was low. Nonetheless, they tried to get outside when feeling capable enough to do so. The older adult shared that the biggest PA in their life was walking, with the assistance of a stroller. Although this person is in a unique situation that not everyone experiences, it is still important to consider that older adults like them can participate in PA-focused interventions if it has a low intensity. The other person has given up on the sports they used to engage in due to health concerns, but walking is also still an activity they do. An estimation of PA per day was low but they were satisfied with it and saw no reason to increase it. Noteworthy, when going somewhere, such as the supermarket, they choose to go for an extra lap to get more steps in. They described themselves as a homebody with low interest in social interactions. This does not stop them from going outside, though, as they enjoy sitting in their garden. It might not be outside in their neighbourhood, but it is good to know that older adults still find spending time outdoors essential. Both of them emphasised the importance of having things nearby as they do not venture far from home; the closer something is, the more likely they are to use it.

The retired older adults with a high SES said they used to do sports alongside their jobs, but combining is challenging. Now that they have more time, they are engaging in it more. These participants had been active for their entire lives, so it could have been easier for them to find a balance between work and hobbies compared to the other group.

All participants knew of the benefits of engaging in PA and what could happen when it is lacking. So, that means awareness is there, and the steps have not been taken to start moving more. Furthermore, the majority of them stated that they were incapable of bodily movements, such as bending or kneeling.

There is a difference in preference for whom they would like to interact with. People with a low SES background prefer to remain in their already established social circles, whereas their counterparts have no preference. This can mean that stimulating new relationships is not a priority for this thesis.

Summarising the findings, it is evident that a significant correlation exists between lower SES and the rate of decline in various age-related aspects. This underscores the crucial importance of this thesis, mainly as the target group is part of a low SES, thereby emphasising the relevance and significance of the study.

## 2.3 State of the art

The knowledge obtained from conducting literature research and interviews provides fundamental building blocks for progressing in solving the problem at hand. Another critical building block is shedding light on what has already been attempted and what can be learned by analysing the state of the art. This was done by exploring existing solutions tackling the same or a similar problem. The solutions mentioned in this chapter were gathered by either hearing about them during interviews, conversations about this thesis with peers, or having experienced them firsthand.

### 2.3.1 Bewegen is Leven

Joël Kruisselbrink is a professional movement therapist who created a series of games designed for older adults. His main goal is encouraging them to stay active and motivated, so he has built a brand around the motto "Movement is Living" [47]. On social media, he shares videos of himself playing these games with older adults. He uses a user-centred design approach, drawing inspiration from the life stories of the older adults he works with and customising each game to their unique experiences. Figure 1 shows three examples of his games that use everyday items and do not require innovative technology. Although the games may seem simple, they are challenging enough to keep people engaged. This is because Kruisselbrink realised that older adults were not interested in being active when invited to a practice room, however, they did show interest in playful activities that were not prompted<sup>1</sup>. Most, if not all, of his games are designed to be played in groups, promoting social interaction among his target group.

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<sup>1</sup> A. N. d. Boer, "Bewegingsagoog Joël laat oudere mensen spelenderwijs bewegen en deelt de ontroerende filmpjes," LINDA., 23 November 2022. [Online]. Available: <https://www.linda.nl/lifestyle/gezondheid/bewegingsagoog-joel-kruisselbrink-ouderen/>.



Figure 1: Games made by Kruisselbrink shared on his public social media platforms. From left to right: A pump shoots a ball towards a pyramid of cups [65]. Outdoor parkour is made in which pairs need to transport a ball together [66]. The mechanic system of a trash bin is used to create a ball-blocking system [67].

This thesis has a similar goal to the games mentioned earlier, but the main difference lies in the technology used. The image on the far left in Figure 1 is the closest to this thesis, as it involves pressing as an interaction method. These games focus on making older adults perform movements in a small indoor setting. The focus of this thesis is to encourage older adults to roam their neighbourhoods. So, the scope of these games is different, which is also visible in the kind of PA these older adults are partaking in. The activities are small in size, and no large movements are made. The playful nature of these games will serve as an inspiration, particularly in incorporating vibrant colours and keeping things simple. Additionally, ways of piquing the user's interest enough for them to engage with the intervention can be derived from these games.

### 2.3.2 Outdoor work-out equipment

During my minor in South Korea, I saw several outdoor workout equipment areas; one example is found in Figure 2, placed in parks, or alongside walking routes. The equipment was frequented by older adults who sometimes would turn their workout into a social gathering by visiting it with a small group of people, usually two to three fellow older adults. The intensity of the equipment placed in these areas varies, resulting in either light or moderate PA [48]. These outdoor gyms are found in South Korea and other countries such as China, Taiwan, Spain, Portugal, and the United States. Research by Chow [49] shows that older adults appreciate these areas and view them as providers of social and psychological benefits.



Figure 2: Pictures taken during my minor of a Korean outdoor workout area with the following equipment shown from left to right: a balancing station, a shoulder press station, and a rotating wheel.

The aim of this thesis is similar to that of outdoor workout equipment, as it increases PA and encourages people to roam their neighbourhood. These designs are also attractive; they blend in with the surroundings, and information is always available for users in the form of text and images. The far left image in Figure 2 shows that, although the difficulty level or intensity cannot be changed, the equipment has a mirrored version for users of different heights, making it accessible to more people. While some

older adults make this a social gathering, users do not interact as the equipment is designed for one person at a time. The mirrored versions, shown in Figure 2, allow two people to use it simultaneously. However, there is still no interaction between them unless they talk to each other during the workout, which is not an interaction induced by the equipment. Some key takeaways from this intervention include the placement of the activity, the method of giving instructions, and the establishment of difficulty levels. Observing the popularity of these, the assumption can be made that even though the equipment does not offer a possibility of changing the intensity or difficulty, older adults still find it enjoyable.

### 2.3.3 Physical activity-inducing video games

Many gaming consoles have games that involve PA in their gameplay. For example, Nintendo has developed games like Wii Fit (U) for its Wii and Wii U consoles and Ring Fit Adventures for its latest console, the Switch. Similarly, Xbox has introduced the Kinect system, allowing players to physically participate in their games. Examples of the PA that these games provide are found in Figure 3.

Wii Fit is a fun and motivating medium for balance exercises [50] and other PA, resulting in positive effects such as improving physical and mental health [51]. Similarly, Ring Fit Adventures is considered an engaging and educational exercise, with immediate feedback and rewards that motivate users and improve the acceptability of the intervention [52]. Kinect offers natural human-computer interaction for users and easy accessibility for developers [53], opening up more possibilities.

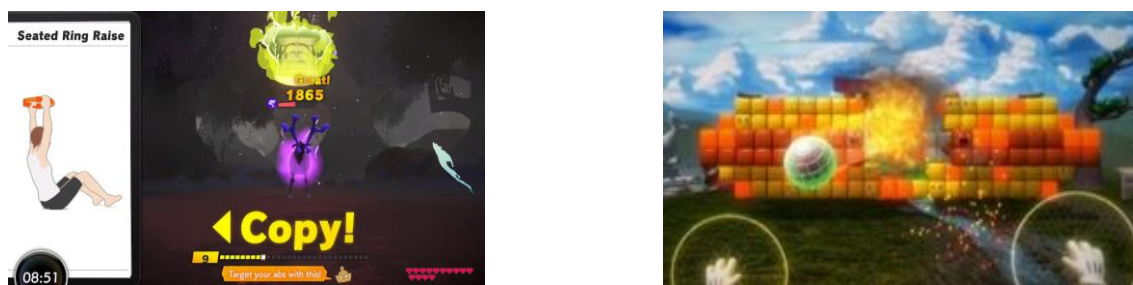


Figure 3: In-game captures of Ring Fit Adventures and Boom Ball. The former was taken from my personal Nintendo Switch, the latter taken from the official Xbox website [68] and used with the permission from Microsoft.

While games for the Kinect system, such as Boom Ball (shown in Figure 3), offer the possibility of playing in pairs, Wii Fit and Ring Fit Adventures are designed for solo play, meaning they do not promote social interaction. Additionally, these games are intended to be played indoors, which is not the focus of this thesis. Although the Nintendo Switch can be played outdoors using the tabletop mode, its small screen size may present an obstacle for older adults.

One aspect of video games that can be extracted is their gamification feature, which offers entertainment and exercise for older adults without feeling like a chore. The Kinect system allows players to physically participate in their games. Examples of the PA that these games provide are found in Figure 3.

### 2.3.4 Walk routes

During one interview, I learned about designated walking routes. They mentioned that they sometimes go on these routes to explore the nature around them. The purpose of these routes is to encourage people to take spontaneous walks. The Royal Dutch Touring Club ANWB has an "ANWB Eropuit app" app that helps users plan their walking routes. The app shows the distance of the path in kilometres, the time required, and the number of steps. These paths are usually located in green areas of the country. The cognitive effort required for these walks is minimal, as each node has signs indicating the direction and

number of the next node. Additionally, maps might be available along the way that show the walking trails in the area. This makes these walking routes user-friendly and easy to use.



Figure 4: Picture of a node taken from the ANWB website [69]

What I find most appealing about this state-of-the-art system is its easily accessible information. The information is available not only through an application but also through physical signs in the environment. The system's simplicity prevents information overload. Nodes are integrated seamlessly into the environment, as shown in Figure 4, which I would like to also implement in my design. Users can choose their route and adjust on the spot. However, the nodes do not interact with users and serve solely to keep them on track. Consequently, users may disregard the nodes as it is only a suggestion and offers no engagement.

During observations in the target area, similar poles placed by the strolling network Twente were encountered. Experiencing it myself, I found the poles to be unclear and not user-friendly. The design is simple as it just shows coloured arrows in varying directions. However, it gives no information on how far the next pole is, or how big the distance is of that walking route. It felt unfriendly for newcomers, like me, as it was difficult to find out what the routes were before finding them and to find any information that could offer guidance. This resulted in a negative experience with confusion being the main emotion felt throughout the whole walk even though the paths were along green fields. This means that understanding must be a high priority because it impacts the experience greatly.

### 2.3.5 Interactive wall

Through my peers, I learned about an interactive wall in the Running Man Experience Centre in Busan, South Korea. The centre allows people to play games for an hour to earn points that can be redeemed later for rewards in the form of pins. Figure 5 shows one of the available games, where users have to press lit-up buttons spread out on the wall. The game lasts 30 seconds, and users must press 40 buttons. The buttons used in this game are similar to the interactive buttons used in this thesis, as they also have LEDs inside. However, there is no sound during the game. The timer and progress are displayed on the screen in front of the user, along with an animation that does not add to the experience since it is not triggered by the buttons being pressed.



Figure 5: The interactive wall in use by a peer. Permission to use this photo was granted by them.

This state-of-the-art demonstrates how interactive buttons can be utilised to encourage PA. The add-on of a timer and points can offer people the incentive to be active throughout the game. However, this is

placed in a centre where people must try to gain as many points as possible, so the audience is already incentivised to be active. Something inspiring about this state-of-the-art is the feature where the buttons stay lit until pressed. This might be something I will integrate as well when choosing to do an active game using the LEDs. The reason is that the game will be paused until the user progresses by pressing the button, allowing for less intense activity if no timer is present.

## 2.4 Media

To learn more about older adults, the media was looked into for various media, such as videos related to the target group to get to know them more. One program that stood out was from the Dutch Public Broadcaster, named "The Big Box Experiment". In this program, seven groups were invited to talk about stereotypes they face and how they impact their lives. One of the groups consisted of people above 60. Seeing this as an accepted definition of an older adult, led to me using this definition for this thesis as well. Thus, when speaking about older adults, people of the age 60 and above are meant. The most notable point from this broadcast was that these older adults did not see themselves as lonely. This could mean that they are satisfied with the amount of social interactions that they currently have.

Moreover, one of the older adults pointed out that he is bothered by youngsters' reactions when complaining about his decreasing mobility. He finds that they assume that he has no aspirations left and that he should be satisfied with his achievements. Both of these points were eye-opening, as I had expected older adults to feel lonely and have fewer aspirations left in life.

*People ask me what I still want to achieve in life when I complain about becoming less mobile. I don't appreciate that because I still want to achieve a bunch – An older contestant from the program "The Big Box Experiment"*

The living arrangements, social life, work life, habits, lifestyle, and SES are unknown, meaning no concrete group of older adults can be linked to these statements.

## 2.5 Environment

Getting to know the target group did not stop at interviews. To gain insights into their environment, I conducted observations in Enschede South to identify ways to promote positive behaviour. A surprising observation was how green the area was. However, this could be the case for this area of Enschede South and not the whole neighbourhood.

During a walk through the neighbourhood, it was surprising to find multiple signs that indicated where the shopping centre and healthcare centre were, as seen in Figure 6. This seems to make it easy for older adults living nearby to go on walks without the worry of getting lost.



Figure 6: Signs found in Enschede South indicating what direction the shopping centre and health care centre are.

The two locations frequently mentioned in interviews with locals were the shopping centre and the park, two out of six interviewees were local. Observations were made at both places. Upon observation of the shopping centre (see Figure 7), it was evident that there were plenty of activities for locals to engage in. The shopping centre was quite spacious, with numerous shops and cafes, and there was a library across from it. While walking through the shopping centre, it was noted that many older adults were either alone or with a companion. Besides engaging with the stores and cafes, some were observed sitting on benches, watching others. This observation, coupled with the proximity of the library, suggested that there were plenty of free activities for locals to participate in. This is an important finding as that means regardless of budget, locals can have an incentive to be in this area. But can still be incentivised to move a bit more as the higher their PA levels, the better it is for their health.



Figure 7: Shopping centre area in South Enschede

Concluding this trip, the park across from the shopping centre was the next destination. Pictures from the park are seen in Figure 8. Again, older adults were found to be either by themselves, with a pet, or with one other person. It was uncommon to encounter them in groups. The park had numerous walking routes, a petting zoo, and a pond. Visiting older adults were there to walk or sit to observe. The ones that were by themselves seemed to be there to sit around and enjoy the scenery. This showed that even though there were no guaranteed social interactions, there was still motivation for these people to go to the park, which aligns with what was found in Section 2.14.



Figure 8: Pictures taken from Wesslerbrinkpark in Enschede South



The observations made can provide new insights for this thesis. For instance, the group size identified can be utilised in Chapters 4 and 5 to provide an understanding of the thesis's scope. Additionally, the potential placement of the intervention can be considered. The most significant finding from these observations is that the number of older adults in the South Enschede area was higher than expected. Allecijfers<sup>2</sup>, a website with statistical information on neighbourhoods, states that about 44% of this area is an older adult. However, this could be due to the above-average weather on that day and the proximity of the observed locations to healthcare centres. This highlights the need to research this neighbourhood more, to find out what gets these people to be physically active outside.

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<sup>2</sup> AlleCijfers, “Statistieken wijk Enschede-Zuid,” 3 July 2024. [Online]. Available: <https://allecijfers.nl/wijk/wijk-06-enschede-zuid-enschede/>.

## Chapter 3 – Methodology

When designing for older adults, involving them in the design process and keeping them at the centre is essential. To achieve this goal, the Creative Technology design process by Mader and Eggink is the method selected for this thesis. This method is user-centred and will be used as a guide for the design process. It is a fitting method as this thesis is based on a design question involving a pre-existing technology developed by Max Pijnappel. This technology serves as the starting point of the Creative Technology design process, which consists of four phases: ideation, specification, realisation, and evaluation [54]. The detailed structure of this method can be seen in Figure 9. In this chapter, the steps that will be taken to develop a technological intervention are discussed.

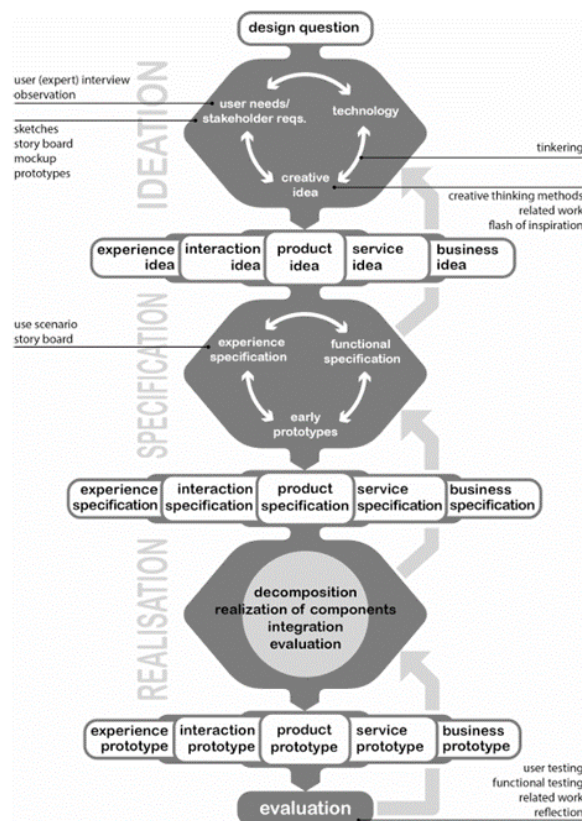


Figure 9: Creative Technology Design Process by Mader and Eggink [54]

The design process employs divergence and convergence models in all the phases except for evaluation. The divergence phase begins by opening up the design space and defining it, and this is influenced by factors such as the thinking techniques employed to explore the starting question, the designer's creativity, experiences, and cultural background. These elements are crucial as they facilitate unique perspectives on potential solutions.

In the convergence phase, the focus is on narrowing down the design space until a certain solution is reached. Each reduction of the design space is a decision based on the requirements of available knowledge. The ideation phase process will be further discussed in the upcoming subchapter, and the other phases will be discussed in future chapters. This implies that each phase follows a defined set of items to achieve the final design.

### 3.1 Ideation

The ideation phase starts with the design question, the starting point for generating the experience, interaction, and product ideas. A service or business idea was not within the scope of this thesis, which focuses on user-centred design and associated knowledge generation.

To start this phase, I employed various brainstorming methods, such as mind-mapping [55], role-storming, and round-robin brainstorming sessions [56]. In addition, the interviewees mentioned in Chapter 2 were also asked about their thoughts on potential routes this thesis could take. The results of this are found in Chapter 4.

### 3.1.1 Mind maps

Before generating ideas, a mind map of older adults in general was made. The goal was to have my views on them on paper to judge whether I was stereotyping them. Additionally, my personal experience with the target group is limited as I do not get to interact frequently with a variety of them. This mind map was made at the start of the project and after background research was conducted. I deemed this important to do as I believed that having (false) stereotypes about the target group can negatively influence the generation of ideas in the sense of potentially limiting what older adults are capable of without it being necessarily true.

Another mind map was made, now centred around the research question. This was done to get initial ideas related to any aspect of the project on paper. No limitations were put on this session, allowing a grand scheme to exist. This was later used to assist in generating concepts.

### 3.1.2 Role-storming

The role-storming method was adopted to understand the needs and requirements of the target group better, considering factors such as age and SES. The method requires you to put yourself in the shoes of the person you are designing for. Role-storming was an efficient method for divergent methods to determine user needs and requirements. It was effective because it leverages divergent thinking to explore multiple viewpoints and thereby uncover comprehensive user needs and requirements.

### 3.1.3 Round-Robin

The round-robin session was used to collaborate with five peers from different projects to gain perspectives that could lead to new ideas. Three rounds occurred, with each person sharing ideas that might work or proposing a direction to pursue. A3 paper and post-it notes were placed in the middle of the table, and each person was free to use these tools to make their suggestions more straightforward or to elaborate further. This session was an important source of inspiration, allowing for more diverse starting points for future brainstorming sessions.

### 3.1.4 Interviews

To get to know the target group, interviews were conducted with them. In total 6 older adults were interviewed. Interviewing them allowed for a more realistic connection with them and made designing for them easier, as their thoughts were heard. In addition, the qualitative answers gave more depth to establish their needs and requirements further. The setting of the interviews was familiar to the target group because it took place in either their home environment or one familiar to them. Four of the interviewees I knew personally and approached them for the interview as they matched the target group. The other two I got put in contact with through healthcare organisation Livio who stated they find the implementation of technology important.

Before meeting with the older adults, an interview was conducted with two second-year Creative Technology students who had participated in a similar project during Module 6. The focus of this interview was the reasoning behind their decision-making and tips on dealing with the user group during interviews and evaluations.

### 3.1.5 Tinkering

A particular activity was a tinker session with Max Pijnappel. In this session, he explained how the interactive buttons work, their strengths, and weaknesses, and how programming them works. This session started the physical exploration of the thesis.

### 3.1.6 Brainstorming

Multiple brainstorming sessions took place using the outcomes of the previous methods. This was the main way of generating concepts. Ideas were sometimes revisited, which resulted in some being more developed than others. Besides the previously mentioned methods, existing games, including games that young children play, were looked at for inspiration. This was done to see what elements could be taken from those games and how these elements could be turned into something that can be done with interactive buttons.

The convergent phase involved using the answers obtained from the interviewees with the target group to establish requirements and narrow down the design space. This approach eliminated some ideas generated in the brainstorming sessions and allowed focus on the requirements that aligned with the needs of the older adults. Requirements that were formed are elaborated on further in Chapters 4 and 5.

## 3.2 Evaluation

Ideally, the outcome of this thesis is an intervention that older adults use autonomously. After constructing the prototype, it must be evaluated with the target group to grasp its effectiveness. The data gathered from these evaluations are used to further develop the concept. The evaluation methods from the Mid-Fi and Hi-Fi prototypes collected qualitative data.

### 3.2.1 Mid-Fi Prototype

For the Mid-Fi prototype evaluation, older adults on campus were invited to participate. After receiving a briefing and signing a consent form, they were presented with the prototype and asked to interact with it. Playtesting was chosen as the evaluation method because it helps identify areas that need attention [57]. This method is suitable as it requires active participation, providing insights into usability issues, behaviour, and reactions. According to Schell [57], in playtesting, the focus is on the experience the prototype provides, not just the prototype itself. This evaluation aimed to determine if older adults over 60 find the provided system effective in increasing PA and if enough motivators are integrated. Observations were made during their interaction with the prototype. Subsequently, they were interviewed to gather their thoughts on the game, sounds, design, required level of PA, and suggestions for improvement. The findings were used to enhance the Hi-Fi prototype. The results of this evaluation can be found in Chapter 5, and the changes made to the prototype are detailed in Chapter 6.

### 3.2.2 Hi-Fi Prototype

The Hi-Fi prototype evaluations had two parts. The first part exists solely out of observations while the second part will ask those in the target group to try out the prototype. The observations are done as it will show whether people will autonomously use the intervention. Notes are made throughout the entire interaction. When the user was about to walk away or appeared to be lost for over 30 seconds, they were approached by me where I verbally informed them about the research and asked them to participate. Permission to use the made observational notes was requested and whether they are interested in participating in the research by answering questions about their experience. The second part of the evaluation is the same as that in the Mid-Fi prototype evaluation. The results are discussed in Chapter 7.

## Chapter 4 – Ideation

This chapter will discuss the outcomes of the methods mentioned in Chapter 3 in the same order. Thus, mind maps, role-storming, Round-Robin, interviews, tinkering, and brainstorming outcomes are discussed.

### 4.1 Iterative Bias Mapping

Two mind maps were created to explore the stereotypes about the target group. The results in Figure 10 revealed that I had a somewhat negative view of the target group. However, while conducting background research, I learned that they are capable of more than I had previously thought and are willing to take on challenges. Despite this, some stereotypes remained, particularly that of being playful as Section 2.3.1 showed it to be an accepted element. In this context, playfulness is defined as being in high spirits while remaining unserious [58]. The initial negativity surrounding these aspects dissipated as the target group exhibited a wide range of physical abilities and life experiences. This shift in perspective is crucial because an accurate representation of the target group is essential for the design process.

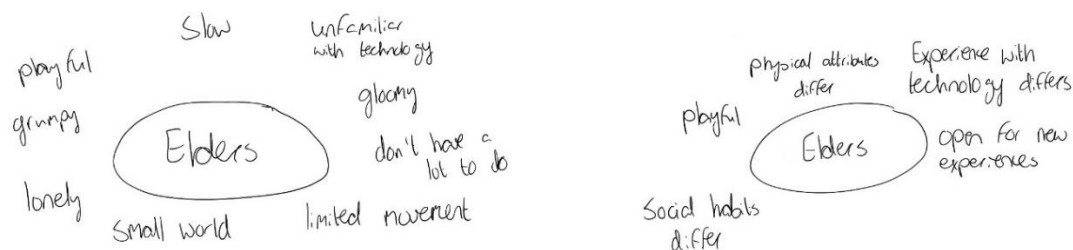


Figure 10: Mind maps on words that come to mind when thinking of older adults. The Left shows before background research and the right shows afterwards.

### 4.1 Mind Maps

Following this, another mind map focused on the research question, seen in Appendix 1, was created. The areas explored here involve technology, construction possibilities, scale, social interactions, the social circle, and movement.

Firstly, in this thesis, the central technology that will be used is predetermined. During exploration, the capabilities of the buttons were examined, starting with the LEDs. After reading about them during the background research phase, I already had some ideas on how to use them. LEDs can help give instructions or feedback and enhance the interaction. Additionally, the speaker can provide feedback or grab attention. Both can be combined and used separately to bring more engagement to the button, so they will somehow be used in the concept. Input methods were also explored, and using different ways of input besides touch, such as throwable objects and easily holdable objects, were considered. However, stepping on the buttons was not used, as it could bring too many risks, such as breaking the buttons and putting the target group out of balance can lead to them falling.

Secondly, building possibilities were explored to see what structures could be considered and how they would affect the buttons. Three structures were considered: nodes, a floor, and a wall structure. All three offer different possibilities to the table, but they can have similar button placement, with the most significant difference being the height difference. All three were considered during future ideation.

The third factor considered was the scale, which refers to the area size. Since the buttons can be spread over long distances from each other, the intervention can cover a large area. Therefore, the location was taken into account, which will be throughout the neighbourhood or in a designated outdoor area.

Fourthly, social interactions were explored to assist in generating ideas for an intervention by considering how users should be involved. The main ideas were the interactions through a game, so users could work against each other, learn about each other, achieve a goal together, or compete. Outside of a game setting, users could move towards the goal together. All of these possible interactions were used in future ideation.

Fifthly, the social circle was explored to aid in ideating what would be a good experience for all parties involved. The social circle of an older adult is expected to consist of their pets, caretakers, neighbours, other older adults, or their (grand)children. During the interview, there were mixed opinions on who the older adults would like to interact with, from not minding who to want to stay in their social circle. So, this was taken into account during future ideation.

Lastly, the type of movement that could be used while imagining where the buttons could be placed was considered. This includes kneeling, running, jumping, twisting, and walking. Kneeling or bending was left out of future ideation, as it would be better to have older adults use objects to reach the button than repeatedly kneel or bend. Interviewed older adults said that they do not have limitations in their movement yet so they can make that movement. However, with the deteriorating health of older adults, it is too risky to make them perform such movements.

## 4.2 Role-storming

The goal of role-storming was to delve into the target group's mind and empathise with them. Knowing more about them at this point made it somewhat easier to imagine how they would feel about certain aspects of an idea. For the role, I imagined a mix of the interviewees using what I learned about their habits and opinions on certain aspects, such as social interactions. During this session, I imagined being an older adult on their way to the supermarket on foot.

I run into someone familiar, and we start walking together on a route that I do not know. While walking, we spot in the middle of a field some pillars that appear to have buttons on them. The acquaintance suggests giving it a closer inspection. Having enough time in the day as grocery shopping is done on a day without many plans, I agree and join them. The pillars themselves do not say anything, and why they are there is unclear. As nobody is around, my curiosity takes over, and I press one of the buttons to see what happens. Sounds and lights start coming from the button, but what to do next is unclear. Not knowing whether the reaction of the button was supposed to happen, we tried to press the other buttons to see if something different would happen. The same happens, but as it is still not clear what the reaction is for, we leave and continue walking. On our way, we stumbled upon a sign that showed many instructions with some illustrations of the pillars. However, as the text was too long and the fact that we had given up on the pillars, we continued walking after briefly scanning the instructions to see if we were close to the right way of interacting with them.

Imagining this scenario was fun to do, and it gave insights into how to implement instructions. Not only do signs have to be in close proximity to the intervention, but the speaker could also be used to instruct. So, for example, when using pillars, they could be numbered on the side, and the speaker could announce the following number. The usage of numbers was also seen in Chapter 2 in Section 2.3.4, where pillars on the route had numbers to indicate where users have reached. Using them can show users where to start and where to go from the start. As some older adults will not seek out a sign with instructions as their curiosity will improve, making the intervention as self-explanatory as possible is essential. When using signs, the information should be concise because explanations in long texts can be dismissed as users might not attempt to read them and prefer to just learn by using the product, meaning the product has to be easy to understand.

## 4.3 Round-Robin

For this method, I met up with four peers in Designlab. Each of us was involved in a different graduation project. After informing each other on the goal, target group, and what is thought of so far, ideas were generated for each other's projects. The main points of our discussion, which could be useful for future ideation, are shown in Figure 11.

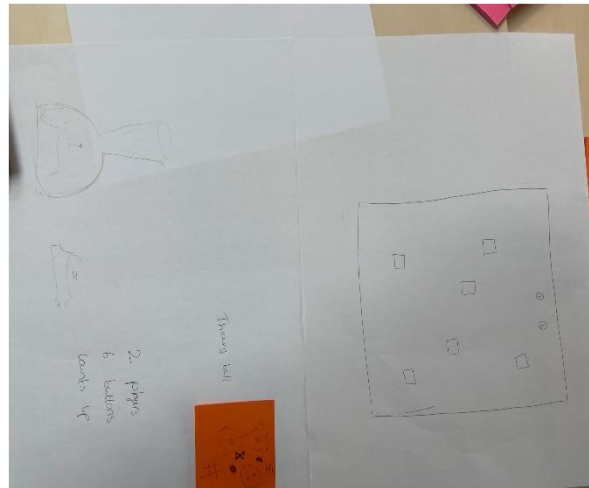


Figure 11: Result of the Round-Robin method

During it, methods to press the button were discussed, such as using a plunger-like object, how a play area could look, and what kind of games would be interesting to think of based on my target group and the capabilities of the buttons. Together, the idea of incorporating dodgeball came to life. Moreover, having a stopwatch instead of a timer stemmed from this method. The difference is that a stopwatch counts how long you are taking, while a timer gives you a time limit. These were the main new ideas that were seriously considered.

## 4.4 Interviews

### 4.4.1 Peers

Before approaching the target group, an interview was conducted with second-year Creative Technology students who had worked on a project with the same target group. This interview took place on campus in Zilverling. The interview questions can be found in Appendix 2. It was semi-structured, so questions were added on the spot based on their answers. The duration was about 22 minutes.

The focus of this group was to give them a way of meeting new people, and thus increasing their social circle, however, during evaluation, it was found to be undesired by some older adults as they preferred staying within their social circle or meeting up with people beforehand and not during. When asked about what they would have done differently, the students answered they would have incorporated more of a balance between existing and new social contacts. The PA that they focused on was walking, because they found the structure of the older adults already in place, so, this was the easiest to implement without messing up their planning too much.

During their evaluation, they also found that older adults were not as hesitant as expected, and they were excited about the addition of technology to their lives. The social aspect is a key part when designing for people. However, the students recommended looking into what truly motivates the target group.

The main takeaway from this interview was that older adults should be asked about their opinions, but they must be reminded that they are not the designers. The students said that in their experience, the

older adults would come up with their ideas instead of giving feedback on what was proposed. Thus, when involving them, a method must be applied where they feel like they can be honest and open without going off track. They also suggested that one-on-one might be preferable as they would be more focused on answering the question instead of trying to add to what others say. In addition, the group recommended looking into the meaning behind colours so that they are self-explanatory and offer guidance.

#### 4.4.2 Target Group

The older adults, integral to this research, willingly participated after a thorough briefing and signing a consent form. The semi-structured interview, consisting of 25 open questions, took place in a familiar environment. See Appendix 3 for the questions and Appendix 4 for the detailed answers. The interviews, lasting between 23 and 52 minutes, explored various topics, including some based on previous brainstorming ideas. The insights gained from these questions will be further discussed.

Most older adults liked the idea of having more PA through a game. The ones who did not enjoy the idea claimed it was due to them engaging in enough PA already, so there was no added value, but they added that it might motivate the unmotivated. When talking about the size of the game, 4 out of 6 interviewees said that if it is going to be a physical game that is supposed to help them move more, they would like the area to be on a large scale somewhere in between 10 square meters and a sports hall. Of the remaining two, one had no preference as they were not interested in the idea, while the other was not physically capable of walking long distances, so a small (indoor) area was preferred.

75% of the older adults from a low socio-economic background preferred activities with their family members, who 50% also selected as preferred opponents. 50% of the interviewees had no preference as long as they were being challenged.

All participants stated that when using a time-tracking element, they would prefer it to be a stopwatch rather than a timer. They expressed more interest in knowing how long it took them afterwards, than how long they have left to do it. Thus, if a time-related aspect is added to the concept, it must be a stopwatch.

The older adults strongly preferred incorporating LEDs and sounds into the game. They recognised the potential benefits of these elements, for example using sounds as guidance or rewards and LEDs to provide visual cues for those with limited vision or immediate understanding of the game. A strong preference for the speaker was found as interviewees had a stronger reaction when asked about the implementation of music or sounds than LEDs. This can mean both are appreciated but the speaker appears to attract them more. When asked what kind of sounds to implement, they said sound effects might be annoying. Instead of sound effects, I proposed sounds from instruments, and 5 out of 6 interviewees liked the idea more.

Noticeably, the older adults with low socio-economic backgrounds said they would if they had the chance to change the playfield. At the same time, the other participants did not share that sentiment, saying that it is situational and that moving might not add or change anything about the game. So, they would trust that it is already correctly placed. All interviewees were okay with repetition in the game.

An interesting comment that was made is that it could be motivational for older adults to be able to pick the difficulty level. In the long run, this could also mean that older adults can slowly improve their skills and eventually do the activities longer and more than they initially could.



Interviewees were asked about their opinions on some ideas to get an indication of what route to go on for this thesis. This was also important to do as found in Chapter 2 as they must be involved in the design process. The ideas that they liked most involved music.

Four out of six interviewees were presented with the six final ideas. The ideas were drawn out in a simple way because Demirbilek and Demirkan [33] found that people are more comfortable criticising when an idea is not fully developed. When providing them with the final 6 ideas, discussed further in Section 4.7, the feedback received was that a table height is preferred, it should be close to their house and maybe even in their house, and that usage of music and lights would provide a nice experience. As the goal is to get them outside, the latter will be dismissed and seen as something that could be developed in the future.

## 4.5 Tinkering

During the meeting with Max Pijnappel, Michelle Gommers and I learned about the capabilities of the interactive buttons. These buttons can perform various functions, such as lighting up LEDs in a range of colours, playing sounds, connecting with other buttons, and staying connected with this network over a large area. Additionally, the buttons do not require advanced programming. The demos provided by Pijnappel will be used to build a new program.

The buttons' hardware allows other electronic devices, such as LED strips, to be connected to them. They run on batteries and function independently, making them suitable for covering a large area. The colours available for the buttons to show are red, blue, green, purple, yellow, orange, cyan, and pink.

Something that could be used to differentiate the users when the intervention is used by more than one is the fact that the button can also register a double press. This gave the idea that when having a 2-player game, the second player could be differentiated by the system by having either the colour of the LED or the input method be different.

The biggest drawback of the buttons is that they sometimes fail to register a button press. This can be confusing, but clear feedback can help users understand when their button press is not registered. This feedback can be in the form of a sound or change in the LED hue; this not occurring would show users that the interaction did not go through.

## 4.6 Brainstorming

Using the knowledge gained through background research, existing games, and the previous findings in the ideation phase, concrete ideas occurred through brainstorming. This resulted in 30 ideas, shown in Figure 12.

The games that were used for inspiration were tic tac toe, memory, hide and seek, bean bag toss, Hook-A-Fish, Duck Duck Goose, Simon Says, Guess Who, dodgeball, and musical chairs. These were selected as it is likely some of these if not all are known by the general public.



Figure 13: Sticky notes on Miro containing the ideas generated through brainstorming with knowledge gained using a variety of methods.

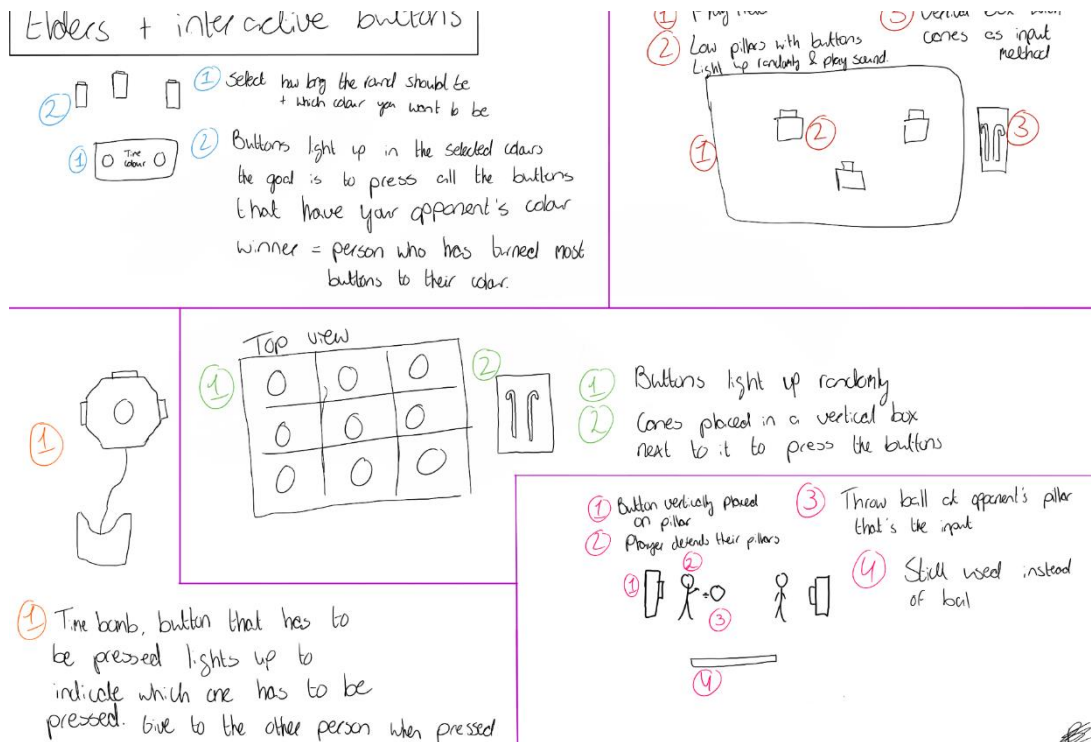


Figure 12: Concept drawings of five ideas.

Some of these ideas were drawn out as I found that to help bring the concept to life. They were selected based on the assumption of it being well-received by the target group. The drawn-out sketches were used during interviews to explain the potential of the buttons and what I was envisioning; this is shown in Figure 13. Positive reactions were given to the concepts, especially the one on the top right because they enjoyed the thought of walking around and making music. After the 30 ideas were generated, they were filtered based on the interviewees' answers. This resulted in four ideas being selected, shown in Figure 14. These ideas were also selected because they each have elements that could expand the other by combining them. For example, music can be a reward for turning each button to the same colour or finding all the matches. Users could arrange the playfield freely to make it more advanced or more straightforward for them and their opponents.

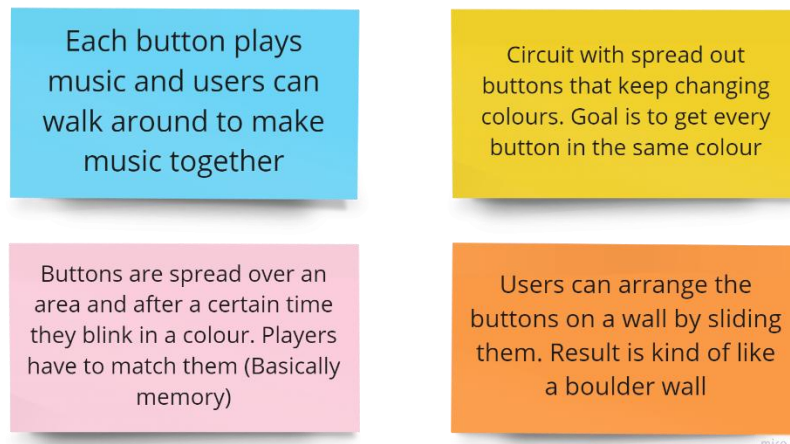


Figure 14: Selected ideas based on the input of the interviewed older adults.

#### 4.7 Final Idea

The four Post-it notes were paired together to ideate further. The results of this are found in Figure 16. When presenting these to the interviewees it was clear that there was no strong preference. Hearing this, I took three of these concepts, numbers 4, 5, and 6 and combined them into one. From numbers 4 and 6, the structure is combined by giving number 6 handles to move the pillars. This would allow users to move around the pillars freely. To plant the idea of putting the structure as seen in number 4, the initial idea was to put corners on the pillars to show how to place them if put together. However, this might be a safety hazard as people can walk into them. So, to avoid that, the idea evolved into painting the top layers so that the pillars can be matched together through visual cues. The moving of the buttons will not be used in the final concept, as the pillars are already movable. Number 5 is selected as it can stimulate the cognitive abilities of the target group.

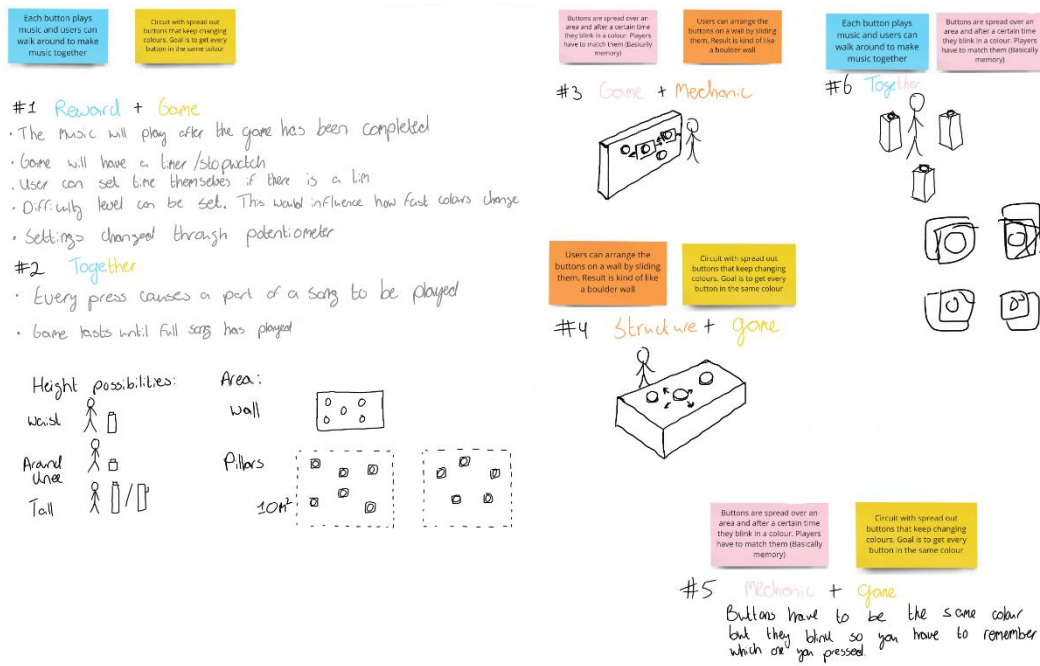


Figure 15: Final six ideas.

Eventually, the final concept was drawn out. It is important to note that the target group requested it to be as simple as possible which comes back in the actual design, seen in Figure 16. The features that are added, are the handles and the bottom frame, both to make it easy to move. The way the top will be decorated is decided during the realisation phase.

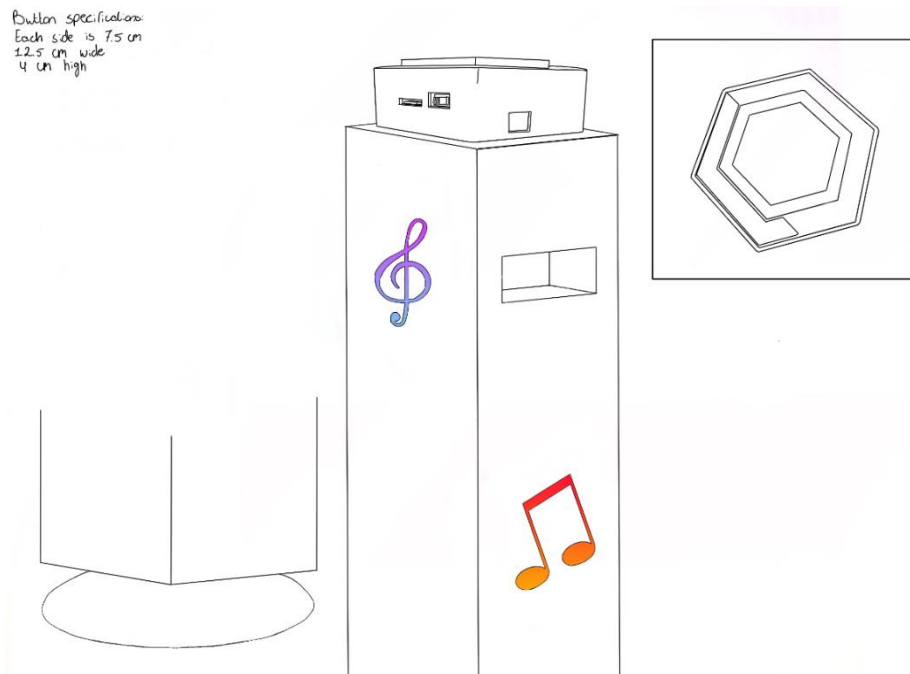


Figure 16: Final concept drawing showing the bottom frame, the body, and the top view.

## Chapter 5 – Specifications

Following the Creative Technology process by Mader and Eggink, having finalised the Ideation phase in Chapter 4, the Specification phase will now commence. This chapter will tackle the requirements that are set to achieve the goal.

### 5.1 Goal of the intervention

This thesis aims to encourage older adults in low socioeconomic areas to be more physically active and spend more time outdoors in their neighbourhoods. To achieve this goal, walking has been chosen as the primary PA for the intervention. This decision is based on the research outlined in Chapter 2 and the fact that during interviews it was discovered that walking is the main, if not the only, PA for the older members of the target group. Therefore, expecting them to engage in other forms of PA may diminish their interest in the intervention. To appeal to as wide an audience as possible, walking is deemed the most suitable choice.

To promote walking, a series of structures will be created and placed in close proximity to each other, forming a kind of course for the users to navigate. They will have to walk to the structures to make use of the prototype.

Dancing was also considered, and it could be an additional PA for the target group, but it would have to be initiated by the participants themselves, as interviewees expressed that they might feel too self-conscious to dance in public. Therefore, dancing is not a primary focus, but it may occur as music is integrated into the intervention. Music will play after each stage of the activity has been completed.

### 5.2 Design

The prototype will consist of six pillars, each with a button on top. The pillars will be made of wood because it is accessible and easy to work with. They need to be sturdy yet lightweight. During interviews, it was found that a basic and simple design is important. Older adults with a low socioeconomic status stressed the importance of an easy-to-use prototype. A simple appearance will enhance user acceptance and increase self-efficacy, as the prototype should not appear challenging, and interactions should not be challenging either, possibly increasing confidence.

The fact that this intervention is for the outdoors can mean two things, it is water-resistant to be left out in the rain, or it can be easily moved to avoid damage. As stated in Chapter 4, a handle is added to the pillar, this makes it easier to transport, meaning the latter option is chosen.

The music notes will be laser cut into the wood. Translucent material will cover them to have a similar look as the buttons. The changing colours of the LEDs might not be visible from every angle, so to make it more clear to users what the colours are, LED strips can be added. Adding an LED strip allows for a better registration of what colours are used in the game. The LED strip could be pasted against the translucent material to mimic the button.

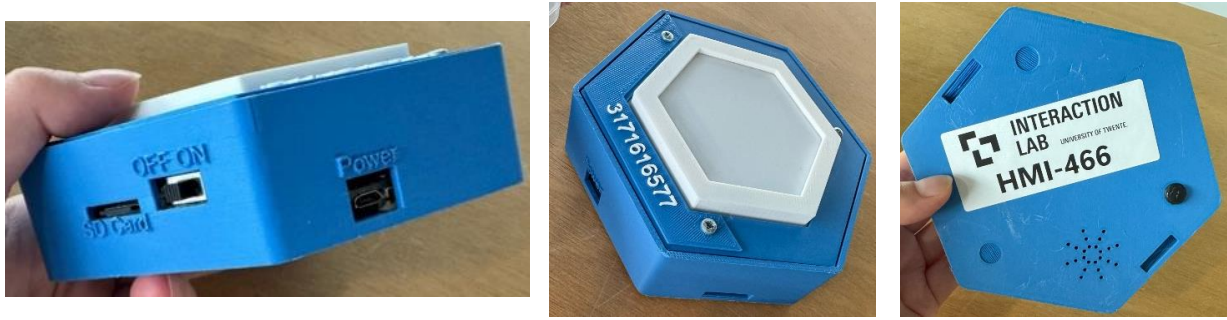


Figure 17: Pictures taken of one of the interactive buttons used in this thesis.

The speaker of the button, seen in Figure 17, is on the bottom of it, meaning that the button cannot have a flat surface covering the entire bottom as the sound would be mumbled. To tackle this issue, a frame must be built to support the button in a way that the button can stand without moving throughout interactions, while not hindering the speaker.

In the ideation phase, Section 4.2, it was found that there is a need for information near the installation. Since the pillars can be moved, it can be challenging to choose a specific spot for instructions. Therefore, instead of having the instructions on a separate structure, it was decided to put instructions on each pillar. This allows users to have more flexibility, as they can always refer to the instructions on how to interact with the pillars without worrying that the instructions are only available in one spot. Moving the pillars in that scenario could lead to inconvenience, so having instructions on each pillar solves this issue. The provided information should be simple, as the prototype should be self-explanatory. Therefore, users should not have to rely on the instructions.

### 5.3 Description of the system

The prototype consists of six pillars, each equipped with interactive buttons that collectively form a game. These buttons are capable of communicating with each other through a connected network. This connection is facilitated by a dongle inserted into a laptop. Python is used to develop a program responsible for controlling the interactive buttons.

The game is designed as a memory exercise, tailored to address the cognitive decline often experienced by older adults. Each button is paired with another, and a specific colour is assigned to each pair. After displaying its assigned colour for five seconds, the buttons stop showing a colour. Users are then tasked with finding each pair by pressing the buttons. When a button is pressed after the initial five seconds, it reveals its colour until a wrong combination is made. If the next pressed button is a different colour, both buttons turn off. If the next pressed button is the same colour, both buttons remain on, and a fragment of a song is played. Once all combinations have been found, a complete version of the song is played. In Figure 18 a schematic is shown that illustrates the functions.

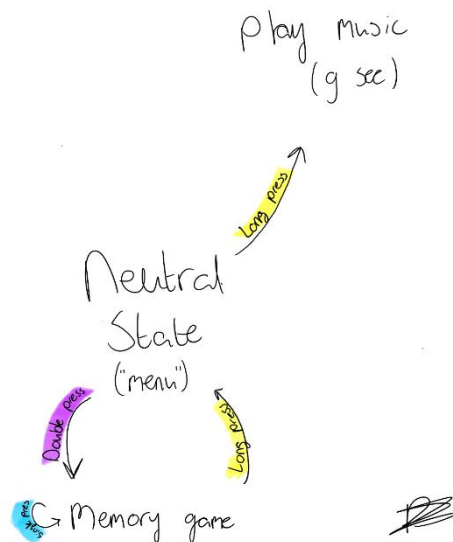


Figure 18: Schematic of the system

## 5.4 – User interactions

The buttons can register three different input methods: a double press, a long press, and a regular press. Each of these presses will serve a specific function in the game. The long press will start the game, the regular press will be the main input for the game, and the double press will reset the game.

The game can be played individually or together by discussing which button to press and walking together to the next button. While a multiplayer mode could have been an option, using this method encourages users to assist each other rather than compete with each other. During interviews, participants only expressed interest in competition when specifically asked about it, suggesting that they may not have considered it or were waiting for the chance to voice their preferences. Furthermore, the goal of the game remains the same – to start a song being played. Since there is no competitive advantage as the reward is the same for everyone, a cooperative game format seems more suitable for this type of reward.

The implementation of a timer or stopwatch is abandoned because of a similar occurrence during the interviews. There was a clear preference, a stopwatch was better, but the nature of the game does not need a timer. However, this can be added as a future work, allowing users to train their cognitive ability and time themselves in the process to log a difference over time.

## 5.3 Functional and Non-Functional Requirements

Functional and non-functional requirements are established to realise the requirements needed to guide the realisation of the concept idea. Requirements are based on previous research findings found in Chapters 2 and 4. The Moscow method is used to identify the importance of each requirement. The Moscow method is used to sort out the importance of the requirements.

### 5.3.1 Functional Requirements

According to Suzanne and James Robertson [59], the definition of a functional requirement is a specification of what the product must do to fulfil its purpose.

#### 5.3.1.1 Must

- 1) There must be at least two input methods of the interactive button used.

*Grounding: Based on the Tinkering session. There are three input methods, utilising at least two can increase the possibilities of the button.*

- 2) Feedback must be given to the user within 10 seconds after they interact with the interactive button.

*Grounding: Background research done in Chapter 2 showed feedback to be important for avoiding confusion and confirming input.*

- 3) The speaker present in the interactive button must be used.

*Grounding: Interviewees were enthusiastic about the possibility of sound.*

- 4) The prototype must be able to reset itself after use.
- 5) The LEDs must go to a blank state 5 seconds after the game is started.
- 6) The system must pair up buttons each time the game starts.
- 7) The system must assign each pair one of the 8 available colours.
- 8) After interacting with the interactive buttons during an active game, they must reveal their assigned colour.
- 9) After two buttons have been interacted with the system must give feedback in the form of a change in LED colour or sound.

*Grounding: Interviewees found receiving feedback in these forms pleasant.*

- 10) When a pair has been found by the user by interacting with them consecutively, the pair remains showing their assigned colour until the game ends.

*Grounding: Concept taken from the traditional board game memory.*

- 11) When a user interacts with buttons from different pairs, both buttons must return to their default state.

#### 5.3.1.2 Should

- 12) The sounds stemming from the speaker should lead to an overall positive experience.
- 13) There should be a clear distinction when an interaction goes through or not.
- 14) The prototype should offer users a cooperative game.

*Grounding: Five out of 6 interviewees preferred being able to play a game with others.*

#### 5.3.1.3 Could

- 15) The prototype could offer more than one activity for the users.
- 16) The prototype could involve more than one song.

#### 5.3.1.4 Will not

- 17) The prototype will not distinguish between users.

### 5.3.2 Non-functional Requirements

After addressing the functional requirements, the next step is to focus on the non-functional requirements. Suzanne and James Robertson [59] describe non-functional requirements as those that emphasise the qualities associated with the product. These qualities relate to usability, attractiveness, and reliability.

#### 5.3.2.1 Must

- 1) There must be instructions nearby with a maximum distance of at least half a meter.
- 2) The design of the prototype must have a simple appearance.  
*Grounding: Literature research showed this style to be preferred among the target group.*
- 3) The weight of the prototype must be under 5 kilos for moving purposes.
- 4) The prototype must have a height between 730 and 760 millimetres.
- 5) The prototype must be at least 125 millimetres wide.  
*Grounding: This is the width of the button.*
- 6) The prototype must provide users with the possibility to transport it by hand.



- 7) The prototype must appear easy to use to boost users' self-efficacy.  
*Grounding: Background research showed that self-efficacy is important for the goal of this thesis. Giving users the impression that it is easy to use, might increase their self-efficacy.*

#### 5.3.2.2 Should

- 8) The prototype should catch the attention of the user.  
 9) The shape of the prototype should be designed to facilitate placing multiple prototypes next to each other.  
*Grounding: During the ideation phase both separate pillars and one body with buttons were appreciated by interviewees. This gives users the option to have both structures if desired.*  
 10) The prototype should be distinguishable through design elements.  
*Grounding: Based on the ideation phase, will serve as assistance on how the pillars potentially can be placed.*  
 11) The prototype should be sturdy enough to survive being transported at least 10 times.

#### 5.3.2.3 Could

- 12) The prototype could stimulate the users to dance.  
 13) The prototype could implement music-related attributes in the design.  
 14) The prototype could add more LEDs in addition to the ones of the interactive button.

#### 5.3.2.4 Will not

- 15) The prototype will not overwhelm the users with information.  
 16) The prototype will not be physically challenging for the average older adult.

## 5.4 Mid-Fi iterations

To finalise the concept, I created a mid-fidelity version to identify necessary changes for the final version. I developed an early version of the design and a more advanced version of the code to observe user reactions to the memory game and the music. These were later evaluated with users to get input from the target group.

### 5.4.1 Design

I made changes to the design, moving away from the original concept shown in Figure 16. I had to create six poles and decided to use stanchions that my supervisor, Robby van Delden, had used in a previous project. I retrieved these stanchions from Designlab. The used parts were 75 cm high with a 5 cm diameter. I drew out three concepts of what to do with the stanchions, see Figure 19, and ended up going with number 1 as it required the least resources.

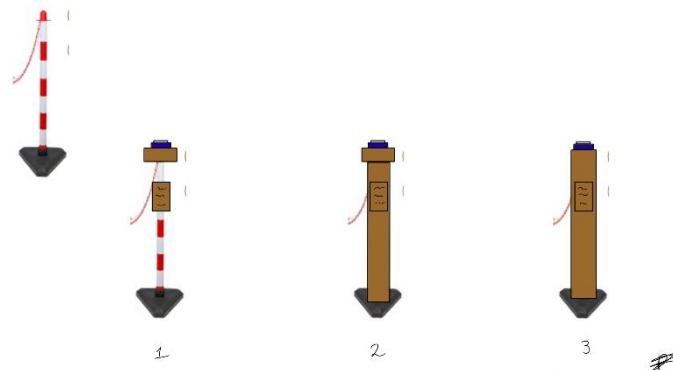


Figure 19: Mid-Fi prototype concepts

The base was left behind to see if users would move the poles themselves; having something as heavy as a three-kilogram base attached to the pole made me think people would not attempt to move them. I also left the top of the stanchion behind, as I wanted a flat surface, and it was obstructing that. Therefore, I only used the pole part of the stanchion, as seen in Figure 18, which was 86 centimetres tall. I created a top and bottom layer using cardboard because it is accessible and can be altered rapidly, making it time efficient. The base was 210 millimetres because the buttons are 125 millimetres wide and following the non-functional requirement number 10 where it is stated that the top part of each pillar should be able to be differentiated, extra space was given to the button to create a design on top. It could have been bigger, for example, 230 millimetres, but I wanted to make the design compact, so a smaller size was preferred.

For added weight and appearance, cardboard sides were later added to the top layer, providing a location for the potential placement of instructions. Since I only had five stanchions, I used a cardboard tube as the sixth pole. The construction of the Mid-Fi prototype is visible in Figure 20. Once I had collected all six poles, the mentioned sides were added, and markings were drawn on with markers, visible in Figure 21, by my peer Natalia Bueno Donadeu and me to give placement ideas to the target group.

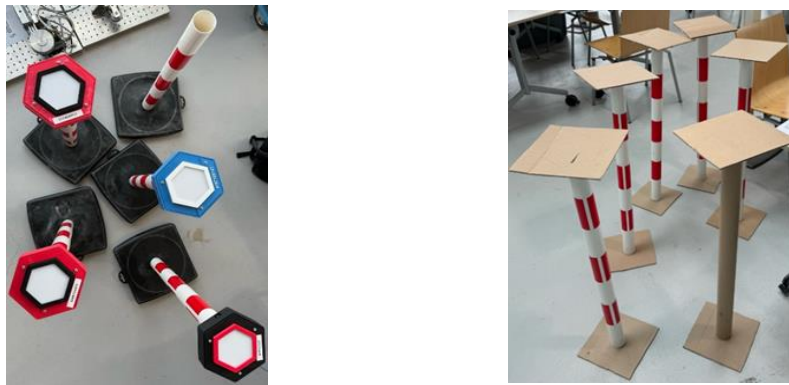


Figure 21: Building process of the Mid-Fi prototype. The left shows the initial state of the poles and the right shows how the stanchions were used

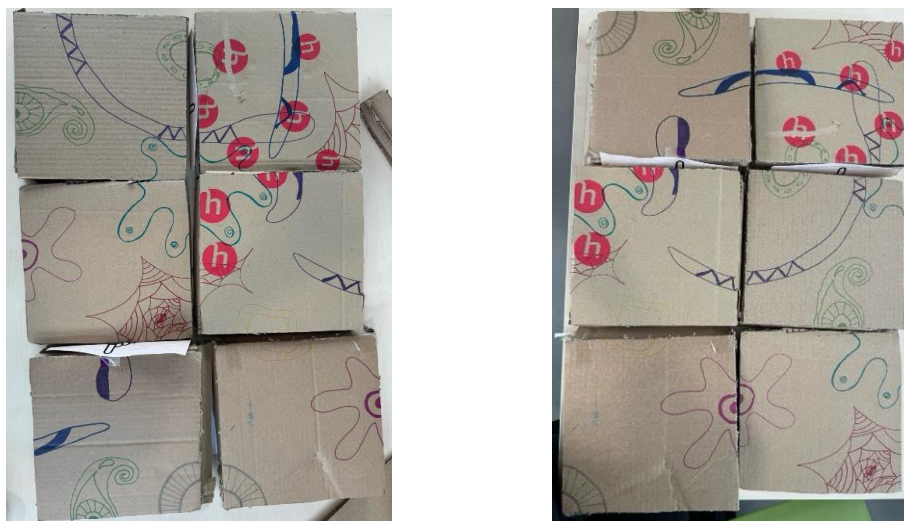


Figure 20: Drawn on top plate with different combinations on each picture

After role-storming (see Section 4.2) I concluded that instructions were needed near or on the pole. The poles being portable means that they can potentially be moved quite far away from the instructions if they were a separate structure. Therefore, the instructions had to be on the pole. The instructions, see

Figure 22, were designed in Canva, the font was intentionally given a large size, and the two different modes of the buttons were separated. This was evaluated later with the target group to see if it had enough information for them to perform the actions without me being there to clarify. The instructions were placed on different heights to do a rapid version of A/B/C testing by having three different heights for the instructions, visible in Figure 23, the results are discussed in Section 5.4.4.



Figure 22: Instructions on how to interact with the buttons created on Canva

I tried to shorten the text as much as possible, which proved to be a challenge with the Dutch language as shortening in most cases results in sacrificing correct grammar. This was done in the first two lines of the first mode to save space. The third line could not be shortened more than shown in Figure 22, the word “herstarten” was not a B1-level word but it was shorter than its B1-level version “opnieuw starten”.



Figure 23: The different height placements are shown on one of the poles

## 5.4.2 Sounds

The music to be implemented was considered based on input from the target group in Section 4.4.2. Classical music was decided upon as it exists solely out of instruments. Additionally, classics from this genre are public domain, so no copyright issues can arise. The pieces that were selected are upbeat, to create a pleasant atmosphere. I was considering six pieces, and after evaluating them two remained. Later the idea of using classical pieces to signal mistakes came to life. Three different pieces were considered for this one, and after evaluating these in the same way as previously done, one was selected.

The evaluation will be discussed in 5.4.4. Two pieces by Johann Sebastian Bach were used, Badinerie was used for the free music play mode, and Toccata and Fugue in D minor BWV 565 was used to indicate a wrong pair. The latter was selected because of its dramatic sound. To select these sounds, two target group members were asked for their opinions. For the game the piece Concerto no. 2 in F major, BWV 1047 – III. Allegro assai by Brandenburg was used.

The same duration of 9 seconds stayed consistent in both modes. After the game finished, a 20-second version of the piece by Brandenburg is played. The 9 seconds were chosen as it covered enough of the piece to influence the atmosphere and grab the attention of others potentially. Additionally, I considered it potentially more motivating to hear instrumental music than a short jingle. The 20 seconds are a reward, covering the most upbeat part of the piece uninterrupted.

### 5.4.3 Code

The code was written using Python and based on an example by Max Pijnappel found on GitHub. In the game created by Pijnappel, single, double, and long button presses were used. A double press started the game, and the program identified which buttons were connected, turning them purple. The user then had to press the button that turned yellow to proceed in the game. After eight times of randomly assigning a button to be yellow, the game ended. A long press was used to reset the game and provide data to the serial monitor on the connected buttons.

In the code used for the Mid-Fi prototype, the LEDs were initially in a rainbow state when the code ran. A long press made the LEDs blink red while a 9-second fragment of Badinerie was played. Each button played a different fragment. A double press started the game, pairing up the six buttons and assigning each pair a colour. After 5 seconds, the colours were cleared. A single press made a button display its colour. The user had to press two buttons of the same colour consecutively for a 9-second fragment to be played to indicate progress. Only the second button played the fragment, as that one is determining whether it was correct or not. When the second button was not the same colour it would play a sound fragment indicating a wrong move, both buttons turned off again. A long press was used to return to the default state of the game, ending it.

### 5.4.4 Evaluation

For the evaluations, five users were asked to participate. Four out of five evaluations took place at Langezjds on campus. See Figure 24 for the set-up, where the pillars were spread over a small area next to the main stairs to not be too much in the way. People who appeared to be above 60 and passed by were approached to ask if they wanted to participate. This method was done as the goal was to get opinions on usability, choice of game, sound, and how much people in the same age group think it will prosper, so asking people directly was the fastest way to do that. The evaluation that did not take place here was conducted in a home setting, where the buttons were spread through the living space on different height surfaces. The ages varied from 59 to 67. Each evaluation was about 10 to 15 minutes long with the trying out the prototype taking about 5 minutes and the questions either 5 or 10.

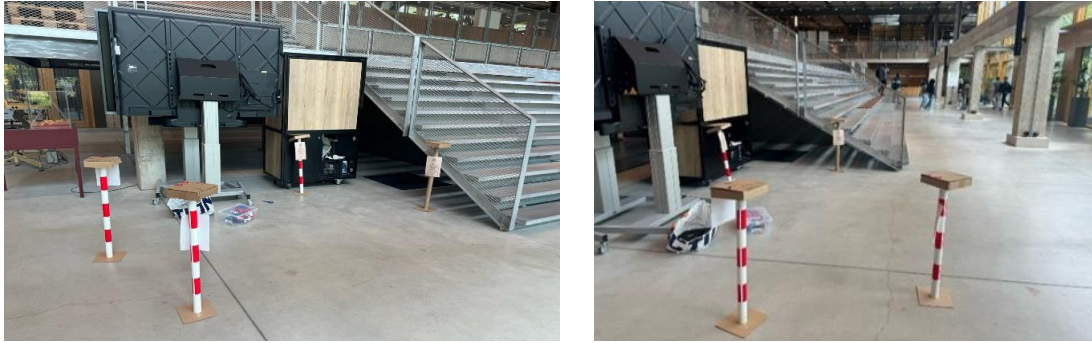


Figure 24: Set-up of the Mid-Fi evaluations in Langezijds

At the start of the evaluation, I briefed each participant on what my thesis was about and what I had created. After they signed a consent form, I encouraged them to freely explore the buttons. I stayed close to them in case the pillars became unstable due to the button presses. It was clear that the pillars struggled to remain balanced as some had to lean against constructions to remain standing. Once they had tried out each feature, I conducted interviews using the questions listed in Appendix 5 and documented their answers in Appendix 6. The answers will now be analysed and discussed.

#### *5.4.4.1 Design*

The main concern during the evaluations was the stability of the poles. Three out of five participants liked the design of the poles, appreciating its simple appearance. Four out of five liked the height of the poles, while one preferred a lower height. However, during the memory game, I observed that it was difficult for the participants to see the displayed colour when the poles were far apart. Despite enjoying the height for pressing, practical concerns were noted. Upon discussing this with the participants, one suggested making the poles adaptable in height to accommodate both taller and shorter individuals.

Regarding the placement of the instructions, all participants found it most convenient to have the instructions as close to the button as possible. Four out of five found the instructions unclear, suggesting that more text was needed to explain the context and how to interact with the buttons. Interestingly, three out of five participants pointed out the omission of certain words to shorten the text. One out of five had no problems with the instructions. The textual part of the instructions was the most confusing, while the bottom part with only an illustration received fewer comments. Two out of five preferred verbal explanations over written ones for more detailed information. However, the other three participants did not pay much attention to the instructions, as they preferred relying on verbal explanations provided by me. Therefore, either a lengthier explanation was needed, or the instructions should be delivered verbally.

#### *5.4.4.2 Sounds*

The selected sounds were enjoyed by all participants. One person suggested that the sounds might motivate people to be more engaged. Two participants made noteworthy comments about the pieces. They suggested that exploring different music styles based on the target group could be something to consider. They highlighted that using music from the cultures of those with an immigrant background might make them enjoy it more or be more involved. They also jokingly suggested changing the wrong sound to a different genre like techno to make it more obvious that a mistake was made. Additionally, they recommended trying out different kinds of non-musical sounds, such as traffic or animal noises. However, the suggested sounds did not align with what was found during interviews so it will not be implemented for the Hi-Fi.

#### *5.4.4.3 Experience*

The feedback from participants indicated that the prototype was perceived as primarily intended for older adults. Two out of five participants believed that individuals aged 20 to 30 would perform better with it, while one noted that younger demographics might have superior memory skills. This response indicated a sense of insecurity about their own abilities, but they were still willing to interact with the buttons, suggesting that this insecurity was not a significant barrier. This finding aligns with the literature on low self-efficacy. Notably, the same participant believed self-efficacy would increase after using the prototype at least twice.

Regarding the game's design, four out of five participants would not change the core game itself. However, one participant suggested incorporating more variety, such as pairing sounds instead of colours. Additionally, all participants commented on the buttons. The blue buttons used during the Mid-Fi evaluation had issues registering presses, which diminished the experience. These will not be used in the Hi-Fi evaluation.

Opinions on the game's difficulty varied. Two out of five participants found it to be of low difficulty, one was sceptical about using technology to increase PA, and two felt it might be too complex for the older age range of older adults. Despite these concerns, three out of five participants indicated they would place the prototype in front of or in a nursing home, while the remaining two suggested placing it outdoors. Thinking of the former location, it was a good finding because even though the target group is 60 and above, knowing that people see this as something for those in the higher age range, can mean it either needs more challenges added to it as those products can be seen as simple, or the target group should be adjusted to focus on the older range. Additionally, all participants liked the concept, with two specifically enjoying the searching aspect of the prototype. Only one participant expressed that they see themselves using it as it can assist in more PA, although all recognised its potential benefits for others. The rest felt they were already active enough and preferred different challenges than those offered by the prototype.

When asked for suggestions for improvement, two out of five participants recommended adjusting the positioning of the pillars, while another two suggested adding more variety by incorporating different sounds. Specifically, four out of five participants saw the repositioning of pillars as a positive change that could enhance the game's difficulty. While observing some participants, I noticed that when one button was pressed and its pair was being sought out, the button would sometimes time out and return to a clear state. This meant that a timer should be added to the code so that users have enough time. The users that had this happening did not look at the first button anymore after pressing it, so they would not notice it. Them not looking at it can mean that they expect a sound to come after pressing the second button, only for it to not happen as the code now only registers one button being pressed.

The objective of fostering social interactions appears to have been met successfully, as all participants viewed the activity as most enjoyable and motivating when done with others. Social interactions were deemed as important for a successful intervention, hearing users say this means that the objective was completed.

The results confirm that the thesis is headed in the right direction because the participants recognised the potential in the way I have attempted to increase PA. They all mentioned the importance of doing this together with others, which highlights the social aspect. The evaluation has also identified areas for improvement, including the stability of pillars, more reliable buttons, clearer instructions, and a larger play area. All these improvements will be incorporated into the Hi-Fi prototype.

## Chapter 6 – Realisation

After receiving feedback on the Mid-Fi prototype, it was time to create a Hi-Fi prototype using those comments. Changes to the code were made to implement more features. The pillars used before were abandoned and a new design was created. The goal of the design was to use as little material as possible due to cost restraints, so the original concept was also abandoned as it did not fit on one plywood plate of 1200x600 millimetres. This meant going back to the drawing table. After completing the design, the two interviewees who were open to future involvement were later asked what design they liked more. Besides the design, the instructions had to be changed as well. Starting from scratch, a new design was made and evaluated by the same interviewees in two different ways. The code used was also altered based on observations. I will now go into more detail about the design aspect and code of the Hi-Fi.

### 6.1 Code

The code used for the Mid-Fi prototype was slightly altered to implement the required changes found during the Mid-Fi evaluation discussed in 5.4.4.3. The game itself was untouched, the same goes for the sounds. The reason behind that is that both received positive comments, so they were kept the same. The game was linked to older adults in nursing homes, which falls under the target group, so the game was seen as successful. The sounds were perceived as enjoyable, so no changes were made.

The changes to the code were minimal, a schematic is displayed in Figure 25 illustrating how the system works. A new feature was added to the buttons, namely instructions. The instructions on paper seemed to not be enough for the target group to understand what is going on. More information was desired, and most showed a preference in a verbal explanation. This is also more helpful for those who struggle with reading. Also, I expect that when the buttons are placed somewhere, those who enjoy exploring the unknown rather than trying to find information about it first will press any of the buttons to see what will happen. Playing on this possible scenario, introducing them to the buttons and their function seems like an appropriate function for a single press. Users can interrupt the instructions at any time by performing a long press.

The biggest change to the code is the addition of return functions. Previously, the only return function in the system was a long press during the memory game. However, this did not take into account that people can simply walk away without finishing the round. Therefore, the code now includes a timer that keeps track of inactivity. After 60 seconds of inactivity, the buttons return to the neutral state they are in at the start. From the observations during the Mid-Fi, it seemed as if a timer for the active buttons was needed, however, when trying to develop the code, it was found that the buttons remained active for almost two minutes. So, the timer was not added as it was deemed as long enough in-between-button interaction. Finally, when long pressing the button from the default state, that button will turn purple, based on the colour used in the written instructions. Only the pressed one was turned purple to clarify the input was done correctly and sound is coming from that button.

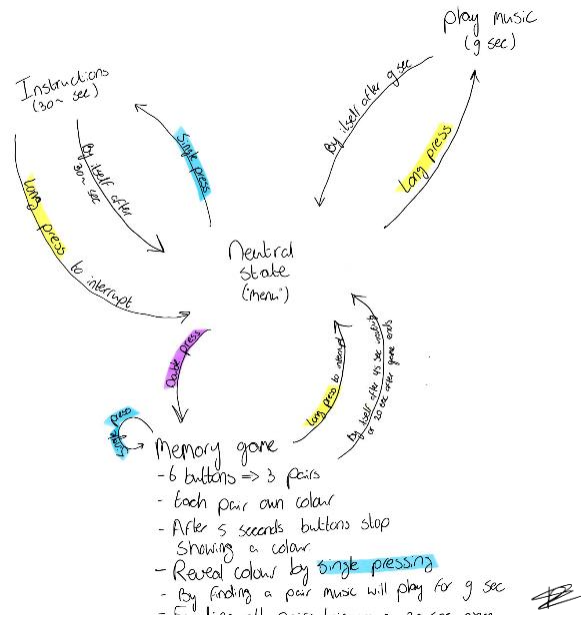


Figure 25: Schematic of how the system works

## 6.2 Design

As mentioned before the design was adapted in this stage of the project. The goal was to get as many pieces as possible to fit on one plate of 1200x600 millimetres. The reason why I wanted to laser cut it was that it would guarantee identical parts, and it is rapid and accessible. The first step for that was to change the height of the pillar. The Mid-Fi prototype was 86 centimetres, which was well-liked by the participants but in the scenario of placing the pillars far away from each other is not practical as the top of the buttons would not be visible. Therefore, it had to be lowered regardless of it being well received. During the interviews participants found the table height an appropriate height for the pillars, so with that in mind the lower range of the average table height, 73 centimetres [60], was used. This height also possibly allows for a new side-user, people in a wheelchair. The width of 21 centimetres remained the same.

Identifying what kind of shape would require the least material, the idea of having parts intertwine with each other to construct the base came into existence. Having identical parts connect can reduce the material depending on what they look like. The main inspiration for the design was the shape of the X chromosome. However, I wanted the legs to intertwine instead of a flat version. This shape was chosen because I expected the connection in the centre would reduce horizontal movement, and with the legs being spread out further than the centre, most of the mass is moved away from the centre, decreasing the chances of buckling. Additionally, this shape provides a place for the instructions due to the straight lines at the start of the legs, this is ideal as the Mid-Fi prototype evaluations showed that the instructions should be as high as possible. The development of the design is seen in Figure 26. The design was slightly altered after discussing it with my supervisor and a tech team employee from Designlab. Following their advice, an edge joint was added to the top and bottom of the legs to make the design more stable. This leg part was 52,50 millimetres wide, and the edge started after 10 millimetres making it 32,50 millimetres long. The width of 52,50 millimetres came into existence after halving the 210 millimetres of the base. Wanting to mimic the shape of an X chromosome, the 105 millimetres was also halved to have sufficient space for a slope.



To get the part to intersect, a cut was made in the middle of the leg part. The size of this cut was 8 millimetres as the wood that was going to be used was 4 millimetres thick, meaning that it should fit seamlessly.

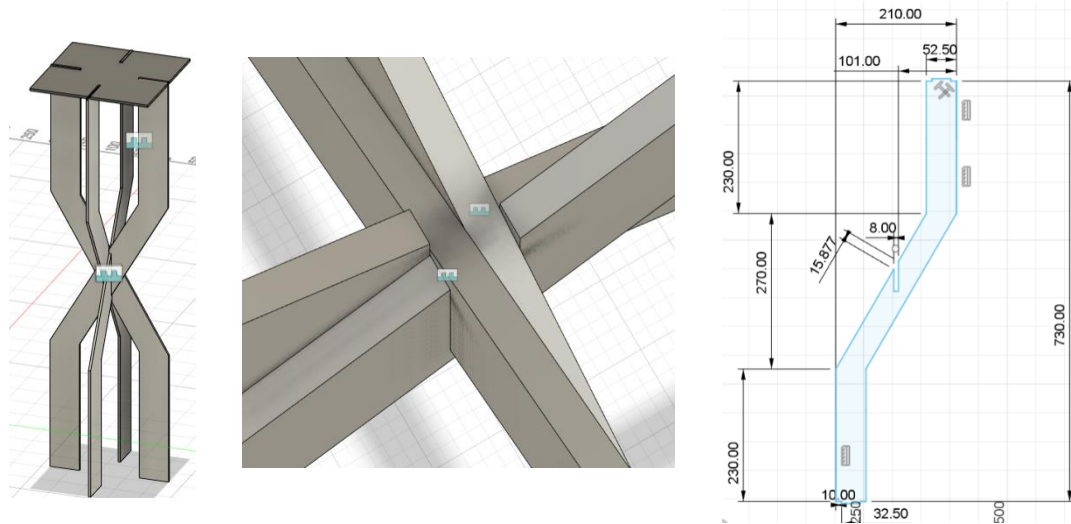


Figure 26: The development of the design on Autodesk Fusion

The base remained the same size 210x210 millimetres, as it was in the Mid-Fi prototype, however, cuts were added to accommodate the legs. These cuts were the same size as the edge joints. Figure 27 shows the sketch of the base used. Initially, only a top base was going to be made to save materials, however, a Tech Teamer recommended adding a bottom base to add sturdiness. So, to accommodate this the same design was used. This means that even though the structure exists out of 6 parts, only two of them had to be designed.

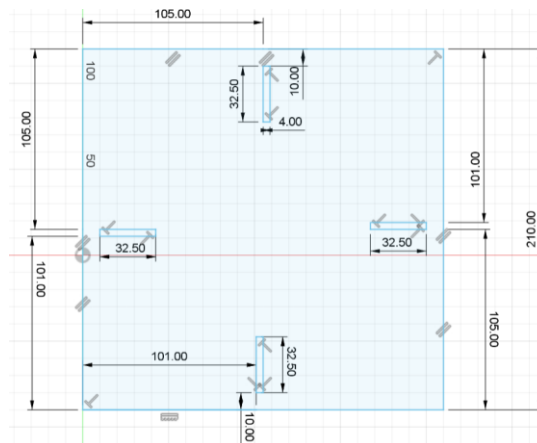


Figure 27: Design of the base shown on Autodesk Fusion

### 6.2.1 Instructions

From the Mid-Fi prototype, it was found that users like it to be more descriptive. Before making changes, the instructions used during the Mid-Fi evaluations were shown to two peers to gather how they would change it. Following the advice of my supervisor, I showed them a video of the interactions with the buttons and asked them to explain to me what they think is happening. These insights helped with making alterations and using a different design approach.

Inspiration was taken from the Dutch Railway, see Figure 28, as this design is used nationwide it is meant to be easily understandable. An aspect I liked about the design was that it was compact and easy to follow the line. The colours used are mostly taken from the literature research findings. Specifically, the research by Davis et al [40] where it is stated, that green represents a passive state and blue is a low-intensive activity. Purple and orange were chosen because of a colour theory by the Interaction Design Foundation [61], where I took inspiration from triadic and tetradic colour schemes. The definition of purple used by Adobe is creativity [62]. According to Adobe [63], orange can be used to grab attention while exuding positivity. Additionally, these colours complimented the other colours, resulting in the colour scheme used for the instructions. A beige colour was used for the background to represent a light wood colour. Besides that, using such a soft colour made the other colours stand out more.



Figure 28: Picture of a train route map by Dutch Railways taken at Almelo Central

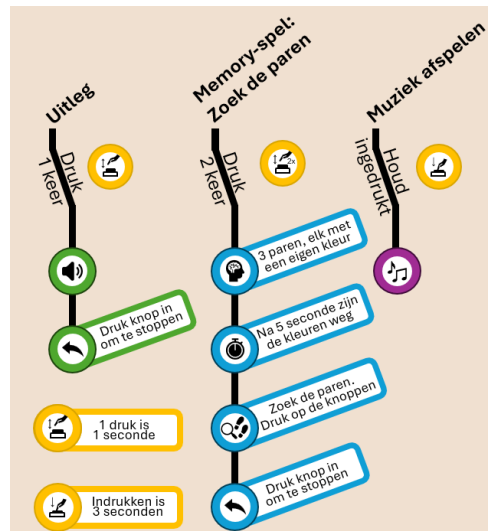


Figure 29: Instructions created for the Hi-Fi prototype

Icons were used in the design as it was found in the Mid-Fi evaluations that users found that aspect of the instructions the clearest. So, to enhance the text, an accompanying icon was added. After finishing the design, the aforementioned participants were asked to give a cognitive walkthrough of the instructions. This was done by presenting them with the instructions and one of the interactive buttons, followed up by tasking them to go through each bracket by reading them and explaining what they understood from it. So, for example, starting at the green bracket the participants were asked what they see, what they think happens after pressing once, what the icon represents, what the text box is explaining, how they think they should interact with the button, if they can show on the button what they would do with it after having read a particular section, and what they think happens when the button is long pressed after pressing once. Each bracket was treated the same.

Lazar et al. [64] state that data gathered from this method assist in getting an idea of how users can interact with or process the information. This data was used to make appropriate changes such as simplifying the text, increasing the font size, and using a different colour for the explanation of what a single and long press entails.

Having completed the written instructions, it was now time to create a verbal one. For this, the description given by my peers was used as a base with slight changes to simplify it. Eventually, two versions of the script were made. They were both evaluated through a cognitive walkthrough with the same participants involved in the written instructions. There was no indication that being involved in the written version was influencing the results of this cognitive walkthrough as both participants still appeared to be struggling with understanding and no comparison or reference was made by them at any point. The format of this walkthrough remained the same. These sessions were a day apart to give the participants time to forget about the written instructions. Each section in Figure 29 was written out in bullet points and read out loud by me. After reading out one bullet point, the participant was asked to explain what I told them and what they think they should do with the button. They were free to interact with the button however they wanted to. This continued until the end of the bracket, where I asked them to explain the whole process of what happens when you, for example, do a double press. Recognising that they found the sentences long and requested me to repeat what I said, resulted in a more simplified version of the script, with examples added to parts of the memory game to add clarity, see Appendix 7 for this script. A more positive reaction was given to this version of the script, but the participants associated the colours used in the examples with the colours of the written instructions. To avoid this, it was explicitly added in the script to announce which coloured bracket was being looked at, and the colours were changed to those not used in the written instructions.

### 6.2.2 Creation of the Pillars

The building started by making a small model of the legs to see if the structure worked, this is displayed in Figure 30. This helped confirm that the connection system was functional. Afterwards, the building began by laser cutting the parts, this process is shown in Figure 31. Once putting one together it was found to not be as stable as expected with a button press making the structure shake. After discussing potential solutions with the Tech Team, wooden beams were added for extra support. Using the shape of the pillar, they were placed at an angle, making it look like an hourglass. Four beams were added to each pillar, requiring 24 wooden beams in total for all six pillars. Three out of six pillars were painted with the plan being to give them a dark brown colour to have a rustic appearance. However, not enough yellow paint was available, so instead of getting a brown colour, a purple-toned brown was used instead. See Figure 32 to see the full process. The decision to paint this number was to replace the design choice made with the Mid-Fi prototype where the top base had patterns that connected with other top bases. This was replaced as observations showed users not noticing the patterns as they were more focused on what the button was doing. So, giving the entire pillar a different look through paint, was the approach taken to determine whether people notice it more. Figure 33 illustrates how users could place the pillars if they would move them to put them together. Figure 34 shows all of the pillars placed in an oval shape, which was mentioned by some participants during the Mid-Fi evaluations as a preferred placement.



Figure 30: Paper version of the legs

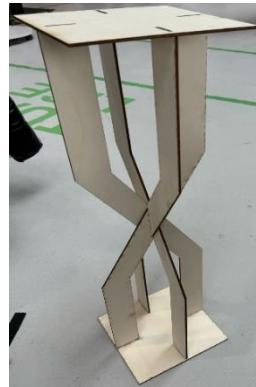
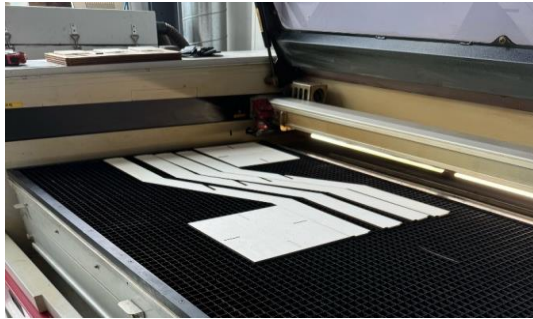


Figure 31: Building process of the first pillar

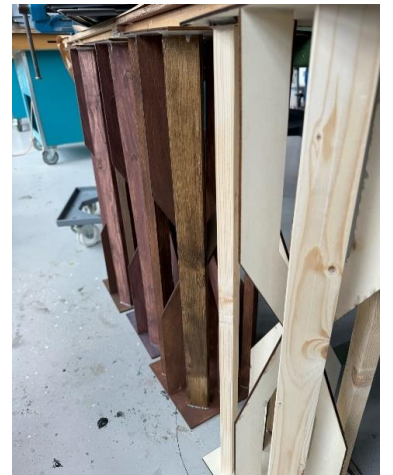


Figure 32: Pictures showing the process of building the Hi-Fi pillars



*Figure 33: Top view of the pillars and how they can be placed if put together*



*Figure 34: The finished six pillars*

## Chapter 7 – Evaluation

After completing the ideation, specification, and realisation phases of the Creative Technology process, it is important to evaluate the outcomes. This chapter will provide detailed discussions regarding the evaluation and its results.

### 7.1 Execution

The Hi-Fi prototype was moved from Designlab to Winkelcentrum Zuid to set it up there. Chapter 2 observations indicated that it was in close proximity to facilities visited by the target group, so a high number of potential participants was expected. The evaluation was completed with the assistance of my peers Natalia Bueno Donadeu and Inez Rommes. They were present during every session, helping with observations and transportation. Three sessions were planned: one in the late afternoon from 15:00 to 16:30, one in the early afternoon from 11:30 to 13:00, and one between 13:30 and 15:00. Setting up outside revealed that the buttons are better used indoors as all functionalities can be utilised there, while the LEDs were not visible due to sunlight. After this realisation, the pillars were moved indoors. The first session was conducted indoors, the second session was conducted both indoors and outdoors, and the third session was held outdoors outdoor setting. The reason for this decision was to analyse how environmental factors influence prototype interaction frequency.



*Figure 35: Pictures of the Hi-Fi prototype evaluation set-up*

#### 7.1.1 Participants

The prototype was presented to individuals passing by or those who stopped to engage with it. Participants were chosen based on their age, with those under 60 being informed about the research if they expressed interest, but no data was collected from them. Once people were informed about the target age group, they verbally indicated whether they belonged to it, which helped in filtering out potential users. Five participants were found through this. The duration of participation was between 5 and 15 minutes.

In addition to the settings depicted in Figure 35, the two interviewees who expressed interest in future involvement were also asked to interact with the buttons. However, the pillars were not included in this session, so the interactive buttons and instructions were the only physical components they had access to. The setting was indoors, with the buttons placed on an oval dining table. They were shown the pictures from Figure 35 so they could answer all questions. This increased the total number of participants to 7, with the ages ranging from 60 to 83.

### 7.1.2 Encountered Problems

During the evaluation, several problems were encountered and dealt with accordingly. The first problem was with the LEDs, as mentioned earlier. The second issue was that the buttons would sometimes disconnect from the network while running the code, leading to all the buttons not running the code anymore. To re-run the code, all six buttons had to be connected to the dongle used for the network. The third problem was my laptop crashing on multiple occasions due to problems with the motherboard, increasing the instability of the buttons. Two solutions were considered: running the code through the laptop of one of my peers and conducting observations without the code running, as stopping to interact is data by itself. Unfortunately, running the code on a different device solved the third problem, not the second one. When participants interacted with the buttons, they were approached to inform them that it was not functioning as it should and whether they were interested in answering questions regarding the concept. Eventually, a video was made of Inez Rommes performing the interactions with the buttons to showcase what the prototype is capable of, which was shown to participants when the buttons were not running the code.

## 7.2 Results

### 7.2.1 Observations

The observation results consist of notes made by my peers and me. These notes are based on observations of approximately 60 people, not just the seven participants.

Initially, people's reactions were curious but not enough to engage with the prototype. This was evident in two ways: some people stood still to watch us set up but did not approach or interact, while others who did inquire about it lost interest upon learning it was targeted at older adults. A few individuals even felt insulted, insisting they were active enough and did not need it. Additionally, those with physical issues, such as leg problems, saw themselves as unfit to participate, highlighting the varying levels of physical well-being. This variation was also apparent in their physical appearances, with some looking significantly younger or older than their age. Despite the low-intensity nature of the PA involved, the target group displayed low self-efficacy, perceiving themselves as incapable of participating. Language barriers also deterred some individuals from engaging with the prototype.

Reactions to the memory game were mixed; some people were hesitant upon learning the objective, while others saw it as a positive challenge. The idea of a 5 to 10-minute interview was generally met with negative responses, with many unwilling to participate due to the duration.

Finding participants for the evaluation proved more challenging outdoors, as people were less inclined to stop and inspect the prototype. Indoors, interactions were minimal; an estimated 1 in 20 people interacted with the buttons, while about 2 in 10 read the instructions before moving on. Outdoors, people either avoided the area or merely glanced at the prototype without stopping. Observations showed that those who interacted with the buttons often mistook them for a touch screen, expecting a response when they tapped them. Passersby were sometimes overheard discussing the installation, but these conversations typically did not lead to further exploration.

One person showed more interest after seeing someone long-press a button to play sounds, suggesting that observing others could increase the likelihood of engagement. When people declined to participate, it was usually due to health concerns or a belief that they were already active enough. This suggests that individuals who are already active may be resistant to adopting new forms of PA, feeling content with their current routines.

### 7.2.2 Interviews

The interviews conducted followed a structured format with 11 questions, which are listed in Appendix 8. This section will present the interview results, based on the findings outlined in Appendix 9.

The interview began by asking participants which age group they thought was suitable for the intervention. Four out of seven participants envisioned older adults, two out of seven said it was suitable for all ages, and one out of seven found it suitable for teenagers and up. When asked whether they would have stopped to interact with the prototype if not approached, six out of seven said they would have kept walking, while one said they would have lingered out of curiosity.

Of the six who would have kept walking, three said they felt no motivation to interact with it. Two assumed it was an art piece and were unsure if they were allowed to touch it, fearing they might break it. One participant was uncertain if it was okay to interact with it and said they needed someone affiliated with the prototype to confirm it was okay to use. Other participants suggested that adding a sign encouraging people to try it or displaying the University of Twente's name would increase their motivation. However, those who preferred personal interaction said they would not see themselves as the target audience if only a sign was present.

When asked about their experience and overall thoughts on the intervention, 6 out of 7 participants were enthusiastic about the sounds, noting increased interest in the prototype after hearing them. One participant found the music acceptable but not motivating enough to interact with the prototype. The buttons received mixed reactions: 3 out of 7 participants found them challenging, while another participant, who claimed the buttons were easy to use, visibly struggled with getting the button to register a double press. One participant remarked that the buttons looked futuristic.

The game was liked by 6 out of 7 participants, with one participant indifferent but not suggesting any changes. Participants responded positively to the sounds during the game and appreciated that it was a cognitive challenge. The design was well-received, with compliments on the pillars and instructions. Five out of 7 participants found the written instructions clear.

Regarding potential changes, 5 out of 7 participants said they would not change anything. One participant suggested changing the layout, and another recommended that all buttons should turn purple during a long press, instead of just one. Additionally, they suggested making the buttons easier to press.

All participants praised the initiative, with 5 out of 7 explicitly stating that walking was a good PA to focus on, as it is a common activity. They saw this intervention as having potential. Two participants mentioned that its effectiveness is tied to intrinsic motivation. When asked about the amount of PA required, all participants said it was acceptable. One added that any PA is a good start, so even though this intervention does not greatly increase PA levels, it is a good beginning. Participants recognised it as a low-intensity activity, making it, according to them, suitable for older adults. One participant stated that while it would not significantly increase their PA, it was sufficient. Another participant believed it could help increase PA because it is not perceived as a workout, requiring only walking and pressing buttons.

When asked if they would use this intervention themselves, 4 out of 7 participants said they would. However, one of these participants said they would only consider it if they saw someone else using it. Another participant thought it was more suitable for their age mates. Those who did not see themselves using it felt they already had enough PA.

Regarding the social aspect, 4 out of 7 participants firmly viewed it as a group activity, while two others were open to the idea. One participant did not consider doing it with others. Some participants



mentioned that even though they saw it as a group activity, it would depend on the group size at the time.

Asking about whether participants would move the pillars, 4 out of 7 participants said they would, to adjust the difficulty level. Two recommended placing the pillars closer together to make the game easier. Another suggested arranging them in a zigzag pattern to create a distinct start and finish point.

When asked about suitable locations for the intervention, 5 out of 7 participants suggested nursing homes. Two also saw it as appropriate for places where games are organised for older adults. One participant thought it would be suitable outside a shopping centre, and another suggested residential areas.

## 7.3 Reviewing Specifications

Having completed the Hi-Fi prototype and its evaluation, it is now time to assess how well the requirements set out in Chapter 5 were implemented. Starting with the functional requirements before touching upon the non-functional ones. The Moscow method was used to form requirements, the same order will be used for this review.

### 7.3.1 Functional Requirements

#### 7.3.1.1 *Must*

Starting with the *Must*-requirements, all 11 were successfully met. Requirement 1 was fulfilled by using all three possible input methods with the interactive button. Each input method triggered changes in the button, such as colour changes in the LEDs and occasional use of the speaker, meeting requirements 2, 3, and 9. Requirement 4 was satisfied in multiple instances, with the system returning to its default state after a long press or during inactivity in an active game. Requirements 5 to 11 were fulfilled through the game's key functionalities.

#### 7.3.1.2 – *Should*

Two out of three *Should*-requirements were met. User evaluations revealed that users enjoyed the sounds, meeting requirement 12. Additionally, the buttons react to interactions, fulfilling requirement 13 for a clear distinction when an interaction occurs. However, requirement 14, which states that the prototype should offer users a cooperative game, was not completely met. While the game can be played alone, the majority of users preferred to play it with others, creating a cooperative experience

#### 7.3.1.3 – *Could*

There were two *Could*-requirements, and both were met. Users have access to two activities, or three if listening to instructions is counted as an activity. Three music pieces were used, meeting requirement 16 which states more than one song could be used.

#### 7.3.1.4 – *Will not*

The *Will not*-requirement of not distinguishing between users was also met as the system does not do so.

### 7.3.2 Non-Functional Requirements

#### 7.3.2.1 – *Must*

Five out of 7 *Must*-requirements were met. Each pillar has instructions within half a meter, meeting requirement 1. The measurements and weights of the pillars and buttons fulfil requirements 3 to 6. Specifically, requirement 6 is met due to the low weight of the pillars and buttons. However, requirements 2 and 7 were not fully met. Requirement 2 aimed for a simple appearance, but participant feedback indicated the prototype was sometimes perceived as art, achieving a modern look instead of a simple one. Requirement 7 could not be fully evaluated due to a lack of autonomous use by participants.

Those who did use the prototype found it easy to use, but it remains uncertain if this requirement is fully met.

#### *7.3.2.2 – Should*

Out of the four *Should*-requirements, two were fully met. Requirement 9, which states that multiple prototypes should be able to be placed next to each other, and requirement 11, focusing on the sturdiness of the prototype, were successfully achieved. Requirement 8 was partly met, as the five participants in the Hi-Fi evaluation all noticed the prototype but did not choose to interact with it. This indicates that while the prototype catches people's attention, it does not necessarily engage them as users. Requirement 10, regarding the distinguishability of the prototype, was also partly met. Although the poles currently have four different colours, one colour is used three times, making only half of the pillars easily distinguishable from each other.

#### *7.3.2.3 – Could*

One out of three *Could*-requirements was met. One out of 7 participants moved along to the music pieces, demonstrating that users can be stimulated to dance, indicating potential in this area. However, requirement 13, which called for music-related attributes in the design, was not met. Additionally, no extra LEDs were added, leaving requirement 14 unmet as well.

#### *7.3.2.4 – Will not*

All *Will not*-requirements were met. None of the participants reported feeling overwhelmed by the information during the evaluations, and no one found the experience physically challenging.

## Chapter 8 – Discussion & Future Work

The Creative Technology process by Mader and Eggink is concluded following the evaluation in Chapter 7. Now, it is time to reflect on the process used to develop the prototype and review the progress of the thesis. This chapter will elaborate on the findings, assess the effectiveness of the applied methods, and discuss potential future improvements.

### 8.1 Review of the Methodology

#### 8.1.1 Ideation

Throughout the ideation phase, various methods were used to gather potential ideas.

##### *8.1.1.1 Iterative Bias Mapping*

Embracing the, for me unfamiliar, target group was the main focus of this phase. One of the methods was a self-conceived approach named Iterative Bias Mapping. This method aimed to understand how I viewed the target group and whether this was biased or not. Being positively or negatively biased could hinder the generation of potential ideas, so knowing my stance was important to avoid dismissing ideas because of an assumption about the target group. Since I was not familiar with the target group, jotting down my thoughts about them helped me comprehend my standpoint as someone designing for them.

Another Iterative Bias Map was created to compare my initial view of the target group with my updated view after completing Chapter 2. This comparison allowed me to perceive the changes in my perspective about the target group, providing a better foundation for my understanding. This step contributed to my growth as a designer, enabling me to be more aware of the actual characteristics of my target group. Once this was established, I focused on how to utilise the buttons to achieve the goal of increasing the physical activity of older adults.

##### *8.1.1.2 Role-storming*

Role-storming was another useful part of the ideation process, as it led to the idea of adding instructions for each pillar. This highlighted the significance of clear and concise instructions and demonstrated their potential to either make or break the project, as overly long or unclear instructions would be dismissed. This would not have been found during interviews as it was not mentioned by participants or me. This could have been brought up if there was a question related to what a must-have is in a game for the target group.

##### *8.1.1.3 Interviews*

Conducting interviews with students who had previous experience working with older adults, as well as with older adults themselves, proved to be fruitful. I gained valuable insights into working with older adults, including their limitations and the perspective needed. This, in turn, assisted with the subsequent interviews with older adults. For example, I drew out ideas to potentially help them envision the approach I was considering, and the interview was made to be semi-structured in case the conversation went in different directions than planned. These interviews provided a wealth of insights into older adults' preferences, serving as a guide throughout the remainder of the thesis. While creating the Mid-Fi and Hi-Fi prototypes, I continually reflected on the responses from these interviews to assess whether they would be well-received.

##### *8.1.1.4 Tinkering*

The tinkering session helped me understand the buttons and their potential. Looking back, another similar session after learning the basics of how to code the buttons could have potentially led to more diverse ideas for the game. So, sessions focused on the interactive buttons were valuable not only for developing an understanding but also for generating ideas.

#### *8.1.1.5 Final Concept*

The final concept stemmed from filtering ideas based on the feedback of the interviewees, making them indirectly involved and attempting to create something they would like. In hindsight, older adults could have been approached to ask their opinion on the game and what should be added to it or changed. This was done in the Mid-Fi prototype evaluation, but the concept was considerably worked out at that point. So, having a session with older adults where they were presented with the buttons and some features of the button functioning, such as the speaker and changes in the LEDs, could have brought more insights.

Two of the interviewees were asked about their opinions on the poles and the sounds, but this sample size could have been larger. Four out of the 6 interviewees were presented with established ideas of what the game would look like, but there was no actual input from them apart from stating whether they think they would enjoy it or not. A better approach would have been to present multiple ideas of what the start, middle, or ending of an activity could look like, and letting the target group fill in the blanks. This could be achieved by asking questions such as "What do you want to happen here?", "If you do this, what happens then?", or "What would the process look like if you want to reach this point?". An example would be giving them the start of a game and an ending and asking them to imagine what happens in between.

Taking inspiration from existing board games that were popular with the target audience was a helpful starting point. The goal was to take something familiar and present it in a new way, allowing people to recognize it in a different context. Although "memory" is a classic game, it still needed to be explained to the target audience. However, it's possible that the need for explanation was due to the fact that technology was used to replicate the game since no one seemed surprised or unfamiliar with it.

#### *8.1.2 Specifications*

One of the key aspects of the specifications was defining the goal of the intervention. This involved articulating the purpose and desired outcome of the design project. The specifications also detailed the design itself, describing the intended visual and functional aspects of the system, including user interactions and a description of the system.

##### *8.1.2.1 Goal Definition and Initial Design*

The design evolved significantly from the initial concept shown in Figure 16, primarily due to cost constraints encountered during the building phase. To deal with these constraints, existing stanchions were used, which greatly influenced the design. Although cardboard could have been used to achieve a similar appearance to the initial concept, it was deemed more valuable to invest time in developing the buttons rather than the pillars. The evaluation goal was to determine whether the target group thought my approach for increasing PA had potential; thus, the design of the pole was not expected to significantly influence their opinion. Comments about the pole during the evaluation were acknowledged by explaining it was a prototype. The focus remained on the game and the overall experience.

##### *8.1.2.2 Functional and Non-Functional Requirements*

Functional and non-functional requirements were also included in the specifications. Functional requirements outlined the specific features and functionalities that the system should have, while non-functional requirements focused on aspects such as usability and accessibility. The requirements served as good baselines, and efforts were made to adhere to them, eventually fulfilling most of them. Of the functional requirements, 16 out of 17 (94%) were met, which was expected as most requirements were based on the game. To reach 100%, a cooperative game would need to be developed, involving events in the game that cannot be perceived by only one player. For example, using the "blink" command of the button can present challenges on its own with this particular target group. Additionally, adding more

buttons to the game can make it more difficult for one player to keep track, potentially making the game more enjoyable in a cooperative setting. These are speculative ideas.

The non-functional requirements were less successfully followed, with 10 out of 16 (63%) being met. Again, the number of requirements could have influenced this percentage. The *Must*-requirements were met with 5 out of 7 (71%), indicating an effort to achieve the design guidelines. A simpler shape for the pillar could have increased the percentage. However, the shape of the Mid-Fi and Hi-Fi were well-liked by people, even though they were not motivating. Additionally, incorporating musical elements could have impacted the first percentage as well. Post-evaluation, it became apparent that requirements related to motivators should have been established. While two requirements focused on motivators were present, it was evident that this was not sufficient.

#### *8.1.2.3 Prototyping*

The Mid-Fi prototype addressed the design, sounds, and code of the system, allowing verification of the approach's appropriateness and potential effectiveness. There was no Lo-Fi prototype, which might have influenced the final outcome. A Lo-Fi prototype could have been developed with the target group using Post-it notes or other paper forms to mimic the memory game and gather feedback on their experience. This might have pushed the project in a different direction. However, positive reactions to the game in both the Mid-Fi and Hi-Fi evaluations suggest that the ideation phase was well-conducted, as the concept was well-received. A Lo-Fi prototype could have provided additional insights, either justifying the concept or identifying necessary changes.

#### *8.1.2.4 Evaluation Outcomes*

The Mid-Fi evaluation showed that participants enjoyed the prototype, with all of them recognising its potential to assist older adults in increasing their PA. Of the five users, only one had a low SES background, and their answers differed somewhat. It cannot be assumed that the four participants' experiences or health would mirror those from a low SES area, meaning their answers might not fully represent the target group. The answers might have differed if all five users were from a low SES area. Comparing the answers revealed some similarities in opinions, but the proportion of 1 to 4 is too small for a proper comparison. It was interesting to see that participants liked the game and found searching for pairs the most enjoyable aspect, justifying the concept and leading to only slight tweaks for the Hi-Fi version of the code.

The evaluation revealed that participants appreciated having instructions on each pole that was kept with the Hi-Fi. During the evaluation, participants frequently turned to me to ask questions or seek validation. While I did respond to each query, it may have been more insightful to refrain from doing so in order to observe how they would continue their interaction. The issue became apparent when I inquired about the instructions, and it became evident that the participants either did not realise there were instructions on each pole or had not read them yet, possibly because they did not feel the need to look for them as I promptly answered their questions. In the future, it should be a priority to focus solely on observations while participants interact with the prototype.

### **8.1.3 Realisation**

Knowing more about what the target group thought of the concept, how they interacted with it, and what could increase usability, changes were made to the Mid-Fi prototype to create the Hi-Fi version.

#### *8.1.3.1 Code*

The first area of improvement was the code. Based on participant feedback, verbal instructions were added to the buttons, as this was preferred over written instructions. This change was particularly important for participants in low SES areas who may struggle with reading, ensuring the intervention remains accessible to everyone.

Interruptions were also incorporated, mirroring the memory game's existing way. So, participants could use a long press to interrupt the instructions. Although skip functions were not added due to time constraints, they could be a valuable future enhancement. For instance, a double press could jump to the memory game instructions, while a single press could explain how to play music fragments. Introducing such skips could provide a more pleasant user experience by allowing participants to bypass parts of the instructions they are already familiar with. Another potential feature could be a rewind or fast-forward option for the instructions, moving back or ahead by 10 seconds. However, this would need further exploration as only two input methods (single and double press) are available, with the long press already in use.

During testing, it was observed that when the button was in a neutral state and a long press was performed, some participants stared at the button awaiting a change. In the Mid-Fi prototype, the feedback they received was purely auditory, with music playing while the button remained in its neutral rainbow state. For the Hi-Fi version, this was changed so that the interacted button also turned purple. This visual feedback was added to enhance user interaction. While some participants liked this feedback, others suggested that all buttons should turn purple. However, this was a deliberate design choice made in case of playing with two or more people. By having only the interacted button turn purple, other users could see which button was pressed, potentially assisting in the observation that each button plays a different segment. This assumption requires further verification since the game was not tested with multiple participants simultaneously.

#### *8.1.3.2 Design*

Due to cost restraints, the thinnest wood was selected for the pillars. Initially, the designed pillars were unstable. Concerned that this was due to the thinness of the wood, I consulted with a member of the Tech Team at Designlab. They suggested that the instability was likely due to the height of the pillars rather than the thickness of the wood.

To test this, I tried pressing buttons on pillars from a different thesis, and the same instability occurred. Wooden beams were then added to provide a more stable platform for the buttons. This adjustment aimed to ensure that users would not hesitate to interact with the buttons after witnessing the initial instability of the pillars.

Despite these issues, the design of the pillars received praise from peers and the target group. However, some participants expressed hesitancy in interacting with the prototype, fearing they might break it and be held responsible. This feedback suggests that the pillars did not appear sturdy enough for the target group. To address this, a simpler design could be considered. Additionally, engraving "Press me" around the base beneath the button could reassure people that touching and interacting with the prototype is okay. I assigned colours to the pillars to indicate how they should be positioned when placed together. While most participants mentioned that they would reposition the pillars, none of them commented on the colours. Therefore, it would have been insightful to ask them to physically move the pillars and observe whether the colours had any significance to them. If not, all pillars can be identical in colour.

##### *8.1.3.2.1 Instructions*

The instructions were well received by the participants. Evaluating both the verbal and written instructions beforehand with two interviewees proved incredibly helpful as it revealed issues with the text and the understanding of the colours. For example, on the left side of the written instructions, the colour green was used. This colour also appeared in the sections explaining what falls under a single press and a long press. During the evaluation, participants thought that these sections were part of the branch due to the shared colour, even though there was no line connecting them. This feedback led to the addition of the yellow colour to clarify the instructions.

The font size was also adjusted based on the evaluation, making it larger for better readability. Asking participants to verbally explain the written and verbal instructions back to me was an effective method for assessing their understanding. Using these revised instructions during the evaluation demonstrated that they were clear and understandable, marking an improvement from the Mid-Fi version.

However, this conclusion cannot be fully confirmed as five of the seven participants were verbally explained how the system works and did not get to try out the prototype themselves—they were only shown a video of it in operation. The other two participants, who had access to both the instructions and the functioning buttons, showed they understood the system, indicating potential in the instructions. The verbal instructions were not tested during the evaluation because, during the setup of the intervention, my peers and I found that the speaker could not play the instructions at maximum volume without distorting the sound quality. The instructions were recorded using an iPhone 15 Pro without anything in front of the microphone, so, the audio clip is clear. Additionally, with the buttons not functioning properly during the evaluation and relying on video demonstrations, five out of the seven participants did not have the opportunity to try these instructions. The two participants who had access to the verbal instructions also found it difficult to hear them clearly.

To further validate the instructions, a similar method used for the Mid-Fi instructions could be applied here to see if users can operate the buttons without my presence. Additionally, with the inclusion of verbal instructions, another test could be conducted. This test would involve three groups of the same number of users: one group with access only to written instructions, one with only verbal instructions, and one with both. This approach would provide insights into which type of instruction is more effective.

## 8.2 Key Findings and Insights

The evaluations revealed that while participants liked the initiative and were open to it once informed, several factors hindered initial engagement. The intervention aimed to increase self-efficacy by providing constant access to instructions, but this proved insufficient. The reluctance to engage stemmed from perceptions that the prototype was not meant for them, concerns about physical capability, and not knowing enough Dutch. Participants with physical issues or low self-efficacy were particularly hesitant, highlighting the need for assuring them they could participate. Those who felt they were already active did not see themselves as suitable for the intervention and showed no interest. This suggests that active individuals may avoid adding new activities to their routines.

Two participants mentioned they would consider using the intervention only if they saw someone else using it first. This aligns with findings from the literature review and was also observed when a passerby stopped to interact with the prototype after seeing someone else perform a long press to play sounds. This raises the question of whether the intervention is more effective if it is done under the supervision of someone affiliated with older adults or games to introduce the intervention to them.

Reactions to the memory game were mixed. While some participants found it a positive challenge, others were hesitant. However, the game was generally well-received for its cognitive challenge and design. The intervention was also seen as having potential for social interaction, with most participants viewing it as a group activity. These participants added that doing it together is more fun, showing the importance of a social aspect. It was evident that the favourite part was the sounds for most of the participants. They seemed to excite participants which means they were well selected.

The setting significantly affected participation rates. People were less inclined to stop outdoors, while indoor interactions were slightly more frequent but still limited. Only about 1 in 20 people interacted with the buttons indoors, and even fewer did so outdoors. However, different locations should be tried out to confirm this.

### 8.3 Challenges and Limitations

It was challenging to get the buttons to function properly during the evaluations. Although the buttons seemed to be connected to the network, they were not always picked up by the dongle. Even when they were initially picked up and the code was running, they would sometimes disconnect, causing interruptions in the evaluation process. This was time-consuming and inconvenienced potential participants. For example, one person who wanted to try out the prototype was unable to do so because of this problem. They eventually left to run errands and returned 30 minutes later, but the issue still hadn't been resolved. Another issue with the buttons was the speakers, which, despite being set at the highest volume, were too weak to play the instructions clearly. This problem did not appear to occur with the music fragments. A limitation of the buttons was that the LEDs were not visible unless they were covered. This issue can be resolved by placing the intervention in an indoor setting or a covered outdoor area.

### 8.4 Recommendations for Future Work

There was potential in the delivered prototype. People were reluctant to engage with it but those who were open to being part of the evaluation all reacted positively to the concept. This means one of the biggest issues this intervention has is the lack of pulling users in. This could be looked into for future research. Most participants of the evaluations found the intervention fitting for a nursing home or revalidation centre, it might be valuable for future work to collaborate with them to be closer in contact with a larger variety of older adults.

The buttons themselves were not difficult to program so in that regard it was pleasant to work with, especially with example code available. However, the usage of these buttons brought a lot of difficulties with it due to the network they were connected to. So, improvements in this area would allow for better usage. Potentially, those who will work with the same interactive buttons could do a test with the buttons before implementing them to identify their limitations and strengths before running into surprises. These tests could be either determining what the distance can be between a button and the dongle before it disconnects or how the button reacts when continuously pressing it.

With 8 colours available, each pillar could have a button showcasing a different colour with each colour starting a different game. So, by pressing the button with a blue LED, game X starts, pressing the button showing yellow, game Y starts. This way multiple games can be integrated on an adjustable scale because of the movability of the pillars.

Feedback from the Mid-Fi evaluation suggested making the poles adjustable in height to accommodate users of different heights, enhancing accessibility and comfort. Additionally, two participants suggested using sounds from non-European origins to make the intervention more inclusive for users with immigrant backgrounds. It was commonly mentioned during the evaluation that variety could be added by incorporating different sounds, not limited to music. Therefore, a system similar to the above-mentioned different game idea could be implemented. The memory game and the rest of the system would remain the same, but pressing a certain colour at the start could determine the language or type of sounds used.



## Chapter 9 – Conclusion

This chapter will conclude the research by presenting the findings of the main research question and the sub-research questions as stated in Section 1.1.

This thesis aimed to create a technological intervention using interactive buttons to assist older adults aged 60 and above with low SES. The challenges faced by this demographic, such as a higher likelihood of depression, accelerated health issues, and cognitive and physical decline, emphasise the need for targeted interventions. Through extensive research and practical application, the project sought to tackle these issues and offer a valuable tool to enhance the quality of life for these individuals.

The aim was to help these individuals passively retain their existing abilities, engaging them in PA without making them aware they are exercising. Walking and dancing were selected as the main forms of PA, as both are considered low to moderate-intensity activities with potential social benefits. Participants saw the low-intensity activity as suitable for older adults and a good start for increasing physical activity levels. Despite initial hesitations, those who engaged with the prototype responded positively. This indicates potential for the intervention if barriers to initial engagement can be addressed.

### 9.1 Research Questions

All the findings were done to answer the main research question, which was:

**How can interactive technology be used to encourage physical activity among older adults in an outdoor setting?**

In addressing this question, the findings of the sub-questions will first be discussed.

#### 9.1.1 Sub-questions – Design

Starting with the design category, where three sub-questions were introduced.

##### **SQ 1.1 How to design technological products for older adults?**

The findings suggest that taking a user-centred approach is important when designing for older adults. By involving them in the design process, their specific needs can be addressed, and the chances of technology adoption are increased. Making them part of the design process can provide more insights into how to tackle issues that may not be considered by designers from different age groups. When designing a product they would want to use, their voice should be incorporated into it. One important insight is their decline in both physical and cognitive abilities. Research suggests older adults prefer retaining their abilities so assisting them in doing so can be appreciated by them.

The challenges older adults face when adopting technology have to be understood and their learning curve should be made low. Bringing in familiarity and considering their previous experiences can help reduce the learning curve and improve acceptance. However, during the evaluations, it was found that providing instructions in both written and verbal form, to make it easy for them to use, will not necessarily increase the interest of the target group.

Older adults can feel encouraged to use technology when they recognise the necessity, and the required resources such as time and money, are low. If they cannot see how technology will improve their life, it is unlikely that older adults will see it as worth it to invest their resources into it.

##### **SQ 1.2 What impact does the neighbourhood have on the physical activity levels of older adults?**

Older adults with a low SES background could be relying more on the neighbourhood and what is available there within reach than others in their age group. This means that the design of the neighbourhood greatly impacts them. Having a walkable outdoor environment can mobilise older adults, allowing for more PA. It also plays a role in social cohesion, which is important for older adults' social interactions, given that social interactions conducted by this target group primarily occur within their neighbourhood.

If older adults find their neighbourhood environment enjoyable, they are likely to engage in more PA, making the neighbourhood a potential promoter of PA for them. Providing activities near the homes of the target group can be beneficial, as most PA occurs near them, so, a closer proximity to these opportunities can potentially increase participation rates.

### **SQ 1.3 How can an intervention meant for the improvement of the physical activity of older adults be evaluated?**

The research methods employed in this thesis involved observations and participant recruitment. Both of these methods were considered valuable. Observations provided data on whether the target group would autonomously use the intervention, simulating a real-life setting. Participant recruitment also proved to be valuable in addition to the observation, as it provided valuable data on why the target group was reluctant to use the intervention.

#### **9.1.2 Sub-questions – Behaviour**

The second category focused on the behaviour of the target group and how it can be influenced. This category introduced one sub-question.

### **SQ 2.1 How to encourage older adults to increase their physical activity?**

Both research and evaluation outcomes showed that the effectiveness of the intervention is tied to intrinsic motivation. Firstly, low self-efficacy is an important hurdle to tackle for the target group to engage with the intervention. Interventions should focus on boosting confidence and overcoming self-imposed barriers, such as age-related concerns, to motivate them. This goes back to the user-centred design approach, as this can assist in discovering their motivations, fears, and desires. By understanding and catering to the preferences of the target group, their engagement and enjoyment can be increased.

Another big motivator is the presence of a social aspect, as group exercises can boost motivation and participation longevity. Group dynamics and cohesion foster a sense of community, enhancing the willingness of older adults to engage in PA. However, maintaining the activity levels of older adults requires more than just social interaction. Instant gratification increases self-efficacy and identifies their progress which is crucial for keeping them engaged.

Encouragement can also come in the form of incentives and feedback. Positive reinforcement and achievements can increase self-efficacy by helping address psychological barriers and enhancing engagement. This was done in this thesis by rewarding people with music playing after successfully finding a pair. The evaluation showed that users became more enthusiastic and ready to explore the game further after hearing the music.

In the intervention that was created, attempts were made to include these motivators, but it was found to be insufficient. For an intervention to be effective, people have to be willing to engage with it. Without the initial action, the goal cannot be achieved. Further research is needed to identify the necessary

elements that must be incorporated into an intervention like the one in this thesis. This will help the target group to take the initiative on their own and continue to use it after the initial contact.

### 9.1.3 Sub-questions – Needs

The third category focused on the needs of the target group, specifically what a social aspect can mean for the effectiveness of an intervention.

#### **SQ 3.1 How important is a social aspect for a successful technological intervention?**

Social interactions have been found to have a significant impact in various ways. By giving importance to social interactions during activities, motivation and benefits can be significantly enhanced. When participating in a group intervention, a sense of community, satisfaction, and shared accomplishment tends to develop, leading to lower dropout rates.

Research has indicated that focusing on already established relationships is better than on making new ones, as the former is found to be more rewarding. However, there is no clear preference based on interviews, as it largely depends on individual personalities.

The strength of the social aspect was evident during interviews and evaluations, where participants expressed a preference for doing activities together. Even though the intervention did not require more than one person, the participants envisioned doing it with others.

These findings highly recommend a social aspect for an intervention, showing a positive influence on the success of a technological intervention.

## 9.2 Main Question

The thesis reveals that interactive technology, especially in the form of buttons, is effective in promoting PA among older adults in outdoor settings. To successfully implement this technology, several key strategies should be considered. Firstly, the intervention must be designed with older adults in mind, considering their needs and experiences to make it more familiar and usable for them. Secondly, leveraging the neighbourhood environment is crucial, as it encourages exploration and interaction within familiar surroundings, which is particularly beneficial for low-SES older adults who do not venture far from home.

Furthermore, placing interventions within walking distance from their residences can significantly increase engagement among older adults who may not regularly leave their neighbourhoods. Evaluating the intervention's usability and effectiveness is essential. Methods such as direct observations, barrier assessments, and collecting data across various settings have proven effective in this thesis. These insights allow for necessary adaptations to enhance user experience and activity levels.

To effectively motivate inactive older adults, the focus should be on fostering their self-efficacy and intrinsic motivation. Offering social benefits through group activities or community interactions can also play a pivotal role in increasing engagement, entertainment, and overall satisfaction levels among this demographic.

In conclusion, when implementing these findings, interactive technology can effectively encourage PA among older adults in an outdoor setting.

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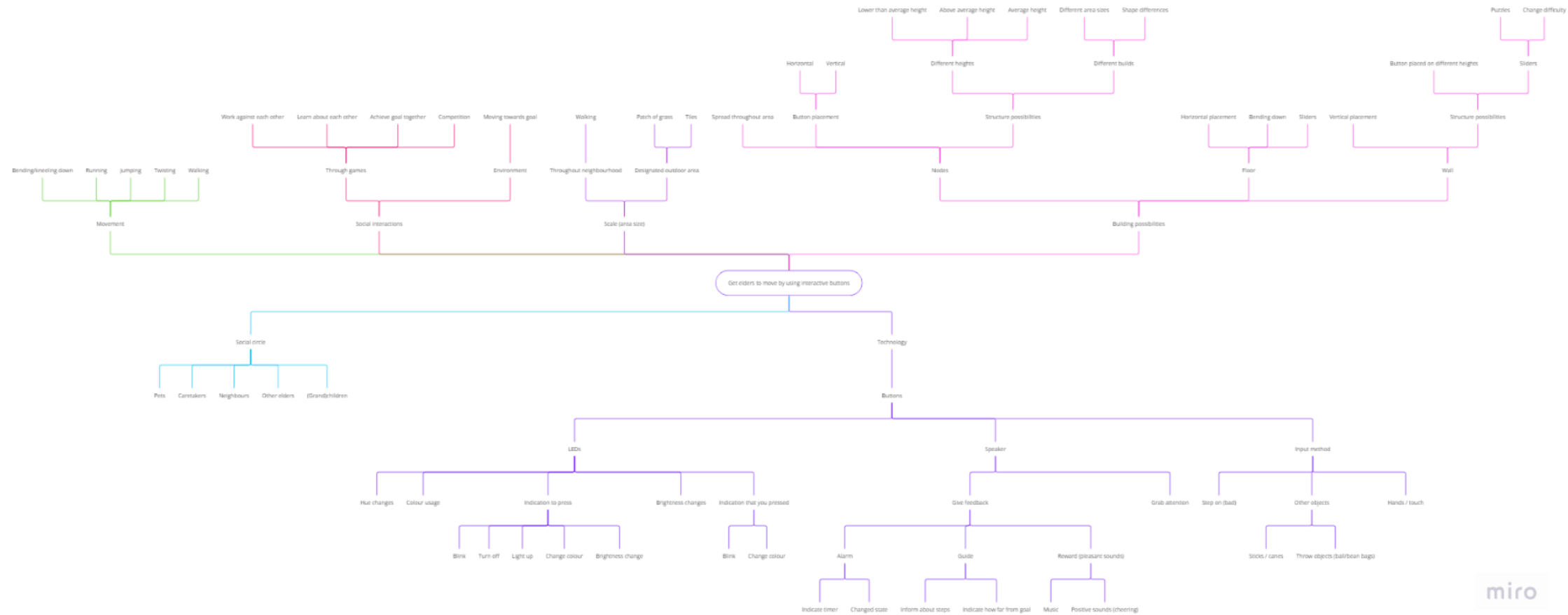


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# Appendix

## Appendix 1 – Mind map focused on the research questions



## Appendix 2 – Interview questions for students

1. Knowing now that elders prefer staying in their social circle what would you have done differently?
2. Why did you go for walking?
3. What was your most insightful research/moment?
4. What was something that you learned during this project that you feel should be looked into more?

## Appendix 3 – Interview questions for older adults

### Interview setup

1. How old are you?
2. What does your daily life look like?
  - a. Do you go outside often?
  - b. Do you prefer to do these activities alone or with others?
3. Did your life look very different in the past?
  - a. What kind of job did you have?
  - b. How active were you?
  - c. What do you think changed this?
4. Who would you most like to have more social interactions with? Peers, grandchildren, or pets?
5. Do you see the amount of your current movement as a problem?
  - a. Would you prefer to exercise more?
6. How much longer would you like to move compared to what you're doing now?
7. To what extent would you like to exercise?
  - a. How much can you move?
8. Are you worried when you move?
9. What's stopping you from exercising more?

### Game-related

1. Would you like to move more through a physical game?
2. If I were to suggest an activity to you, to what extent could it be repetitive? (Rather something they have to do sometimes than something they have to do all the time)
3. Suppose I present you with a game that requires you to move, who would you want as an opponent?
4. How do you feel about sound effects before, during, or after an interaction?
5. If I were to suggest a game with building blocks, to what extent would you go about building a game area with those blocks?
6. How big should a movement-inducing game be?
  - a. Timewise
  - b. Size wise
7. How do you react under time pressure? (How do you feel about time limits?)
8. If there was a nearby game for physical exercise, would you prefer it to be on the way to the supermarket, or would you go there separately?

Appendix 4 – Interview results of older adults

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6
1.	66	63	68	71	83	75
2.	<p>Go to work at 5 am, work until 4 pm, go home, have dinner, shower, watch TV, and then go to bed.</p> <p>Go outside when necessary for groceries or an appointment.</p> <p>Activities like cooking I rather do alone as nobody can dictate what I will be doing then. At my job, I also do things alone. So, I rather do things alone.</p>	<p>In my day I have a cup of coffee, clean up the house, have breakfast, clean up again, have another coffee, cook dinner, and then await the arrival of others.</p> <p>I don't really go outside much. Just if I really need to or if I need to go to work. I don't really like to go out though. I don't mind walking around, but the weather is bad. I know you shouldn't look at the weather. If the weather would be nice I would like to walk to my daughter's house or just walk around a bit. I don't think only the weather is the issue</p>	<p>I'm retired. I have something to do every day. We often go on trips, household chores, I sport three times a week. I play volleyball, do Zumba, and go to some kind of gym once a week. Besides that, I go to gymnastics with my grandchild. Babysit other grandchildren if needed. In that way, there is something to do every day. I also have a lot of hobbies, like reading and working with my hands.</p>	<p>I on average play badminton twice a week. That would be 3,5 hours per week. Saturday is my walk day, and then I walk 30 kilometres with a colleague walker.</p> <p>I enjoy being outside. I can be in the garden for hours. I wouldn't say I'm very active then as I'm retired so I have a lot of time to do things. Back when I was working I had to do all of the garden work in one weekend so that was more taxing.</p> <p>I do grocery shopping often as well.</p>	<p>I would say normal. I don't really go shopping much, and I'm not allowed to cycle anymore. I make my bread in the morning. In the afternoon I get the mail. In the evening I eat two slices of bread.</p> <p>If it's good weather I go outside. So, this month often.</p> <p>I usually do things by myself. I just do it like that. I am</p>	<p>Not so proper. I have lung cancer so my daily life is not pleasant. I don't go outside too often because it is too tiring for me.</p> <p>I have received activities to do from my physiotherapist, but they are already too exhausting for me to do.</p>

		<p>though, I also have to make time for it and be prepared for it. If I would have the time then I would go out, but not a lot. I prefer being at home.</p> <p>I don't really always have the motivation to go out much. It has to be complete for me: having time, not having chores at home, and having the energy.</p> <p>There are activities that I like to do myself. Like household chores as I know where I want to put them. If you're talking about more fun activities then I would want to that with my children.</p>	<p>I do a lot of things alone as well. Going on a walk I for example do alone, but doing sports, I do with others.</p> <p>Zumba I started doing when I retired because it's on a morning so I couldn't do that since I could have shifts. Since I know that volleyball will stop at one point due to my decaying physical capabilities, so that's why I started doing Zumba. When I am physically incapable of doing volleyball, I will continue doing Zumba, the gym, and cycling.</p> <p>A part of my friend group is as active as me but also a part that has more age-related</p>	<p>Let's just say that I don't sit on the couch, I'm always doing something. I also maintain things in the house, now less than before but I still do it.</p> <p>I would say I spend more time moving than sitting down.</p> <p>Badminton is always in a group. The 30 kilometre walk I do, half of that is with another person. That just happens to work out because of where we live. The other half I walk by myself. Sometimes I also just want to walk on other days but then I walk for about two to three hours, just for fun. I like to do that by myself as it's like relaxing mentally.</p> <p>Badminton I have been doing a bit over</p>	<p>happy to do it by myself.</p>	
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		<p>disabilities going on. Some friends sometimes have problems with their joints, but they do try to walk around every day, about 5 kilometres or less. They just try to keep moving. There is a big difference visible in our age group.</p> <p>I think why I am still capable of doing all this exercise because I have been exercising my whole life but you also need some luck with your genes. I did not get injured a lot throughout life either which I think also plays a role.</p> <p>I think my life would change a lot if I was not as active. A lot of my current activities</p>	<p>45 years now. So, I would say I've been doing it my whole life. The walking I started 20 years ago, around 2000. It built up slowly, the 30 kilometres started with 5 and throughout the years it kept increasing. For the past 10 years I have been definitely walking those 30 kilometres.</p> <p>I wouldn't add anything new. I sometimes thought about adding something like a gym to my routine, but it seems boring as the equipment is not that interesting to me cause you're just doing the same thing.</p> <p>At my age, I think for at least the next 10 years I will have plenty with badminton and</p>	
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			<p>would disappear. My social life would change a bit. Not per se in my friend group but my contact with the sport group would be less. My volleyball group I've known for around 30 years, and we do stuff outside of it as well so I think that would stay, but other social contacts would fall off.</p> <p>Having social contact is a factor for me when it comes to volleyball. I enjoy volleyball but I also like the social contact. So, that's a reason why I want to that as long as I can.</p>	<p>walking unless an ageing disability shows up and a doctor tells me it's not allowed anymore.</p> <p>I'm also cycling. Since we're on holiday right now, we go cycling for a couple of days. That's still going really well.</p> <p>I don't want to brag but I feel like from all the men I know that I'm the strongest.</p> <p>One of my friends had to get both his knees operated on. But it could also have been a cause of him being a bit overweight so more pressure going to his knees. I wouldn't say I am very active in avoiding knee-related injuries, but in the background, I do worry about getting</p>	
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				<p>them as that would mean I cannot play badminton anymore. So, I do look out for my weight as well. Not per se for one kilo but when I see a difference of about three kilo then I feel alerted.</p> <p>I would say if I didn't have this active lifestyle, I would get pretty bored. I don't think it would affect my social life a lot though.</p> <p>I want to remain physically active. I see that as more important than the social aspect.</p>		
3.	Used to be a goldsmith but been working in a water filter company for around 25 years now. What I earn here in a month is what I used to earn in three days.	Every year my life differs. I used to have two jobs for a bit. I would work as a dishwasher and a maid. After doing that I started only working as a maid.	Before retiring activity wise, I was kind of doing the same thing except for Zumba. I was very busy though as I also had to work. Now without work, you do	I think my life was definitely very different before. From working 40 hours per week to being free is a very different life. Activity-wise, it didn't really change	Well, in the past I had to work. I worked in the textile industry. I worked three shifts.	Yeah, I used to be a salesperson at the market. Very social job that I miss a lot. I miss the freedom and being outside. I

	<p>I moved more back in the day. I would say the reason is that my life just changed so much, from my job to my living circumstances.</p> <p>When I come home from work, I'm too exhausted to do anything outside. The Netherlands also doesn't have good weather to do anything. I don't feel like there is anything to do nearby. If I didn't have a job, I probably would do more exercise, like cycling.</p>	<p>I used to be more active as I had more energy and was younger. You feel the change in your body through the years as your body seeks out rest more often.</p>	<p>everything a bit more relaxed since you have the time for it.</p> <p>I worked in the healthcare.</p> <p>I used to cycle to work as everything was near me. Now that I'm retired that fell off. But in some areas, I would say I am more active now than before as I have the time for it.</p>	<p>much, maybe I started doing more now like badminton and walking as I have the time for it now.</p> <p>I worked in the technological department of the shipbuilding industry. I did that for 40 years. I would say of those 40 years 34 years of them were a desk job and 6 years in production. I think that also might have been the reason why I went to seek out physical activity as you start to feel the need of exercise. So, I started cycling to work, it was 10 kilometres going there and 10 back. I was very conscious of it because I felt like</p> <p>If I didn't cycle to work, I would move too little.</p>	<p>I did sports back then as well. Like football. I would do it every Sunday. I stopped a while ago because I had a problem with my shin.</p>	<p>used to travel everywhere and did a lot of handy jobs as well. All of this stopped because of my disease. I would have still been working if I was not sick, even at this age.</p>
4.	I rather do something with my children or	I rather have social interactions with my	I would like a balance. We have a	I have more friends that are around the	I only have my sister left. I	I like to have more social

	<p>grandchildren as they make me happy. I'd like to stay with the people I already know. I'm not really interested in people around my age as I haven't really tried. As we age our minds also change so I am unsure whether we would get along. Talking to younger people will make you feel young as well, so I'd prefer having social interactions with younger people.</p>	<p>family. People around the ages of my children or grandchildren. I don't really mind what the age difference is as long as I am comfortable with the person. I need to know the person beforehand. I know enough people, if I really need to then I would talk to people, but I don't see why I would talk to someone if I don't need to.</p>	<p>lot of contact with people our age. But encounter younger people as well. I have no preference. I like having social interactions with anyone.</p>	<p>same age as me. The other group I interact with are grandchildren, which yeah at that point you would go down to 3 and 4 year olds. I think how it is now is nice, in balance.</p>	<p>sometimes visit her. Once a week. I can go there by foot.</p>	<p>interactions with anyone. Grandchildren and people of my age. Most of my friends are younger than me. I would say I am a social person. But it is quite exhausting for me. I get visitors. I sometimes go outside with my wife; we go to the market then or go to birthdays.</p>
5.	<p>Because I move little I am getting more problems with my diabetes and blood pressure. So, I would like to move more but I don't have the time or energy.</p> <p>If something were to be nearby then I would probably go though, such as a</p>	<p>I think the amount of movement I have now is enough as I also have to play around with my grandchildren when I babysit them.</p> <p>I just want to be able to rest.</p>	<p>I think I move enough.</p>	<p>I feel like I do plenty.</p>	<p>I think I move enough. I walk the stairs up and down three times. I get assistance once a week and then I go to the garden centre. I sometimes go to the park.</p>	<p>I would love to move more. But it is just too exhausting for me. The most movement I get is walking. When I go outside I take a walker with me because it allows me to sit down when I get too tired. I</p>

	gym, or a pretty park, walking through the streets isn't nice and not motivating so I'd rather go into nature.					couldn't do the walking without my walker. If I walk from my apartment to the elevator, I am already out of breath and in need for a sit down. I don't want to use it at home though as it would make me too dependent.
6.	<p>I want to move more so that I can remain healthy. The more you move, the healthier you are. So, I find it important to try to move as much. I move around in the house.</p> <p>I would like to spend 6-8 hours on moving. Right now because of work, I would say I spend 10 hours but that is the movement I do during work. Outside of work I</p>	I don't want to move more. I'm satisfied with how things are.	No, not really. I do notice that I am less alert and fast as 20 years ago, but I can still do everything.	You notice that everything with sports and working in the garden that it's more laid back.	Most movement I get is from indoors. I would say I move 3,5 hours a day.	

	don't move a lot. In the weekend I don't either, couple hours maybe as I want to recover from the workdays. Those 8 hours I mentioned I would like to spend on actual sports such as cycling, walking, or going to the gym.					
7.	There aren't any bodily movements that I cannot do at this point in life.	I can still do all bodily movements.	-		I can still kneel down and tie my own shoelaces. But working in my garden I cannot do anymore. I get a friend to do it now.	
8.		I do not worry when I move, it is normal to do. However, I do worry about moving a lot the day before I have to work as I cannot afford to be very active then.	I feel very lucky that I have good genes and don't really have problems, but I do notice that I sometimes feel stiff.	I never was involved in having to do surgery or having troubles with limbs so I feel extremely fortunate. So, I don't feel worried.	No I don't worry.	
9.		I do think that engaging in physical activity is really	-	-	It's hard. I am satisfied with what I do for	

		<p>important to feel that you're mentally and physically improving. I rather do stuff and be occupied than sit down and think. I don't think there is something that is keeping me from doing it, but I do lack motivation. I cannot force it; it has to be intrinsic. I would have to be at peace to be motivated to engage in more physical activity. I do think it's good to work indoors and outdoors to have some balance as being only indoors can be stressful. If I had the time, I would walk around more. Has to depend on the weather though.</p> <p>I also cannot do a lot of physical activity, and then go to work the next day as that would be hard on me. If I didn't have work</p>			<p>now at my age. The main exercise I do is walking. I used to go fishing but I stopped because I don't know where to leave the equipment. Cycling I am not allowed to do anymore. If I could move I would be gone already to the nearby lake.</p>	
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		the next day, it would be okay because then I can do whatever I want.				
10	Yeah, I would like a game, like a football place. I could play that with my grandchildren.	I think the idea of a physical game is nice, but I don't like to go outdoors much. I used to enjoy it more but the older I get the less I enjoy it. I prefer to go to work and do household chores. I wouldn't know how it would be when I retire.	I like stuff like that. I like games. I would immediately say yes and see it as a motivation.	I don't really like the idea. I like games but I am not really a game type of person. I move enough, so I wouldn't think "That is something I need".	I like puzzles and play games on my tablet. I don't like the idea of a physical game. I like games but not that much. I think I move enough. Seems difficult. I cannot move that much anymore, and I don't want to think a lot.  (I presented concept #6) That seems fun. I enjoy dancing to music. But I rather do that inside. I am not interested in such a device though because what if I die,	I would try it.

					<p>who will take care of it?</p> <p>Soon it will be warm again, I think I'll just sit in my garden with a book. I don't move then though; I fall asleep often. Something that would get me outside of my property would be walking. I wouldn't like it on a route through the forest, because I don't come there often. If I would be already there and the poles are there, I would not use it. I like bam bam music, so would not say something really slow. But even with that music, I</p>	
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					<p>wouldn't find it interesting.</p> <p>If it was in my garden then I also wouldn't use it, no matter what the structure is, I would have music everywhere at that point.</p> <p>I think I do enough and come outside often enough. When I go to the shopping centre, for example, I purposefully walk around the entire mall just to get more movement.</p>	
11	I don't mind. It's not annoying. The important thing is that you're moving and using your mind. I don't think it'd be boring as at my job I	I think that's normal. If I am comfortable, I will do it, if not 5 times, then 10 times. I think I would have to try it out to actually answer this though as	I don't mind repetition as it's part of the assignment. Sometimes repetition is needed for something.	I mentioned a gym earlier, and well the thing that I don't like about a gym is that you're doing the same thing over and over again which is		Doesn't matter. I try what I am able to.

	do the same thing for the whole day, year in and out.	it depends on the moment.		something that doesn't attract me. So, I rather do a sport than a monotonous activity just to exercise my arms, legs, or chest. I rather go swimming then.		
12	Someone younger. I'm not scared of losing to them, it's a game after all. You're occupied and you're moving.	I don't think winning is important as long as I have a good time. I don't think there is a big difference as I would be as happy doing it with my grandchildren or children. I think the most important thing is that I know the person and enjoy the game.	Someone that I am an equal to or someone that is a bit better than me. Age wouldn't matter in this case.  I don't care for winning. I rather have a fun game and lose than win easily. I would like it to be challenging.	I would say someone stronger than me. With badminton, I sometimes also play with beginners because I understand that they have to learn it somehow as well. But I wouldn't play with them for a long time, like an hour, because that would be terrible.  I don't need to win but I do play for winning. I would have to put effort into the game for me to enjoy it.	I rather do things by myself. I don't care for competitive games.	I have no preference if I had to choose between a game with competition or one where you play together.
13	Sounds would be annoying or exhausting. I think LEDs and sounds would be different. I	Buttons that give sound? I think it depends on what the sound is. Some could be annoying. I think	I would find it okay. If it's part of the game, then so be it.	I don't mind. If that's part of the assignment, then it's part of the assignment.		

	<p>think sounds would be more annoying as it affects you more mentally.</p> <p>Sounds like a piano would be good. Music instruments I would like. I don't think it really matters though, like having LEDs or speakers could be nice I just think that the volume of the sounds should not be too loud.</p> <p>I haven't tried anything that uses sound to guide me, so I don't know what to say to that.</p> <p>I think sounds being played after an interaction would be good or sounds that express that the game is going to start.</p>	<p>LEDs and sounds can help in making things easier. For example, LEDs can help seeing things.</p> <p>I think sounds coming after an interaction, would depend. You wouldn't know what happened during your first time but over time you would get used to it.</p> <p>I don't know if sounds would be nice for in games though. I think music instruments would be nice though. It is important that it starts off soft, so you don't get scared or startled. More relaxed.</p>	<p>I think it would be annoying to hear a sound after pressing it. But as it can serve as confirmation it would be good.</p>	<p>I think sound could play a role in the speed or understanding.</p> <p>Having sound after an interaction would give you the assurance that you pressed the button.</p>		
14	Yeah, I would like to look around the place	Depends on the game and how much I	I don't know actually. I think I would leave	I would leave it the way it is as I assume it		I don't really mind. If you tell

	<p>to see if somewhere else would be a better fit.</p> <p>I have to see for myself what would be good to do before moving it.</p> <p>I would like it more to build my play area.</p>	<p>would change. I would change things though if I had the freedom. I would be curious to see what happens.</p>	<p>it the way it is. I don't see a reason why me moving something would improve the game.</p>	<p>would already be good enough to be used.</p>		<p>me that I can move it, I'm not sure if I would. I don't know If I'm physically capable.</p>
15	<p>Timewise I would say about one hour. I don't think that I would be exhausted from it. It does depend on the kind of activity though. Running for an hour would not be possible. I think cognitive games I could do for an hour, such as putting building blocks together or doing a puzzle.</p> <p>I don't see movement possibilities with a puzzle as it is mostly your mind that is doing the work.</p>	<p>I think every game differs in this as well. For walking around, I think I rather have someone measure how long I take. I think I would start with around 30 minutes and then build up to an hour.</p>	<p>Depends on the kind of game. Some games you could be spending 30 minutes on.</p> <p>Something big like a sport hall.</p>	<p>I have to see how physically taxing it is. If you do something like a obstacle course, then after an hour I would be at my maximum level of exhaustion.</p> <p>I think I would love the game to be challenging even if I was not physically capable of making it to the end.</p> <p>I think the size of a sport hall would be good.</p>		<p>Not too long. I think it would bore me pretty fast. I am not that into games. I will say less</p> <p>The size of the game should not be too big as I would not be physically able to perform.</p> <p>(gave an example of it being in his kitchen) I would be able to do that.</p>

	<p>I don't much about games that require you to solve something. Maybe you could do something with movement with that, but I am unsure. If there would be movement in it, I would then say 30 minutes.</p> <p>Area wise I would say maybe 10 square meters or 12 square meters.</p>					
16	<p>With a time limit yeah, you would do your best to finish in time. I don't think I would become stressed.</p> <p>I prefer just having the time, so that I can finish the game in peace. Maybe you fall during the game or something like that,</p>	<p>I wouldn't become stressed by a timer. But I would become stressed if someone kept telling me to hurry up.</p> <p>I think a stopwatch is better as you start at the beginning. Seems easier and gives more comfort. I prefer</p>	<p>A time limit would make it more fun for me. I think having time pressure, would result in everyone doing their best. It could give positive pressure to go a bit above what you would usually give. If there is no time pressure, then people are more inclined to stop.</p>	<p>I rather just do the game and hear later how long it took me. Having some time pressure is fun, yeah but sometimes the game is just better when it doesn't have a time pressure. With badminton for example, I wouldn't want to hear a whistle after 10 minutes. So, I rather hear afterwards that I took very long</p>		<p>I don't mind but I think I like a time limit more. I think that would make it more fun.</p>

	this will just take away from your time.	something calm that will not rush me.		or did it fast. If someone would cut me off halfway, I wouldn't like it.		
17			<p>If it is nearby, then I would go out for it. An example I can give is these walking routes. These are designated paths where you just follow the numbers, it leads you through beautiful places. Yesterday I walked 20 kilometres because of it.</p> <p>It helps that you can see how long the distance is. I like knowing what I will be seeing on my way as well.</p> <p>Knowing what is coming is also a motivation.</p> <p>If I had a bad experience on a route, I wouldn't stop with</p>	<p>I would go out of my way to go somewhere where I can have physical activity. Walking routes like that, we are both very stern about not quitting midway. So, when we decide on a route then we must complete it.</p> <p>Knowing the duration of the walk helps decide on which route to take.</p> <p>It is fun when you are walking, and you can enjoy the environment around you. I prefer walking through nature more than the city.</p> <p>I like to know what is on my way, but I</p>		<p>Does it have to be outside? I would need it to be close because I cannot go far. I prefer it to be in my house though.</p> <p>I don't think I would use this if I was on my way to the supermarket. I am way too tired for that. Also wouldn't use it on birthdays. I think I would only use it if I was at home. Or right outside.</p>

			walking in general, but I would try out different paths instead.	would actually find it interesting to try out walking from a known spot and then just walking without knowing where my endpoint is.  I do have to say that I don't walk to see things, I walk because I want to walk.		
(ADDED DURING INTERVIEW) 18. Do you think making walking interactive would make it more fun?	-	-	I don't think now but maybe 5 years from now. I think if you would do it with other people, you would go out easier.	I think for beginners it would be nice as it could give them a challenge. For me, it wouldn't add anything. I walk because I feel like it.		
Added during interview 19 Would you like to have instructions beforehand or explore something yourself first?			I like to explore it myself first.  When talking about technology I prefer having instructions.	I don't need to know the details. When we go cycling, we also do paths like that, and well we see pictures of what we will see but we actually don't know where we are going. I like that.		
20 How would you try to motivate people around your	-	-	I think it is good for people to have others to do activities with	Having someone to do something with is a good motivator.		

<p>age to engage in more physical activity?</p>			<p>as they can motivate you to go check out activities you normally wouldn't do.</p>			
<p>Comments made</p>			<p>I think it just depends on how you fill in your day. I have friends that like to go on long walks, but others like to cycle more.</p> <p>I think it could help to add the possibility of adjusting difficulty.</p>	<p>We have always been active in our lives. So, I think it could be hard to motivate people that are not moving a lot to suddenly do so, as I think it should also come from within.</p> <p>I think people that do not engage a lot in physical activity, that they are easier to motivate through a game than by saying "Let's go walk without a goal".</p> <p>I don't think you have to motivate people that are already engaging enough in physical activity, but for those that aren't, a game could be a good motivator.</p>		<p>(Presented the idea of making music by pressing the buttons) Sounds good.</p> <p>(Presented the change the colours of the buttons by pressing them idea) Yeah I like that idea.</p> <p>(Asked if they would enjoy bits of a song or a whole song to be played) I think getting a bit of a song after pressing is nice.</p>



				<p>Finding a way to build up your time spent exercising could be hard. Eventually, you would like to go from doing something for 30 minutes, to 45, and then maybe an hour.</p>	<p>(Asked about height) I think facial height would be good, then the button would have to face you.</p> <p>(Wall structure) Seems okay. I like the wall idea more because that means I can just stand there and press the buttons.</p> <p>(Memory game) I think that's nice. I think randomly pressing might be better as it is simple.</p>
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## Appendix 5 – Mid-Fi Prototype Evaluation Questions

1. How old are you?
  - a. For which age group is this suitable? Why?
2. What do you think of the prototype?
  - a. What would you change?
3. What do you think of the height?
4. What did you think of the game?
  - a. How was the difficulty?
  - b. How would you change it?
5. How do you feel about this as a way to increase exercise among older people over 60?
6. What do you think of the information given?
7. Do you think you would use this yourself? Why?
  - a. What about peers?
8. Which part of the product needs to be bigger or better?
9. Do you think you would move the prototype? Why?
10. What do you think of the sounds used in the product?
11. Would you do this with others or on your own? Why?
12. What did you like most about the product?
13. Where would you put this product?

## Appendix 6 – Mid-Fi Prototype Evaluation Results

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5
1	67	66	59	64	66
2	I think if the pillars would not be as close as they are right now, then yeah.	I think people between 20 and 30 would be the best at this. I do think it is appropriate for older adults.	When I think of my mother who is far above 60, I think she would just laugh about this concept with the thought “This is not something I need right?”. Other people do maybe need this though and are more actively open to it.	I think this is suitable for a lot of age groups. I see people of my age or older do this if they must. I do not think it is very challenging for them.	I think between 25 and 30. Those people are brighter than older people. I do not think that older people can distinguish so many colours and sounds. I think it is a bit difficult as there are so many. It’s not remembering 3 colours but 6. The game is not hard it is just that you need storage space in your brain which, I think, is easier to have when you’re young. You have to do this a couple of times to understand it.  I like the height of the instructions to be as high as possible.

3	<p>It could have been sturdier. The poles were unstable. The game was good though, I liked it.</p> <p>I would change the poles. Besides that, maybe get all the buttons to function properly.</p> <p>(Note: the blue buttons have difficulty with registering a press.)</p> <p>The game does give a certain impression. I think I wouldn't change the game.</p>	<p>I liked the prototype. It was kind of challenging to think about what was actually going on.</p> <p>I would change the stability of the poles. Maybe better buttons because they would sometimes lag.</p>	-	<p>I would add more buttons and more variety. Right now, it is just colours, but I can imagine you can add pictures or something like that. This seems more like something for a nursing home.</p>	<p>I liked the game. I do not think I would change anything about it.</p>
4	<p>The height is good. I think the design is good too, keeping it simple is good.</p>	<p>I think the height was good. I would not make it lower. I would put the instructions as high as possible so that it is directly beneath the button.</p>	<p>I do not have measurement tape on me, but I think they can be a bit taller. I think the highest position for instructions is good.</p>	<p>I think the height is fine. Maybe an adjustable pillar would be good as something can be short for people who are 2 metres but tall for others.</p>	<p>I would have the buttons on a height around 60 cm high because that'll be easier to see.</p>
5	<p>I did not think the game was difficult. I think older adults can do this just fine. I think it is a good way of moving a bit more for those above 60.</p>	<p>I think this is a bit too complex for elders because it is kind of unclear what the purpose is. Am I supposed to just listen or also walk somewhere?</p>	<p>I think it is kind of artificial. Having to use technology to get more movement. I feel like there are plenty of natural ways to get people moving more. Maybe I am wrong though and technology is helpful in this context.</p>	<p>I think this game is too easy but it depends on which target group. It also depends on how fast they are. I do not think this is a good way of getting people moving, the pillars are too close for that.</p>	<p>I think if you do this game about 2-3 times then you will be used to it. I think that is a good thing though. As a movement game, I think you must put the pillars further away from each other.</p>
6	<p>I thought the verbal explanation was clear. Maybe</p>	<p>I would like more instructions.</p>	<p>Instructions must be short, and these</p>	<p>I think having an explanation is good to have. I</p>	<p>Yeah, I think for a Dutch person this would be</p>

	<p>at the start mention that you're going for colours and something about the music.</p> <p>I would add clearer instructions that also indicate what the purpose is of the whole thing.</p>		<p>are, so I think it is okay.</p>	<p>would change the text on the current instructions as it is not very clear.</p>	<p>understandable, maybe not for me. I think the instructions have to be more descriptive for me to understand it. I think the long press part is clear though.</p>
7	<p>I would not use this myself as I move enough.</p> <p>I am not sure if people who do not move enough would use it. It depends on what kind of person you are. I think if you would place this somewhere like Japan where they do tai chi and other things like that, they would be more into it as this is a slow-movement game.</p>	<p>I do not think I would use it myself. I think people who get elderly care would use this.</p>	<p>People who have something that puts them behind, like lack of PA, usually also have problems elsewhere, like cognitive abilities. So, I think this is a good challenge for them.</p> <p>I hope I will not use this. When I am older, I'd rather have other challenges than this.</p>		<p>I have a job, so I do not have time to use this. I would use it though. People my age would I think use it as well as it has PA in it. I think they'd go by themselves.</p>
8	<p>I would just change the pillars.</p>	<p>I think for ease it would be better to have the pillars in front of you.</p>	<p>Is this something you want people to do often? In that case, maybe add variety. I would add more or other sounds, such as animal sounds, traffic sounds, something like that.</p>	<p>I would add more variety or maybe instead of trying to match colours, you can match sounds.</p>	<p>I think the length is fine, when games are too long then you would get sick of them, but it depends on the person. I definitely see people do this multiple times though.</p>
9	-	<p>Yeah, I would put them in an oval shape in front of me.</p>	<p>I think it can be part of the game, moving it so that you have new challenges.</p>	<p>If you do move it, you might lose a good view of the field.</p>	<p>I think moving it would be fun as it allows for more challenges. I do not think that you have put anywhere</p>

					that you can move it.
10	I like the sounds. I think it is fitting.	I would adapt the music to who your target group is. Maybe something that is Dutch would be better. You now also have a lot of old people with an immigrant background, so maybe music from their language would be even better.	I understand why you chose classical European pieces but I think that there are plenty of people that get enthusiastic by other types of music. If the last one is supposed to indicate a mistake then I would make it more extreme. Like for example, use techno to indicate a wrong.	I like these sounds.	They're not bad. I am sure that older adults would enjoy these sounds. I think they create motivation as well.
11	For fun, I would do it with other people. I see it as a social activity.	No, I definitely would do this with others. I really see this as something that you need to do with others, everyone can laugh about it.	I think it is something you do with others. It would bring external challenges. I do wonder if people would do this by themselves once, if they would ever do it by themselves ever again. I feel like they would need a group to keep doing this activity.	I would do it with other people, it would not be fun otherwise. Doing a game by yourself is not so fun.	I do not think this is an activity that you can do by yourself. I would not know how to start if I were to be by myself. So, having someone there who can explain it to me really helped. I would still try it out though if I saw it somewhere just to see what it does.
12	I cannot really think of something to specifically mention as "fun" since this is just something that you do.	The searching, once a colour popped up, looking for it was fun. I think the 5 seconds were long enough.		I think it was fun in general	The searching was the most fun.

13	Outside but then you would need dry weather.	I would place it inside a place for elders. Inside because of the weather.	I would put it in an elderly home. It would be nice if you could prepare it to be usable inside or outside.	As I said before, I would put it in a nursing home.	I would place it outside in a park or garden.
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## Appendix 7 – Script for Verbal Instructions

Welcome. In front of you is a project from the University of Twente. The goal is to get the older adults more active with the help of buttons, light, and sound!

- This is the explanation; this is the green branch on the board under the button. You can long press a button for 3 seconds at any time to stop the explanation.
- If you press a button twice, 1 press is 1 second so twice in quick succession, a memory game will start, this is the blue branch on the board under the button. This game works like this:
  - The six buttons are divided into pairs, and each pair is given a colour. For example, two buttons turn red.
  - After 5 seconds, the colours will disappear.
  - Find the pairs! Press a button one time to see the colour. For example, if the button is pink, find the other pink button.
  - When you find a pair, music will play.
  - Do you want to stop the game? Press a button for three seconds. The game also stops when all pairs have been found and the music has ended. To restart the game, you need to press a button twice again.
- If you press a button for three seconds, music will be played by that button, this is the purple branch on the board below the button. This music is different from that of the memory game.
- Have fun moving!

## Appendix 8 – Hi-Fi Prototype Evaluation Questions

1. How old are you?
2. What age group is this suitable for?
3. Why did you choose to (not) use this?
4. What did you think of the experience?
  - a. Game
  - b. Difficulty level
  - c. Design
    - i. Height
    - ii. Appearance
  - d. Buttons
  - e. Sounds
5. What would you change to improve it?
  - a. Which part needs to be expanded or improved?
6. What do you think of it as a method to increase exercise in people over 60?
7. What do you think of the amount of exercise it took to be able to do it?
  - a. To what extent do you think this can help older people increase their physical activity?
    - i. What needs to change to achieve higher levels?
8. Would you use this yourself? Why?

- a. What about peers?
- 9. Do you see this as something you do alone or with others? Why?
- 10. Would you move the pillars? Why?
- 11. Where would you place this?

### Appendix 9 – Hi-Fi Prototype Evaluation Results

	Participant 1	Participant 2	Participant 3	Participant 4	Participant 5	Participant 6	Participant 7
1	73	60	73	62	80	63	66
2	All ages	Suitable for old people	Suitable for 65+	Suitable for older people	Suitable for older adults	All ages	15+
3	Thought it was art. Would not have stopped because they did not know who it belonged to and feared breaking it.	Was not interested in stopping to interact with the prototype.	Did not find it interesting. Did not care for it.	Felt no motivation to interact with the prototype.	Felt like they had spent enough time in the area and were unsure what it was.	Would have kept walking because they did not know whether it was okay to interact with it. Has to be told by someone that it is okay, a sign is not sufficient as they will not see themselves as the target audience.	Would have stood around for a bit if they had time because it looks interesting.
4	Loved the sounds. Likes the game but thinks it might be hard. Positive about the buttons and did not experience them as hard to press. Thinks the	Liked the sounds and the game. Thought the buttons looked futuristic.	Thought the game was not hard but he would not have changed anything about it. Thought the sounds were okay and said they would not motivate them to stop to interact with the	Liked the sounds and the design. Thought the game was good and appropriate for older adults. Thought the instructions were understandable.	Was intrigued by the design and thought it was art. Loved the sounds. Thought the instructions were clear and liked the design of them. Was positive about the fact that the game had a	Said it was fun and motivating. Enjoyed it because it was new. Liked the sounds the most, then the light, and finally the game. Struggled with double pressing, and besides that thought	Thought it was fun. Had more fun this time than before because they understood the game more. Liked walking around. Thought the buttons were sometimes hard to



	height is good.		buttons. Did not think the buttons were difficult to use. Thought the instructions were clear.		cognitive aspect.	the buttons were not hard to interact with.	press. Liked the sounds. Preferred holding the instructions as it allowed them to put them close to them.
5	-	-	Would not have changed anything yet would not have used it.	Would add a sign inviting people and naming the university. This sign would not be part of the pillars.	Would not change anything about the game.	Would not change anything. Thinks the game is easy.	Would have liked it if all buttons turned purple when long pressing. Would have made the buttons easier to press.
6	Thinks walking is a good activity to choose to increase PA among older adults.	Thinks it is a nice way to get people in nursing homes to move a bit more.	Thinks it can be helpful for older adults to walk around.	Loves the initiative.	Thinks older adults need intrinsic motivation so it depends on the person.	Thinks it is a good way of increasing PA for older adults above 60 because it is relaxing due to the music.	Thinks it is a fun way to make older adults increase PA.
7	Thinks any bit of PA is already good, so even though this does not increase PA that much it is still good.	Thinks it is okay.	Thinks it is okay.	Liked the distance.	Thought the distance was okay.	It was as desired. Does see it as something that will not increase PA a lot, but they find that it does enough.	Thinks this will moderately help increase PA as it is not an actual workout, just walking.
8	They would have considered using it if they saw someone else use it.	Would not use themselves as they think they move enough but see it as a	Would not have used themselves.	Would not do it themselves as they move enough.	Consider doing it themselves but see age mates use it more than them.	Would like to use it because it is a game. Maybe once or twice a week. Depends on	Would use it himself, once or twice a day to be occupied physically and

		possibility for other people.				intrinsic motivation.	cognitively. Sees age mates do it as well.
9	Unsure about doing it together but does see it as a possibility.	Would do the activity by themselves. Did not consider trying it out with other people.	Thinks it depends on the group size that you are in. So, sees multiplayer as a possibility	Would do it with other people but sees the possibility of doing it alone as well.	Sees it as a social activity as games are more fun when done together.	Would do it by themselves but do consider doing it with others because they think that would bring more challenges.	Sees doing it together as a must as you will have someone to keep track of you.
10	Would not have moved the pillars as they were unsure about whether they were allowed to interact with the prototype.	Would have put the pillars in a zigzag to have a clear start and finish point.	Would not move the pillars as they think it is fine the way it is.	Would move the pillars depending on the situation. Recognises that moving the pillars would influence the challenge.	Would put the pillars closer to each other as it makes the game easier.	Would not move the pillars as they do not whether it is allowed or not.	Would move the pillars closer to each other so they can remember the pairs better.
11	Would place it outside of a mall.	Would place it in a nursing home.	Would place it in a nursing home.	A revalidation centre or nursing home.	A nursing home or an organisation for older adults that organises activities for them.	Would place it in residential areas.	A nursing home or a place where people go to play games.