Game Induced Exercise Promotion for Children with Developmental Coordination Disorder

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Abstract

Children with Developmental Coordination Disorder (DCD) struggle more with motor skills focussed on coordination and/or balance compared to typically developing children. This causes them to have negative associations with physical exercise, which might influence them to avoid physical exercise altogether and develop high risks in becoming obese. Therapy is mainly focused on strengthening self-esteem and motivating children to become more physically active. The RE-Play project aims to motivate children with DCD and Cerebral Palsy to become more physically active through the use of an interactive playground. This thesis focusses on creating two interactive playground games with three different systems each: the current system, an adaptive system and a static system. Based on proxy testing, the interactive playground seems to score slightly higher than regular therapy sessions do in motivating children to become more physically active, although this might only be on short term. Out of the three systems, the adaptive system was preferred most based on proxy testing. The static system could come in handy when more different types of motor skills are being tackled in a session. The current system might be a good version to use beyond the scope of the RE-Play project, for example in school settings. Results seem promising, but more testing is needed to be able to conclude if the interactive playground helps to motivate children with DCD to become more physically active.

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Chapter 1. Introduction

The main focus of this thesis is to develop an interactive playground application game that can be used by *physiotherapists* and *implemented in therapy settings*, aimed at *autonomous motivation of children with DCD regarding participating in physical activity beyond therapy sessions*. This introduction chapter will provide background on the motivation behind this thesis, the challenges, the aim and the guiding research questions.

Background

Children with Developmental Coordination Disorder (DCD) have lower-than-usual physical abilities compared to their peers. They are prone to be less physically active due to this lack of motor-skills. Current treatment of children with DCD is focused on increasing daily life skills, linked to what the children want to learn themselves. Children tend to get negative associations with physical activity based on their lack in motor skills compared to other typically developing peers (Eggleston, Hanger, Frampton, & Watkins, 2012; Omer, Jijon, & Leonard, 2019). It might be helpful to create a playful experience to help enhance motivation towards physical activity. Therefore, the aim of this project is to help children aged 8-12 with DCD to create more autonomous motivation towards physically activity beyond the therapy sessions by means of an interactive playground. This will be done as a co-operation between the University of Twente (HMI) and Roessingh Research and Development (RRD)

Previous studies have been conducted using the AIRplay as a basis, which was initially created for children with asthma. The latest concept is the RE-Play system for children with DCD and/or cerebral palsy (CP) which uses an interactive playground platform and a wearable connected to an application that, all combined, aim to motivate children to become more physically active. The wearable is used to track children's daily/weekly physical activity and use that information for tailoring in therapy sessions. Unfortunately, due to technical difficulties, the interactive playground hasn't been tested enough by the intended user group: the therapist working on the RE-Play project and children with DCD. Therefore, a next step for this project is to investigate less technology dependent versions, as well as to further improve embedding of therapy settings during technology enhanced sessions.

Objectives and Challenges

The **current system** has 12 different games that can be played (Folkertsma, 2019; Markova, 2018). All games work on basis of a depth-channel via interaction with multiple Kinects, with which the computer system is able to understand the playing field. The depth channel is able to see top-down where the players are and translates it to a 2D projected playing field. The real-world physical position of a player translates into the virtual projected playing field. When the children move around, their digital position is updated correspondingly. The position of the players in stored in the computer system and is used in real-time as input in to the digital game. More information about how this system works can be read in 'Augmenting playspaces to enhance the game experience: A tag game case study' (Moreno, van Delden, Poppe, Reidsma, & Heylen, 2016).

Games on this platform might benefit from an **adaptive system** that supports adjustments of the player variables. When a therapist sees that a specific child lacks skills, compared to other children in the therapy session, he can adjust that child's player settings accordingly. Also, when the game does not pose a challenge on a certain child, the therapist can alter its player variables, which gives that child the opportunity to grow. This way, the system is more flexible and the games can have an individual difficulty level in a way that maximises children's motivation and improves physical activity levels. This leads to a more balanced game where children can feel more competent in expressing movements.

Using the playground, there are some technical difficulties such as the long start-up time, failing in starting up the Kinects or low frames per second due to limited processing power. The system does not always detect a player's position on the playground. The children might benefit from a more sturdy **static** version of the **system**, where the projector just displays an image on the playground, regardless of the game or input-technology working. In case of technical difficulties, this system can be used so the children can still enjoy a technology-enhanced activity.

The challenge is to create a system that has these different versions:

1. Current system
2. Adaptive system
3. Static system

On the one hand, these different versions would offer solutions for different applications. For example, the current system could be used to get children started on exploring the interactive playground games, which are also suitable for entertainment purposes. To extend the functionality, the adaptive system can offer therapists a novel solution to new supportive programmes. When the position registering units fail to do their task, the projector can display a static playing field. This gives a lot of creative freedom to the designers.

On the other hand, researching these different aspects of the system could give insight in which versions of the system are preferred and which versions users tend to enjoy better. Experience with the system shows that the motion sensing capabilities are not always accurate. This leads to interrupted game play and a lowered satisfaction of the users.

Therefore, testing the system is very important. Reliability is key to having a successful installation. Due to COVID-19 restrictions, it was prohibited to test the system physically. Therefore, another method of testing is used. The system will be tested through proxy testing through a physiotherapist. A mobile phone was used by the researcher as remote for a mock-up application that ran on a personal computer. The program that represents the interactive playground was screen-shared with the client. The client will test the system from both a professional perspective and child's perspective.

Research Questions

Main RQ

To what extent does a physiotherapist think children with DCD will experience more autonomous motivation[1] towards physical activity compared to regular therapy sessions, induced by the current, adaptive and static state of the interactive playground intervention games?

Sub RQ's

- *How are motor skill interventions used to motivate children towards physical activity?*
  a) *What are the implications of DCD on children's daily life?*
  b) *What type of interventions are used for children with DCD?*
  c) *What types of motivation are there?*
  d) *What is autonomous motivation?*

[1] ***Autonomous motivation:*** *both intrinsic and some types of extrinsic motivation where people have identified with values of an activity in such a way it integrated into their sense of self* (Deci & Ryan, 2008). *People get a feeling of self-endorsement of their actions if they are autonomously motivated.*

e) How can technological advances be used to enhance motor skills in children with DCD?

- *How can autonomous motivation be enhanced according to an adult diagnosed with DCD?*
- *What do physiotherapists' and ergotherapists' interventions for children with DCD without the use of technological advancements such as the interactive playground look like?*
  - *How do physiotherapists and ergotherapists promote motivation for physical activity in children with DCD?*
- *How does the interactive playground intervention enhance automated motivation compared to regular therapy sessions?*
- *To what extent do experts think children with DCD will experience more autonomous motivation towards physical activity through the use of*
  a) the current system (interactive playable games for the playground)
  b) an adaptive system (supports adjustments of the player variables)
  c) a static system (no interaction; projected virtual playing field)
  of the interactive playground intervention?

Expectations

The following part will give an expectation of the main research question. Overall, it is expected that:

- The interactive playground intervention helps to enhance autonomous motivation towards physical activity beyond therapy sessions
- Of all three models, the expected motivation due to the adaptive model is rated highest
- Of all three models, the expected motivation due to the static model is rated lowest
- Compared to regular therapy, all three models are rated 'just as high' or 'higher' in enhancing autonomous motivation towards physical activity

The expectation is that the *current system* will be rated (slightly) higher than usual therapy techniques for increasing motivation towards physical activity. This is mainly expected because it brings novelty to physical exercise through technology. Schell defined a playground as "any space where children gather for improvisational play" (Schell, 2015, p. 31). A game displayed on a floor by the use of a projector is a quite an interesting and novel thing, as it isn't widely used (yet). Therefore, it might seduce a child to interact with it without thinking of it as an exercise. Compared to regular physical therapy exercises, the child might be stimulated to be more physically active without thinking of it as something they must do or practice – pure out of their own interest because they think it is fun, through intrinsic motivation (Personal Communication, May 14, 2020). After using the current system of the interactive playground multiple times, it is expected to become less interesting, up to a point in which it cannot be called 'intrinsic' motivation anymore. However, this might be tackled by having a constant flow of new games to present. It is expected that children will be interested in the new games. Without the development of new games and without the ability to change some variables, it is possible that children might lose interest. Because the current system doesn't adapt its difficulty to its players, it can be too easy for some, as well as too hard for others. Therefore, the adaptive system might be a better fit than the current system.

The *adaptive system* is expected to be rated higher in enhancing motivation towards physical activity compared with regular therapy, because the therapist can adapt the difficulty settings in game to match a specific child's needs. Children with DCD experience negative feelings doing physical exercises, because they – compared to peers – struggle more and have less successful experiences (Anonymous, personal communication, May 14, 2020). A (physio-)therapist is skilled in knowing what is best for children with DCD, and can change the settings accordingly and on-the-fly. This might create more successful experiences for children: challenges are not too difficult or easy and skills of children are taken into account. The intervention is mainly based on promoting group-based physical activity for children with DCD. This called for the need of a multiplayer version in which children probably want to compare their actions and achievements. The *adaptive system* will have the option to change settings for an individual. For example, if one of the three children has a need for easier settings (because they need more successful experiences, they have more trouble moving than the two others, etc.), the settings could make it easier for this child to score likewise. Also, if one child is more advanced than the others, the difficulty level could be set higher. Changing the settings to increase or decrease the difficulty level can be a part of balancing a game. In this case, it is not quite dynamic game balancing, as the game doesn't change the settings automatically, but the therapist does. This could avoid the problems with dynamic game balancing as stated in Schell's The Art Of Game Design (2015, p. 236). Also, there will probably be a better challenge versus success rate (Schell, 2015, p. 207), as a therapist can probably successfully avoid anxiety and boredom in children in such a way that enhances flow.

The *static system* is expected to score the same as or slightly higher than usual therapy methods, because of the novelty of the technology – even though nothing is responding automatically. Using new types of technology might fit the interests of children, because virtually anything can be projected and used as a game. Through this system, designers and developers have the possibility to create a new kind of game while combining multiple game elements. For example, because the static version doesn't react to the players, one could project a board game layout on the floor, while instructing children to perform a physical task when 'landing' on a specific tile. In a broader perspective, the static version could also be used in primary school settings to, for example, learn new words by making a picture of a street in the near proximity of the school, displaying it on the floor through the interactive playground intervention and letting children run to specific objects displayed on the floor.
The attributes used in the 'games' in this static system are the same kind of attributes children normally use during therapy sessions. The only difference here is that there is more of a theme to the game, because of its (novel) aesthetical aspect of the floor's contribution (novel when taking into account that a child hasn't played with the Interactive Playground before). The therapist and children with DCD might prefer this static system over their regular therapy sessions. The static system can be switched easily between different games. The use of physical attributes combined with the static system can contribute to a higher diversity in games; the possibilities are endless. Moreover, attributes combined with the static system help to set a theme and practice a variety of different types of motor movement. To children, this might be more appealing, as they are able to be engaged in the game world, as opposed to the regular exercise room.

Outline

This paper will first expand on a literature background about DCD, motivation and technology used for interventions. Then it will focus on autonomous motivation through personal experiences of someone with DCD. Information from interviews with physiotherapists and an ergotherapist will explain how motivation is tackled in regular therapy sessions and which of these methods tend to work best in practice. In 'Chapter 3. Process Phases', it will focus on the methods used for the rest of the paper's chapters: ideation, specification, realisation and evaluation. The last two chapters will present this paper with a conclusion, discussion and future work section.

Chapter 2. Context Analysis

This chapter will first focus on a literature review on the implications of DCD on children's daily life, different types of motivation, what type of interventions have been found helpful and which motivation types can be found in literature. This literature review is adapted from 'Developmental Coordination Disorder in Children: Interventions and Technological Advances' (Winderlich, Developmental Coordination Disorder in Children: Interventions and Technological Advances, 2020), written for Creative Technology Module 11 Academic Writing class. Secondly, the review will focus on State of the Art. After that, it will focus on Motivation and DCD: Experience. Lastly, interviews with experts were used to give more information about regular therapy interventions for children with DCD, which will be provided in the part Physiotherapy and Ergotherapy.

Research questions that will be answered in the Literature Review are:

- *How are motor skill interventions used to motivate children towards physical activity?*
  - *a) What are the implications of DCD on children's daily life?*
  - *b) What type of interventions are used for children with DCD?*
  - *c) What types of motivation are there?*
  - *d) What is autonomous motivation?*
  - *e) How can technological advances be used to enhance motor skills in children with DCD?*

The research question that will be answered in Motivation and DCD: Experience is '*How can autonomous motivation be enhanced according to an adult diagnosed with DCD?*'.

The State of the Art will further answer the question '*How can technological advances be used to enhance motor skills in children with DCD?*'.

The following questions will be answered in Physiotherapy and Ergotherapy:

- *What do physiotherapists' and ergotherapists' interventions for children with DCD without the use of technological advancements such as the interactive playground look like?*
  - *How do physiotherapists and ergotherapists promote motivation for physical activity in children with DCD?*

Literature Review

Introduction Literature Review

Developmental Coordination Disorder (DCD) is a chronic neurological developmental disorder that impacts motor skills. Children with DCD fail to reach certain developmental stages, such as walking, tying shoelaces, swimming, writing or even crawling (American Psychiatric Association, 2013). The disorder has been historically referred to as 'clumsy child syndrome', as this lack of motor skills causes these children to be described as 'clumsy' (Miyahara & Register, 2000; American Psychiatric Association, 2013). Besides struggling with daily tasks such as writing or tying shoelaces, being referred to as 'clumsy' takes a toll on children's self-esteem (Eggleston, Hanger, Frampton, & Watkins, 2012; Farmer, Echenne, & Bentourkia, 2016). Physical health therapists aim to improve motor skills in children with DCD through motor training intervention. Additionally, a vast amount of therapy is based on getting children to enjoy moving again, as children with DCD may prefer not to take part in physical activities due to their own negative perception of competence (Pless, Carlsson, Sundelin, & Persson, 2001; Eggleston, Hanger, Frampton, & Watkins, 2012).

Since nowadays technology is more and more embedded in society, and children use smartphones and digital games in their free time, it might be helpful to utilise recent technological advancements to improve motor skills in children with DCD. Motor training interventions might benefit from using digital games to promote physical exercise in children with DCD. Therefore, the main goal of this paper is to give insight into the question *how technology can be used in motor skill interventions to affect implications of DCD in children.*

Impact of DCD

Just like any disorder, Developmental Coordination Disorder can have grave impact on one's life. Symptoms of DCD can impact social functioning and learning performances (Eggleston, Hanger, Frampton, & Watkins, 2012). DCD is a comorbid disorder that can be associated with verbal and/or orofacial dyspraxia (difficulties with speech and/or mouth movements), learning disabilities and Attention Deficit Hyperactivity Disorder (American Psychiatric Association, 2013; Eggleston, Hanger, Frampton, & Watkins, 2012; Farmer, Echenne, & Bentourkia, 2016). Besides learning performances, personal care, self-sustainability and mobility are also aspects that are negatively impacted by this disorder (American Psychiatric Association, 2013). Regarding mobility, DCD with balance problems is seen as a sub-type of DCD (Zhu, et al., 2014). Children with DCD have also been found to be less physically active than typically developing peers (Pless, Carlsson, Sundelin, & Persson, 2001; Zhu, et al., 2014). Motor difficulties also have an impact on self-esteem, which is described as the confidence in one's own abilities (Eggleston, Hanger, Frampton, & Watkins, 2012; Pless, Carlsson, Sundelin, & Persson, 2001). Besides having low self-esteem, children with DCD can become frustrated because of their motor problems and avoid participation in sports altogether (Zhu, et al., 2014). Without therapy interventions, low physical fitness due to avoiding participation in physical activities might continue later on in life.

A possible side-effect of being less physically active might be weight-gain or even obesity, which could lead to serious health issues. Low physical fitness is associated with higher risk of obesity (Zhu, et al., 2014). Zhu et al. (2014) found that, compared to typically developing children and children without balance problems, children with DCD who also show balance problems were significantly more likely to be obese. Also, boys with DCD and balance problems are more likely to be obese than girls (Zhu, et al., 2014; Wagner, et al., 2011). Consequently, obesity in children with DCD might have a detrimental effect of severe DCD in adolescence, as general motor skills are lower in obese children than in normal-weight and overweight children (Wagner, et al., 2011). Wagner et al. (2011, p. 1974) state that "An obesity-induced shift towards a less active lifestyle presumably leads to a lack of locomotion and therefore to a lack of situations that train and challenge postural control". In conclusion, DCD symptoms can be a factor for children to become obese, and obesity can be a factor for experiencing severe DCD symptoms in adolescence. Motivating children with DCD to become more physically active might be of great importance to tackle low physical fitness later in life.

Changing behaviour: Motivation

Motivating children with DCD seems to be an important part of therapy as it is needed to change behaviour. Motivation is defined as all brain processes that energise and direct behaviour (Michie, van Straalen, & West, 2011). Michie, van Straalen & West (2011) designed the COM-B system, a framework for understanding behaviour (see Figure 1). COM-B stands for Capability, Opportunity, Motivation and Behaviour. In order to generate wanted behaviour, motivation should be combined with capability (having the necessary knowledge and skills to engage in the activity) and opportunity (all factors outside of the individual that energise and direct behaviour). Potential influence between the systems components is represented through single and double-headed arrows, as can be seen in Figure 1.

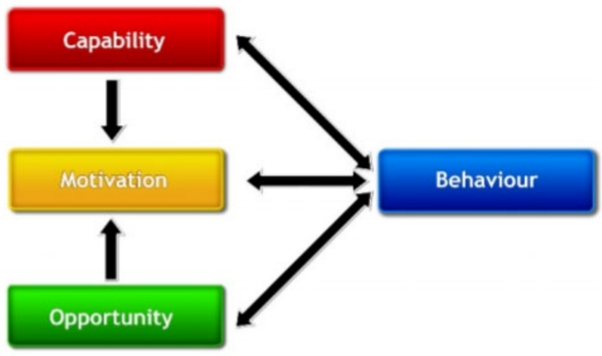

Figure 1. The COM-B system – a framework for understanding behaviour. Adapted from 'The Behaviour Change Wheel: A New Method for Characterising and Designing Behaviour Change Interventions' by Michie, van Stralen & West, 2011, Implementation Science, 6(42), p. 4.

The definition of motivation as previously stated is quite broad. When looked at from the Self-Determination Theory (SDT), a macro theory of human motivation and personality concerning inherent growth and innate psychological needs, it explains (intrinsic) motivation behind choices people make as a result of the basic psychological needs: autonomy, competence and relatedness (Ryan & Deci, 2020), as displayed in Figure 2. Competence is the need to control the outcome and experience mastery, autonomy is the desire to be a causal agent in one's own life, and relatedness is the need to belong. For example, forms of control on behaviour of others are the cause of a decrease in intrinsic motivation, as this control influences one's own perception of autonomy, competence and/or relatedness.

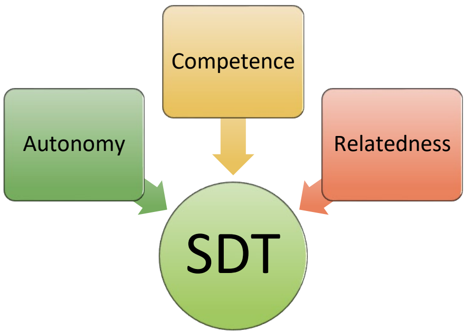

Figure 2. Self-Determination Theory (SDT): Autonomy, Competence and Relatedness.

Motivation can be divided into intrinsic and extrinsic motivation (Ryan & Deci, 2020; Deci & Ryan, 2008). Ryan & Deci (2020) created the Self-Determination Theory's Taxonomy of Motivation (see Figure 2), in which extrinsic motivation is then divided in subsections: external regulation, introjection, identification and integration. It seems they created a scale on which amotivation turns into extrinsic motivation, and then from external regulation it crosses over into (internal) intrinsic motivation through internalization. Activities done for one's own sake or for inherent interest and enjoyment are seen as intrinsic motivation. Extrinsic motivation is often seen as the opposite as internal and intrinsic motivation and concerns activities or behaviour done for other reasons than one's own interest, but Figure 3 states that internalisation of motivation already happens during extrinsic motivation.

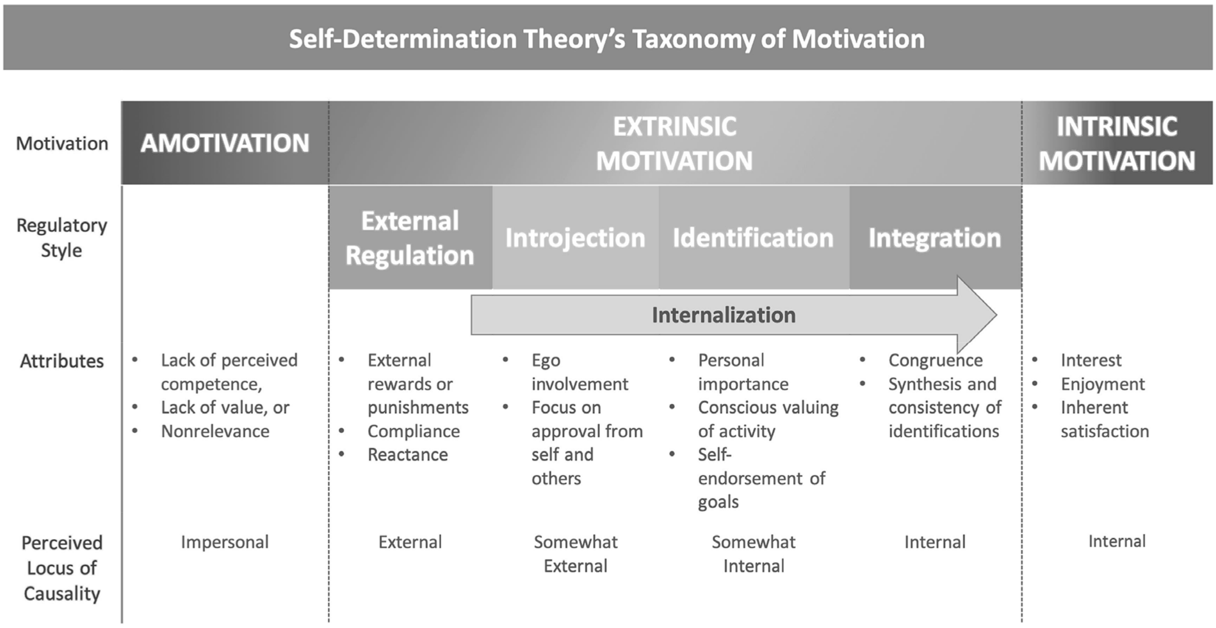

Figure 3. Self-Determination Theory's Taxonomy of Motivation. Adapted from 'Intrinsic and extrinsic motivation from a self-determination theory perspective: Definitions, theory, practices, and future directions' by Ryan & Deci, 2020, p. 2.

Motivation can also be divided into autonomous motivation and controlled motivation. Deci and Ryan (2008, p. 182) eloquently describe the nuances of autonomous and controlled motivation:

> ***Autonomous motivation*** *comprises both intrinsic motivation and the types of extrinsic motivation in which people have identified with an activity's value and ideally will have integrated it into their sense of self. When people are autonomously motivated, they experience volition, or a self-endorsement of their actions.* ***Controlled motivation****, in contrast, consists of both external regulation, in which one's behavior is a function of external contingencies of reward or punishment, and introjected regulation, in which the regulation of action has been partially internalized and is energized by factors such as an approval motive, avoidance of shame, contingent self-esteem, and ego-involvements.*

The Self-Determination Theory is used in current direction of research to enhance motivation through games and 'gamification', by demonstrating how features of games satisfy autonomy, competence and relatedness for "the motivational draw of successful video games" (Ryan & Deci, 2020). This also relates to transformational games[2] and gamification, as explained in Schell's 'The Art of Game Design' (Schell, 2015, pp. 507-510). Transformational games are often used to "transform the player" through clearly stating the wanted changes and how these changes should occur, something the SDT also aims to do. Sometimes, they are used to "replace the need for a skilled instructor", but in reality, most of the time transformational games are used as a *tool* to help an instructor transform someone (Schell, 2015, p. 508). Thus, SDT might be beneficial for creating successful (transformational) games.

Interventions

In order to improve daily life skills of children with DCD, therapy sessions with health care professionals such as physiotherapists can be scheduled. Most interventions for children with DCD that show improvement consist out of pure motor-based intervention, integrated psycho-motor

[2] Often called serious games.

intervention and/or psychologically based intervention, but a combination of these seems to be most effective (Peens, Pienaar, & Nienaber, 2008; Pless, Carlsson, Sundelin, & Persson, 2001). Children's self-concept can be tackled through psychological interventions that for example help children understand and accept their physical appearance and feelings of shame (Peens, Pienaar, & Nienaber, 2008). Multiple studies showed that levels of internalising symptoms of deficits seem to be greater in individuals with DCD than in their peers (Omer, Jijon, & Leonard, 2019). Interventions that aim at success instead of failure tend to work well within children with DCD, as these success experiences might enhance competence and self-worth (Ericsson, 2008; Peens, Pienaar, & Nienaber, 2008; Wilson, 2005). This indicates that multiple effective interventions can be integrated to improve daily life skills of children with DCD.

Integration of interventions based on multiple levels can present children with DCD with a complete intervention that could address underlying problems as well. According to Wilson (2005), interventions should be based on multiple levels of function and be theoretically-principled in strategy, but should also leave room for an individual approach:

> *Taken together, a multi-level approach to assessment and treatment is recommended for children with DCD. The use of multiple and converging measures will circumvent existing issues with diagnosis and promote a fuller appreciation of motor development at different levels of function – behavioural, neurocognitive, and emotional. This approach supports continued efforts to validate new screening instruments that better reflect current trends in motor control/learning and development, integration of neurocognitive assessment (where applicable), and biomechanical analysis in cases where serious limitations exist in a child's movement patterning. The hope is that assessment of multiple levels of function will ultimately map more seamlessly to intervention.* (p. 819)

These interventions, as well as developing new screening instruments, might benefit from using technological advances.

Technology and DCD Therapy

Technology might be an effective way increase motivation and improve daily life skills in children. Mobile games and gaming applications are also used to improve physical activity nowadays. However, a recent review of the state of the art on mobile games that aim to improve physical activity behaviour found limited theoretical foundation for most of the games, even though literature suggests when comparing interventions with and without a behaviour theory foundation, interventions with a theoretic foundation tend to show significantly larger effect sizes (Tabak, Dekker-van Weering, van Dijk, & Vollenbroek-Hutten, 2015). Behaviour change techniques (BCTs) used in those reviewed mobile games and gaming applications were: prompt (specific) goal setting as a motivation strategy for engagement, provide feedback on performance, provide general encouragement (rewards) and provide opportunities for social comparison (competition). The BCTs on itself tend to work well based on literature (Abraham & Michie, 2008), although the use of it for gaming applications should be researched further. Overall, the use of behaviour change techniques may positively influence mobile gaming applications.

As computers are widely used for teaching nowadays, the number of applications that can be used for teaching is growing. Writing, one of the symptoms children with DCD have difficulty with, could be addressed using computers, as children with DCD preferred typing on a keyboard over writing or printing (Klein, et al., 2008). Children in this study were perceived by therapists as being more motivated during communication tasks. Other research suggests that computer-based teaching programs created for children with developmental disabilities seemed to be effective in teaching to construct words or Kanji characters, although more research is needed as these studies lack significant numbers of participants (Stromer, Mackay, Howell, McVay, & Flusser, 1996; Sugasawara & Yamamoto, 2009). Besides using a keyboard, other physical input devices can also be used for improving writing. Snapp-Childs, Mon-Williams, & Bingham (2012) conducted a study among children with and without DCD in which a robot-arm holding a pen was used to teach children sensorimotor movements needed for writing letters. While children would hold the pen, they were given visual feedback on movements using a computer screen. Results showed that children with DCD made substantially more improvement in writing than children without DCD, which enabled them to catch up with their peers during the intervention. Children also expressed enjoyment and enthusiasm and told the researchers they were disappointed that the study ended (Snapp-Childs, Mon-Williams, & Bingham, 2012).

Besides writing, balance is one of the main issues children with DCD seem to have problems with. Balance is a problem that might be addressed by using video games. Using a Wii-Fit balance board, a screen and software, researchers created iBalance, a both static and dynamic balance control training program intervention (Ju, et al., 2018). After a four-week program in which children with DCD played video games on the balance board, children significantly improved balance control. Researchers assign their positive results compared to other software programs to the instantaneous feedback on children's performance facilitated motor learning by enhancing children's body position awareness (Ju, et al., 2018). Instant feedback might therefore be an important aspect for improving balance and body awareness. These aspects might be addressed with the interactive playground.

Other research implicates the use of Active Video Games (AVG) such as Playstation 3 Move or Microsoft Xbox Kinect can help gain task engagement amongst children with DCD, but when the goal concerns good-quality movements, children should be assessed individually to decide whether AVG can address difficulties, as children with DCD tend to have different moving patterns compared to typically developing children (Gonsalves, Campbell, Jensen, & Straker, 2014). This might indicate that AVG's can be part of therapy, especially for task engagement, but aren't fit to replace therapy completely.

Conclusion Literature Review

This literature research investigated what the implications on daily life are for children with DCD, how motivation can be used to influence behaviour, what interventions are aimed at and how technology can be used in motor skill interventions to affect implications of DCD in children.

Multiple studies showed low self-esteem and/or obesity as implications for children with DCD (Eggleston, Hanger, Frampton, & Watkins, 2012; Peens, Pienaar, & Nienaber, 2008; Farmer, Echenne, & Bentourkia, 2016; Pless, Carlsson, Sundelin, & Persson, 2001; Wagner, et al., 2011; Zhu, et al., 2014). Motivation, combined with capability and opportunity, can change behaviour (Ryan & Deci, 2020). Motivation can be split into intrinsic and extrinsic motivation, but this is a step-wise scale from extrinsic to intrinsic motivation (Ryan & Deci, 2020). Intrinsic motivation can exist when basic psychological needs (autonomy, competence, relatedness) are met (Ryan & Deci, 2020). Interventions are based on multiple levels such as behavioural, neurocognitive and emotional levels (Peens, Pienaar, & Nienaber, 2008; Pless, Carlsson, Sundelin, & Persson, 2001; Wilson, 2005). It has been found that different types of technology might positively influence symptoms as writing skills and balance (Klein, et al., 2008; Snapp-Childs, Mon-Williams, & Bingham, 2012; Stromer, Mackay, Howell, McVay, & Flusser, 1996; Sugasawara & Yamamoto, 2009). Also, motivation towards physical activity might be tackled with the use of (active) video games (Gonsalves, Campbell, Jensen, & Straker, 2014; Ju, et al., 2018). Most state of the art mobile games and gaming applications do not use behavioural technology when creating their games, although when theory is used, games tend to have a larger effect (Tabak, Dekker-van Weering, van Dijk, & Vollenbroek-Hutten, 2015). The use of BCTs may positively influence gaming applications, but more longitudinal research is needed in order to find if these interventions have a positive long term effect (on children with DCD).

Motivation and DCD: Experience

To get an idea of the impact DCD has on one's life and what this does for motivation towards physical activity, an adult male (age 25-30) with the DCD diagnosis was interviewed (Personal Communication, April 30, 2020). He got the diagnosis when he was 23 years old. He always thought he was just extremely clumsy.

This part aims to answer the question:

- *What are personal experiences regarding motivation during childhood for an adult diagnosed with DCD?*

During his childhood he struggled a lot with motor skills. He always had bruises that he could not explain, and nearly every time he came home from playing outside he'd have wounds and was bleeding somewhere. Participating in physical activities was very hard for him. Even though he wasn't diagnosed as a child, teachers recognised his lack of motor skills and decided to give him extra personal attention by physical exercise interventions in their local gym. This didn't help him at all, because all the exercises they gave him were so hard for him he just wanted to run away. An example he gave was that he had to do a head roll, but even after seeing someone perform one and someone teaching him how to move, he wasn't able to do one and the teachers just didn't understand what was wrong so they gave up. This was also the same for swimming – after three years of swimming class, he never even got one diploma. He said that he could learn to 'swim' for a day, but if he has to repeat these motor skills the next day, he wouldn't know how to. This was really demotivating and took a toll on his self-esteem.

Writing was – and still is – something he struggles with. It took him way more time to finish writing assignments than his peer students. Because the writing movement didn't come natural, he always had sore hands after a writing exercise because "his muscles tried so hard". There was one year in elementary school where he got a few 10s as a grade for writing. He said that that was because he had an amazing teacher that gave him extra time and that could motivate him to do his best by praising him and acknowledging his effort.

Even though he wasn't diagnosed with DCD until later in life, he got group therapy for his bad motor skills. He explained that he had to do some balance exercises and exercises that aimed at improving self-esteem. These group exercises were traumatic for him, he said he was definitely more aware of his bad motor skills because of it. This being more aware of one's motor skills was also found in literature for children of age 6-8 with DCD (Pless, Carlsson, Sundelin, & Persson, 2001) (Farmer, Echenne, & Bentourkia, 2016). He did state that it made him realise that even though his motor skills were bad, there were a lot of children in that group that were even weirder than he was, which made him put his skills in perspective.

There were some success experiences. He played the guitar for a while and got quite good because he was extremely intrinsically motivated, but this only worked well when he kept playing every day, as he seemed to lose his ability to play when he didn't play for some time.

Since he got his DCD diagnosis, puzzle pieces seemed to fall in place. He always felt out of place and ashamed, and this caused him to have low self-esteem. He was really demotivated to exercise and he was ashamed others might find him weird if he participated.

This interview gives a good example of the implications DCD has on daily life that were also found in literature: low self-esteem, avoiding physical exercise and struggling with daily life skills. It also shows that motivation is a big factor to do learn to do something. This helped to understand how someone with DCD might experience the games that will be created, and what is needed to create a game that gives players successful experiences.

State of the Art

The literature review above already mentioned some of the state of the art that exists for (mobile) gaming applications and technologies used for children with DCD. This chapter will provide more concrete information about the current state of the art of games created to increase physical activity among children for the use of inspiration for gathering ideas and comparison of what is out there. A more complete overview of existing interactive playground games for the RE-Play project can be found in the related bachelor thesis 'RE-Play: An Exploration of Game Induced Exercise Promotion in Clinical Use.' (Folkertsma, 2019). A short summary of the 12 existing games can be found in Appendix 1: Overview of Existing Games.

AIRplay

AIRplay[3] is a gaming environment for children with asthma that aims to support physical conditioning and self-management of asthma among children. Biomedical sensing through wearables is used in daily life for collection and monitoring of information, which then can be used for coaching children with asthma in daily life. An app on a tablet uses this information for monitoring and coaching physical activity and symptoms in daily life. Information gathered by this app is then used in hospital visits with an interactive playground (see Figure 4 and Figure 5). The games have positive indications that they are successful as a tool to motivate children in engaging in physical activities[4].

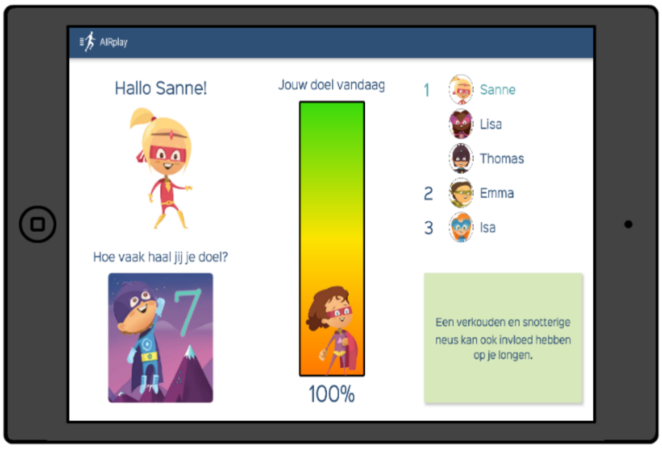

Figure 4. AIRplay monitoring and coaching app main screen. Retrieved from: http://airplayproject.nl/?page_id=97.

[3] http://airplayproject.nl/

[4] http://airplayproject.nl/?page_id=25

Figure 5. AIRplayground at the hospital Medisch Spectrum Twente. Retrieved from: https://www.utoday.nl/news/64361/opening-of-the-airplayground.

RE-Play

The RE-Play[5] project builds upon AIRplay. It was designed to promote physical activity in children with Cerebral Palsy (CP) and DCD through mobile sensing and gamified environments. Although the main focus is on children with DCD, children with CP were also included, as they experience difficulties regarding physical activity as well. Similar to the idea behind AIRplay, wearables are used to provide the system with information about children's daily life activities, which can be used by physiotherapists during therapy sessions. Therapy sessions also make use of games that are displayed using the interactive playground. Movement in-depth is detected, which is translated into usable data for the games. Many games were designed by University of Twente students, specifically for this project. Betina Markova's game Rock-Paper-Scissors (2018) can be seen in Figure 6. Kevin Folkertsma (2019) adapted two existing games Uncover and Block Dodger, and created a third new game Dragon's Dungeon, which can all be seen in Figure 7. A short explanation of all games can be found in Appendix 1.Most games seem promising, but further testing is needed to conclude if these games have the effect on motivating children to become more physically active, as they intend to have. A complete overview of existing games for the RE-Play project can be found in Folkertsma's bachelor thesis (RE-Play: An Exploration of Game Induced Exercise Promotion in Clinical Use., 2019).

Figure 6. RE-Play game Rock-Paper-Scissors. Adapted from 'RE-Play Interactive Playground Games to Motivate Playing.' by Betina Markova (2018). p. 52.

[5] https://www.utwente.nl/en/techmed/research/research-programmes/ehealth/applications/

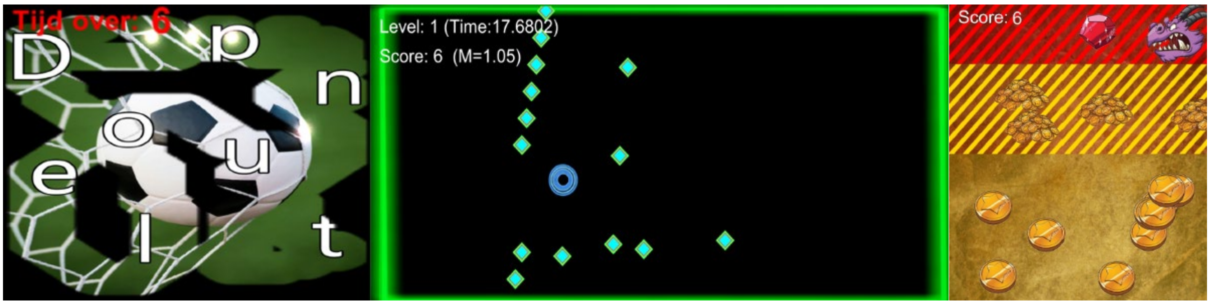

Figure 7. Left: Uncover. Middle: Block Dodger. Right: Dragon’s Dungeon. Adapted from 'RE-Play: An exploration of game induced exercise promotion in clinical use' by Fevin Folkertsma (2018). p. 53, 55, 56.

Sportbouwer

The application Sportbouwer[6] by 8D Games uses the method ‘zelfstandig sporten van kinderen met DCD’[7,8], which has been created to promote exercise in children with DCD. It uses an independent learning process for these children that accord with their personal level. Children can choose which sport they would like to learn. In the app, they can find step-wise instruction videos and other information needed to perform these sports. Children with DCD seem to need visual instruction way more than verbal instruction, so these videos come in handy. Via this app, they can work on goals that are concrete and time-bound, for example: After four weeks I want to have completed step 6 from tennis. When they practise, the method asks for them to reflect on their process: 1) What will I do? 2) How will I do it? 3) I am practising, how is it going? and 4) How did practise go? Teachers help children with these steps. Children seem to like these sports lessons, as nearly 95% of the lessons are rated fun to super fun. Unfortunately, this app seemed to be discontinued.

Figure 8. Sportbouwer App. Retrieved from: https://play.google.com/store/apps/details?id=com.a8dgames.kinderbeweegapp&hl=nl.

6 https://play.google.com/store/apps/details?id=com.a8dgames.kinderbeweegapp&hl=nl
7 https://www.allesoversport.nl/artikel/zelfstandig-sporten-van-kinderen-met-dcd/
8 https://www.kenniscentrumsportenbewegen.nl/kennisbank/publicaties/?eindrapportage-zelfstandig-sporten-van-kinderen-met-dcd&kb_id=24288

Rehab Gaming

Ghent university students created a virtual reality balance game called ‘Rehab gaming’[9] to increase motivation for balance training in children with balance disorders as DCD and CP. They aimed to investigate the difference of motivation towards traditional balance therapy and their gaming mat using VR. Children showed better balance after the intervention. However, traditional balance therapy showed the same increase in balance. Also, motivation in children didn’t significantly differ when comparing traditional balance therapy to the Rehab Gaming method. Unfortunately, there were no pictures included in the document. Pictures could have helped in providing further details of the implementation.

Physiotherapy and Ergotherapy

Children with DCD benefit from therapy to help them in daily life. Ergotherapy and physiotherapy are common for children with DCD. Ergotherapy focuses on daily life skills, such as making a sandwich, tying shoelaces, stepping onto a bike or making connexions between speech, reading and writing. Physiotherapy focuses on movement in general, such as jumping, keeping balance, throwing balls and walking. The following part is based on interviews with three therapists that work with children with DCD (Physiotherapist and Ergotherapists, Personal Communication, May 14, 2020; A. Dijkstra, personal communication, June 16, 2020). The semi-structured interviews used for this can be found in Appendix 2. It aims to answer the sub-questions:

1. What do physiotherapists’ and ergotherapists’ interventions for children with DCD normally look like?
2. How do physiotherapists and ergotherapists promote motivation for physical activity in children with DCD?

When a child seems to have motor problems, it will be tested to get an indication of the level of motor skills of said child, for example through the ABC-Movement test. This test shows how a child scores compared to children of the same age. These kind of tests can be used as a first step to help a child with motor skills that are below average, or as an indication for further research when a child scores really low, by targeting those elements that are in need of improvement.

Often, the child will be helped by a team of experts: ergotherapists, physiotherapists, speech therapists, creative therapists and remedial educationalists. Treatment through interventions by physiotherapists and ergotherapists is mainly focused on specific requests for help, based on actions the child struggles with. First the team focusses on what goes wrong: does it have to do something with attention, coordination, balance or fear? Knowing this, the team can focus on helping the child.

According to the people interviewed, these things seem to be important in enhancing motivation:

- Use a child’s interests in therapy sessions. For example: when a child likes football, play games with a ball during therapy.
- Breaking it down into smaller steps that can be completed more easily. A request for help, for example “learning how to ride a bike”, is divided in several small steps: stepping onto a bike, keeping balance, steering, stopping, slowing down, speeding up, making turns and stepping off of a bike.
- Start with things a child (knows it) can do. This gives the child a feeling of success. These successful experiences are very important to keep a child motivated. Successful experiences feel good.

[9] https://lib.ugent.be/fulltxt/RUG01/002/350/200/RUG01-002350200_2017_0001_AC.pdf

- Let the child think about their own goals and reflect on them, but help them make it small, doable and realistic. A method for this can be 'het beertje van Meichenbaum'[10], also called Stop-Think-Do, which focusses on verbalising actions:
    1. Stop. What am I going to do?
    2. Think. How am I going to do it?
    3. Do. I do the thing!
    4. Reflect. How did it go?
- Repetition is important for learning, but also for success. This can be made fun if feels like a challenge or a game. An example could be to throw a ball in the air without dropping it for ten times straight. How many times does the child think he/she could do that? To create success experiences, one can start with a balloon – this type of 'ball' falls more slowly and is quite big. The chances of catching it are higher, which helps for success.
- Rewards are very helpful. 'If we do this now, we can play with that later.' Praise also works well, especially by parents.

Parents of children with DCD are included in the intervention sessions. Therapists work closely with parents, because therapy sessions mostly take about 30 minutes a week, and parents are asked to do specific exercises with their children at home. Positive feedback and praising by parents is used a lot in therapy sessions to enhance children's self-esteem, competence and motivation because this seems to work very well for most children. However, all children are different and require different approaches.

According to therapists that were interviewed, taking small steps seem to be an important method during therapy sessions to help children with DCD. A reason for this might be that small steps give more chance on getting a successful experience, which is extremely important to enhance motivation in children that are mostly de-motivated because they cannot do specific activities. The Model of Action can be used for motor improvement, it focusses on recognising where it goes wrong, breaking apart the exercise, making it simpler, connecting it and repeating the complete task. Associating tasks also seem effective.

In conclusion, in most cases treatment is based on specific requests for help. Therapy interventions focus on this request by conducting clear goals for the children and by using small steps, positive feedback and creating successful experiences to enhance motivation. Most of these used methods were also found in literature: rewards, small steps, start easy, letting the child set their own goals (SDT: autonomy, competence, relatedness (Deci & Ryan, 2008)).

Conclusion Chapter 2

Developmental Coordination Disorder (DCD) is a chronic neurological developmental disorder that impacts motor skills. Children with DCD fail to reach certain developmental stages (American Psychiatric Association, 2013). Multiple studies showed low self-esteem and/or obesity as implications for children with DCD (Eggleston, Hanger, Frampton, & Watkins, 2012; Peens, Pienaar, & Nienaber, 2008; Farmer, Echenne, & Bentourkia, 2016; Pless, Carlsson, Sundelin, & Persson, 2001; Wagner, et al., 2011; Zhu, et al., 2014). DCD symptoms can be a factor for children to become obese, and obesity can be a factor for experiencing severe DCD symptoms in adolescence. Motivating children with DCD to become more physically active might be of great importance to tackle low physical fitness later in life.

[10] https://zienindeklas.nl/wp-content/uploads/2015/07/Wijzer-Beertjesaanpak-Stippestappen-Stop-denk-doe-Methode1.pdf

Physical health therapists aim to improve motor skills in children with DCD through motor training intervention. Often, the child will be helped by a team of experts: ergotherapists, physiotherapists, speech therapists, creative therapists and remedial educationalists. Treatment through interventions by physiotherapists and ergotherapists is mainly focused on specific requests for help, based on actions the child struggles with. First the team focusses on what goes wrong: does it have to do something with attention, coordination, balance or fear? Knowing this, the team can focus on helping the child. Most interventions for children with DCD that show improvement consist out of pure motor-based intervention, integrated psycho-motor intervention and/or psychologically based intervention, but a combination of these seems to be most effective (Peens, Pienaar, & Nienaber, 2008; Pless, Carlsson, Sundelin, & Persson, 2001). Interventions that aim at success instead of failure tend to work well within children with DCD, as these success experiences might enhance competence and self-worth (Ericsson, 2008; Peens, Pienaar, & Nienaber, 2008; Wilson, 2005). Motivating children with DCD seems to be an important part of therapy as it is needed to change behaviour.

Based on personal experience of an adult with DCD, autonomous motivation could be enhanced by positive feedback, praise, expressing acknowledgement in someone's efforts, give extra time to complete tasks, break tasks down into small steps and a lot of repetition with succesful experiences.

According to the people interviewed (Physiotherapist and Ergotherapists, Personal Communication, May 14, 2020; A. Dijkstra, Personal Communication, June 16, 2020), these things seem to be important in enhancing motivation amongst children with DCD:

- Use a child’s interests in therapy sessions
- Breaking it down into smaller steps
- Start with things a child (knows it) can do
- Successful experiences
- Let the child think about their own goals and reflect on them (Stop-Think-Do method)
- Repetition
- Rewards and praise

Chapter 3. Process Phases

In order to be able to answer the research questions, I used a variety of different methods and design steps based on phases in a Creative Technology Design Process (Mader & Eggink, 2014): ideation, specification, realisation and evaluation. This chapter gives a short overview of those phases.

Context Analysis

First, a meeting was set up with the supervisor and critical observer to get a more clear view of the goal of this project. The research question was formulated and sub-questions were made to be able to answer the research question. After that, a literature review was used to answer some of these sub-questions. Then a short overview of state of the art was made. A person with DCD was interviewed, which helped to set a real-life example of the implications DCD has on someone's life and what this means for motivation. This interview helped to empathise implications of DCD and is something to keep in mind when designing. More interviews were conducted with an ergo therapist and two physiotherapists. Lastly, an ethical analysis was made, which can be found in Appendix 3.

Ideation

In the ideation phase, ideas for interactive playground games were generated. One of the constraints was that the game could be played on the interactive playground, another was that it could be a multi-player game. The target group had to be taken into account, of course. To get an idea of what games are played nowadays, the list of top games on Google Play was used as inspiration. Also, games on online websites were used as inspiration. The researcher chose to not look at the existing games for the RE-Play project, as this might steer ideas into likewise games. Most ideas for the games were generated during a free association session, but some ideas came to mind at a random point in time – they were written down immediately so they could not be forgotten. Ideas were put into a digital Notebook, every idea as a single text box scattered throughout the page – like a digital version of a blank space.

Specification

In the specification phase, more selection criteria were added based on input from the client. Other selection criteria are: technical feasibility, fun for multiplayer and single player, fun for target group, personal feasibility and novelty. A top three of ideas was selected. The three selected games were worked out further. For each idea, three versions were thought of: one for the current system (ordinary gameplay), one for the adaptive system and one for the static system. These three ideas were presented to and discussed with the client. One of the games had a resemblance to tag, which is a very good game on itself, but hard to use as an interactive playground game, because of technical difficulties. Therefore, two of these ideas were chosen to be realised in prototyping.

Realisation

The two game ideas were worked out using Unity. A smartphone was used as a remote to give a resemblance of the multiple inputs the interactive playground gets during gameplay. A lot of tutorials on Unity were used to gain skills needed for creating the prototypes. This was hard, as most tutorials covered an older version of Unity, and the latest version of Unity used a completely rewritten API. This meant that most of the code from tutorials couldn't be used and had to be rewritten, looking up the right references in the newest Unity reference list, which contained very few examples of how specific code should be written and used at the time of writing.

Evaluation

After creating the two prototypes, they were tested by the client. Testing was done via a video call with the client. The prototypes were shown to the client through screen-sharing. The prototypes were played by the researcher, using a smartphone as remote with multiple touch input – because multiple inputs had to be taken into account as the interactive playground can sense multiple players as well.

Chapter 4. Ideation

This chapter will cover the ideation phase. The goal of the ideation phase was to come up with multiple games that could be used for the interactive playground.

First, the initial problem should be stated, because the purpose of design is to solve problems (Schell, 2015, p. 73). According to Schell, a good problem statement tells both the goal and the constraint. In this case: How can I make an interactive playground-based game that children with DCD will like?

To generate ideas, a free association session was done. One of the constraints for the ideas was that the games could be played on the interactive playground. To get an idea of what games are played nowadays, the list of top games on Google Play was used as inspiration. Also, games on online gaming websites were used as inspiration. The researcher chose to not look at the existing games for the RE-Play project in this phase, as this might steer ideas into likewise games.

The target group had to be taken into account, of course. The target group was children age 8-12 with developmental coordination disorder. This age group falls in categories 'kids' and 'preteen' according to Schell (The Art of Game Design, 2015, p. 119). Children these ages are considered to start making their own decisions about what they like and dislike; children are able to talk about things more deeply. It is also an age of obsession; children will start to become passionate about their interests. Information from interviews made it clear that most of the children with DCD that received therapy were boys. Sporadically there were some girls. Knowing this, differences could be taken into account while creating the games. Boys and girls have a tendency to like different types of games, although certainly not true for each individual, but overall, generalisations could be useful (Schell, 2015, pp. 120-124).

When designing games, it is good to keep in mind any latent needs, such as designing for colour-blindness. Also, it should be noted that dark colours cannot easily be projected, as black light doesn't exist. Therefore, colours should be high in contrast, both with each other and with the background (floor).

Gathering Ideas

Most ideas for the games were generated during a free association session, but some ideas came to mind at a random point in time – they were written down immediately so they could not be forgotten. All games incorporate some form of location and movement as core elements. Ideas were put into a digital Notebook, every idea as a single text box randomly scattered throughout the page – like a digital version of a blank space. With this approach, 35 ideas were thought of. After initial thoughts and reflecting on the context, the most promising 21 ideas were selected based on my personal preference. These ideas can be found in Table 1.

Table 1. First Game Ideas.

Name	Idea
Sonar tag	Children stand on a coloured dot that gets bigger and smaller like sonar waves. The player that has to tag people has a different colour. Someone can be tagged by jumping really high on the floor next to a different player. The player closest then has to tag someone. (Inspired by COVID-19: don't get too close)
Obstacle Course	Based on guitar hero and piano tiles. Children can see obstacles coming their way on the floor. They avoid them or jump over them.
Ball Games	Children can score points by throwing physical balls onto the floor that displays the targets and keeps count.
Paper.io	Based on Paper.io 2[11]. Children all have their own coloured dot which is their starting point. With the path they walk they can create a bigger space of their own colour – everything between their path and land gets their colour. A child can win when it has the largest area or when x% of the total area is covered.
Speed Colour	Each child plays a paint brush. They work together to paint the entire floor as fast as they can.
Paint Blank Canvas	Children can pick their colours and sizes of brushes. They use the floor as an empty canvas. The therapist can give exercises or give an example that the children have to mimic.
Labyrinth	The children have to solve a labyrinth. Can be multiplayer or single player with different types of labyrinths.
Race Game	Children are cars and race each other to the finish line.
Cat vs Dog	Children throw garbage at each other. If one's health bar gets empty, they lost. Based on http://www.spelletjes.nl/spel/cat-vs-dog
Angry Birds	Children use real physical attributes to smash buildings on the floor.
Puzzle	Children solve a puzzle by dragging the right pieces onto the right places.
Match the Colour	One side of the screen is some exact colour. The other side is a colour wheel. Children change the wheel by walking around it slow and precise, until it matches the colour on the other side of the floor.
Fruit Ninja	Children run over images to collect points.
Snake	Children are snakes and try to not step on others' tails.
Draw Something	Children try to draw the object the therapist whispers to them. Some draw, others guess.
Story Count	A story is being told. Every time a number is heard, children run to the line with that number to get points.
Plant Care	Children can take care of the plants by walking towards water and bringing it to the plant, giving the plant a different place or change the lights. In a plant shop, plants need to grow up to a certain level. They need water, a place with good light and the right food. The plant tells you what it needs in a speech bubble. If it is grown up to size, it can be sold. Money = points.
Room Designer	Children get to create their ideal room by dragging furniture around or changing colour of the walls by painting. Can be seen as a series of mini-games, for example colouring the walls as Speed Colour (mentioned as a game above).
Whack a Mole	Jump on appearing images fastest to increase score.
Music Master	Images of musical instruments can be played by jumping on it. Take Piano Tiles as an example: click on the piano – the floor will change in a keyboard – follow the example by jumping/standing on the right note at the right time.
Football/handball	Play in a team against an AI team of players. The ball is displayed on the floor (thus not real), that way the AI can shoot the ball too.

[11] https://play.google.com/store/apps/details?id=io.voodoo.paper2&hl=nl

Chapter 5. Specification

During the specification, interviews with the client were conducted. The interviews were conducted using the mobile phone, in accordance with COVID-19 regulations at the time. The client input was used to create further selection criteria. After hearing from the supervisor that the playground cannot detect balls, some of the ideas were considered not feasible. Also, games where people walk next to each other really closely are seen as not feasible, as the interactive playground cannot detect details that well; players sometimes get switched if they stand too close. The playground can also not be used to detect gestures, as detection isn't precise enough.

First Interview Client

During the first semi-structured interview with the client (Dijkstra, Personal Communication, May 14, 2020), it became apparent that the client would like to motivate children with DCD to become more physically active. This should be done in a fun way, where children don't get the feeling that they have to exercise. Children with DCD generally don't enjoy exercising, as they have negative associations with physical exercise due to their lack in motor skills. Exercise should definitely be encouraged in a positive way using positive feedback. Positive feedback is needed for children with DCD to grow in competence and autonomy levels.

Second Interview Client

A semi-structured second interview (see Appendix 2) with the client gave some insight into which existing games worked best during therapy sessions (Dijkstra, Personal Communication, May 14, 2020). These were: Pong, Coin Collection and Uncover (see Appendix 1). The game Rock Paper Scissors was considered fun, but was not worked out well enough according to the client. This game might be considered in future work.

During this interview, the client came up with more criteria for selecting games. First, the games should be at least multiplayer, because the games will be used in group therapy sessions of four children. Second, the games should invite the children to either (1) be active (by walking a lot, changing directions, stopping or walking in various speeds) or (2) precise (throwing an object at a target for coordination).

Considering the interactive playground's limitations, making the games 'precise', as requested above, would not be feasible. Thus, the games should invite children to be active.

Grid Analysis

The first selection criteria is technical feasibility, as it became apparent that there are some restrictions when it comes to developing games for the interactive playground, for example that attributes are not recognised by the system. Since all games have some form of active movement (running, stopping, turning and balancing), this specific selection criteria was not put in Table 2. Multiplayer was added as selection criteria, combined with single player, as the games should be fun for both. It should definitely be fun for the target group, as children with DCD aged 8-12 need a positive environment to grow. Furthermore, it should be feasible for the researcher to create, and it should be novel. The games crossed with the selection criteria can be found in the grid analysis in Table 2.

Table 2. Grid Analysis of Selection Criteria on Ideas

Name	Technical feasibility (Playground playable?)	Fun for multiplayer AND single player	Fun for target group	Personal feasibility (can I create this?)	Novel	Score
Sonar tag	-+	+	++	+	++	++
Obstacle Course	+	+	-+	+	--	-
Ball Games	--	+	+	-+	---	-
Paper.io	+	++	++	+	+	++
Speed Colour	-+	+	+	+	--	-+
Paint Blank Canvas	-	+	-+	-+	-+	-+
Labyrinth	+	-+	-+	+	--	-+
Race Game	++	++	++	+	-+	++
Cat vs Dog	--	-+	++	-+	-+	-+
Angry Birds	-+	-	++	-+	-+	-+
Puzzle	-+	--	-+	+	--	--
Match the Colour	++	--	-+	-+	+	-+
Fruit Ninja	-+	++	++	-+	--	-+
Snake	+	-+	-+	+	--	-
Draw Something	-	++	+	--	-+	-
Story Count	++	++	--	++	--	-+
Plant Care	-+	--	++	-+	++	-+
Room Designer	-+	--	++	-	-+	-
Whack a Mole	-+	-+	++	+	--	-+
Music Master	+	-	++	++	--	-+
Football/handball	--	+	--	--	--	--

Selection of Ideas

Based on the criteria of the grid analysis shown in Table 2, combined with client input, a top three was selected. The games were ordered based on my personal preferences.

1. Sonar Tag
2. Paper.io
3. Race Game

This top three was explored further by generating options for the adaptive version and the static version. This can be seen in Table 3. The current system has already been explained in Table 1.

Table 3. Top Three Game Ideas.

Game	***Adaptive and Static version***
Sonar Tag	**Adaptive version**: larger or smaller area of sonar; one can only tag someone from a certain colour/sort; all players change colour so the player that tags has to run around a lot; multiple players that tag others; **Static version**: Not a real player that tags, but a dot on the floor children have to avoid; children lose a life when they get tagged.
Paper.io	**Adaptive version**: start in a larger or smaller area; tail is thinner or thicker; win at a smaller area percentage. **Static version**: use physical attributes to create a wall surrounding your land - the therapist checks who got theirs surrounded first; display a matrix of circles/squares on the floor – children get their own colour seed bags (pittenzakjes) which they use to claim the circles/squares. If all parts are claimed, the colour with the most parts wins.

Race Game	**Adaptive version**: cars are larger or smaller; roads are straight (simple) or have lot of curves (harder). **Static version**: playground displays a race track, the therapist uses a timer to check who won. Children get coins/balls/objects every time they win – the one with the most out of 10 wins all.

Third Interview Client

Discussing the games from Table 3 with the client in the third semi-structured interview (Dijkstra, Personal Communication, June 16, 2020), it also became clear that he preferred the static version to work without any technology. So the ideas for the static version as mentioned in Table 3 needed to be extended with a non-tech version. Also, according to the client, Sonar Jump would not be a good idea to create. It is a variation of tag, and this is an excellent game on itself. Improving it in a way that it has added value would be really difficult. Also, after discussing it with the supervisor, it became apparent that the playground doesn't detect jumping. However, this still could be fixed by creating a vector while running a certain way or through combining running with standing still. Overall, the playground has problems with detecting people walking really close together, so it would be better to completely avoid it.

Overall, the client was really enthusiastic about both Race Game and Paper.io, so in the end, these two games were selected to be created. I believe this can be achieved within the time range of this project.

Final requirements

Given the information above in combination with the selection of ideas I came up with, I chose to create Race Game and Paper.io.

The final implementation requirements for the realisation of the system are the following:

- Can be used on an interactive playground
- Multiplayer and single-player gameplay
- Should invite for active gameplay
- Should increase motivation for physical activity
- Should incorporate positive feedback
- Fun for target group
- Novel
- Adaptable user settings
- Can be used on a multi-touch device (mobile phone, tablet) for testing purposes
- Should be made using Unity (for future implementation)
- High contrast colours
- Three different states of the system: current, adaptive and static
- Colour-blind friendly
- Personally feasible

Chapter 6. Realisation

In this chapter the two games, Race Game and Paper.io, will be specified further. This process involves a lot of iterating, testing and trial-and-error. The games were made specifically for a Samsung Galaxy S10, as I tested the games with a multi-touch remote. I used Unity version 2019.4.2f1 for creating the games. The assets and tutorials used are in footnotes.

Race Game

In Figure 9, the first idea of Race Game is displayed. Based on how many children are playing, race cars are selected and put at the start of the track. The game counts down, after which the children can start racing. The racing track should preferably have a contrasting colour with the surroundings. To emphasize this, I chose a lighter colour green for grass and a dark colour for the road (so it is not projected as a colour on the physical floor).

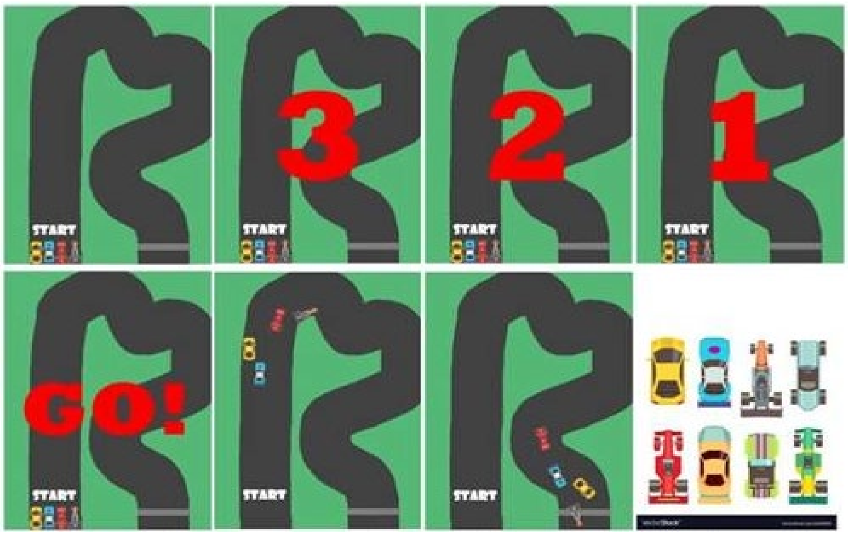

Figure 9. Race Game Ideation. Cars adapted from: https://t1.thpservices.com/previewimage/gallil/47b7d5a4d70ff9ea406dd8bbf9ddafa2/esy-051357023.jpg

Using Unity's Asset Store, a package of racing assets[12] was found. This was a perfect fit for the idea of Race Game, as it contained clear and high quality images. A simple setup can be seen in Figure 10.

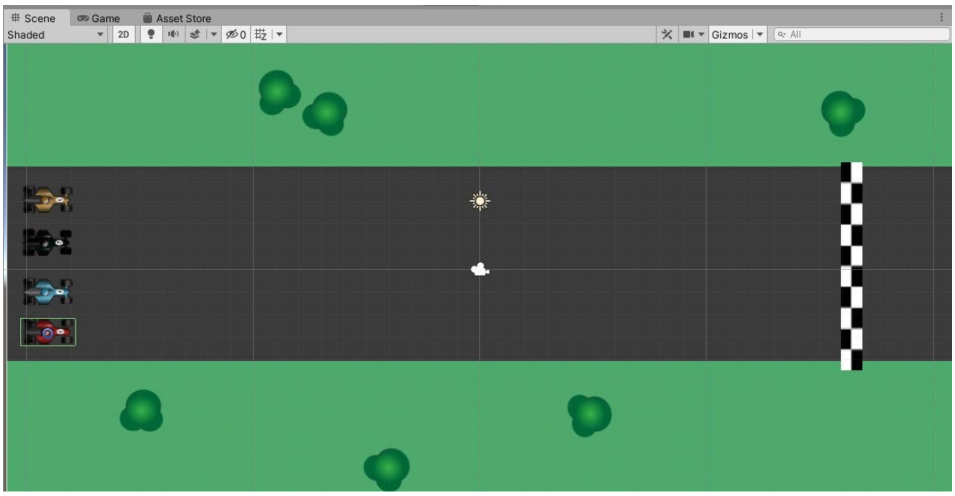

Figure 10. Race Game Asset Store Assets

[12] https://assetstore.unity.com/packages/2d/textures-materials/f1-speed-car-pack-56098

Coloured Cars and Colour Blindness

The assets package[13] came with a variety of coloured cars, which can be seen in Figure 11.

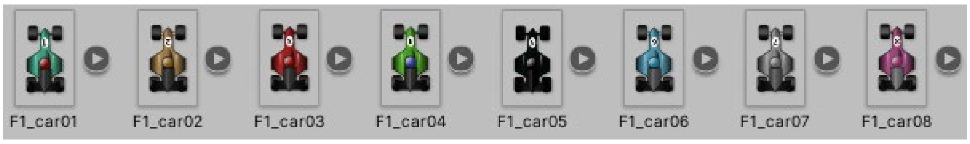

Figure 11. Race Game Cars

Colour blind people have a hard time to see specific colours. Informal intermediate testing with a red-green colour blind person gave me these insights: Car 1&2 are alike, 3&5 are alike, 4 is unlike others, 6-7-8 are alike. Based on that input, a selection of four cars was created in Figure 12.

Figure 12. Race Game First Selection of Cars

Interesting to see that for someone with red-green colour blindness, car 3 (red) and 5 (black) are alike, while car 3 and 4 are not - which I would've expected from someone with this type of colour blindness. To make the selection of colours more distinct, I created a new car by editing car 8 with Paint.net in such a way that I created car 9: lighter than any other car and with enough contrast compared to all other cars. This can be seen in Figure 13. I didn't change the number (8) on the white car on purpose, because a 6 and 9 would probably be too confusing during playing on the Interactive Playground.

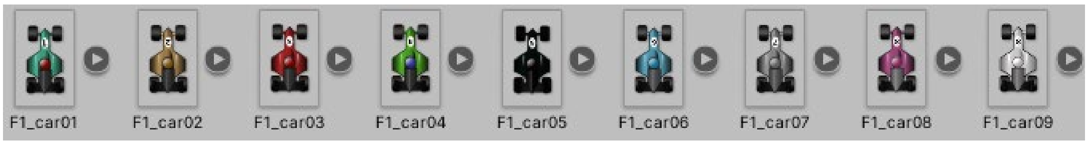

Figure 13. Race Game Edited Cars

A second check with a person with a different type of colour blindness gave me the insight that out of those 9 cars, these 5 were the most distinct: 3, 4, 5, 6, 9. Overall, this person experienced that most games do not care for colour, and black and white are found to be good colours to use because these are always visible for them. However, the first test person thought 3 (red) and 5 (black) were much alike, so one of those should go. To keep in different colours for the non-colour blinded, I made the choice to keep red and discard black, as can be seen in Figure 14.

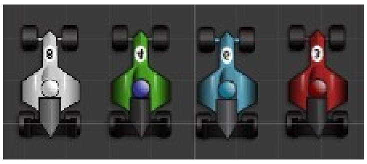

Figure 14. Race Game Cars Selection 2

[13] https://assetstore.unity.com/packages/2d/textures-materials/f1-speed-car-pack-56098

Testing for colours was found to be very helpful for designing the game. Out of the three options of car sets, the last set (with the white car) was preferred by both persons with a different form of colour blindness.

Testing for Size

During testing the android application on the phone, I found out that the cars needed to be a lot bigger if I ever wanted to grab these with four fingers. Thus, the background, cars and finish line were scaled larger. This is probably also needed for the interactive playground, as there is also limited resolution in recognition there. I also found out that I accidentally flipped the images over the Y-axis, that's why the numbers were mirrored in Figure 10, Figure 12 and Figure 14. With those fixed, it looks like Figure 15.

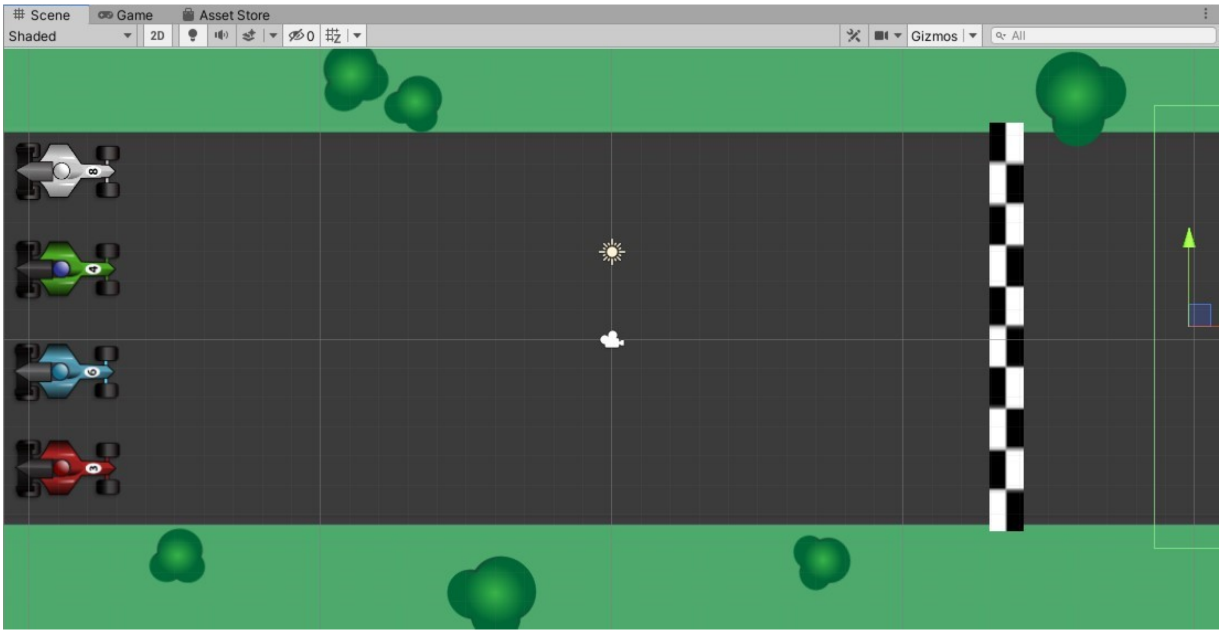

Figure 15. Race Game Cars Not Mirrored

After this scene, a single player scene was added in Figure 16, with a different road with a curve in it. The U-shape was chosen because

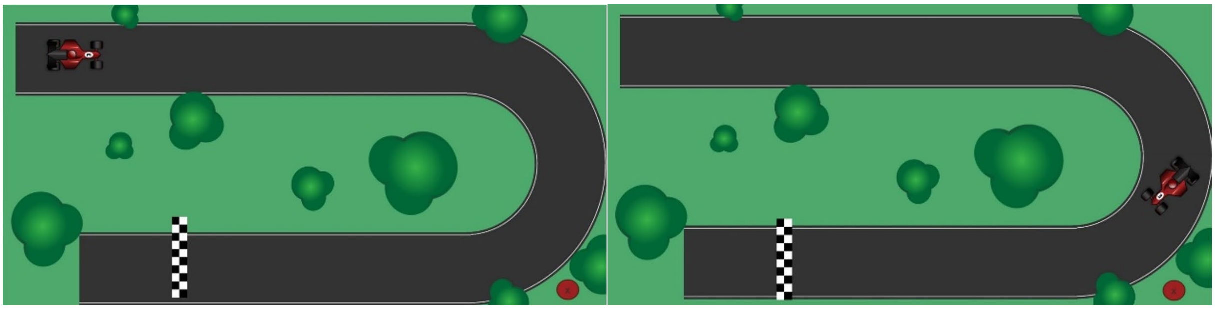

Figure 16. Race Game Single Player

After that, a curved road was created for multiplayer in Figure 17.

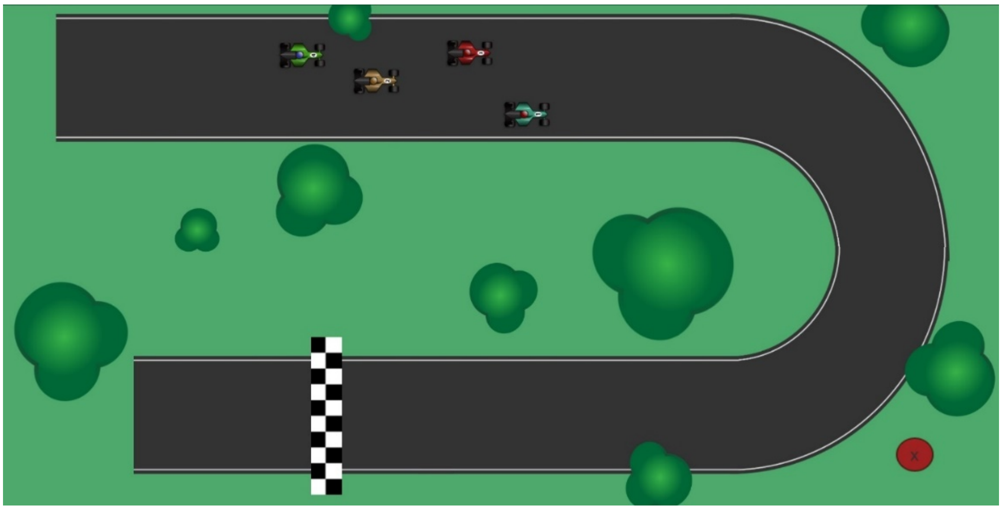

Figure 17. Race Game Multiplayer Curved Track

Lastly, a menu overlay was created to easily switch between different scenes with more ease. This can be seen in Figure 18.

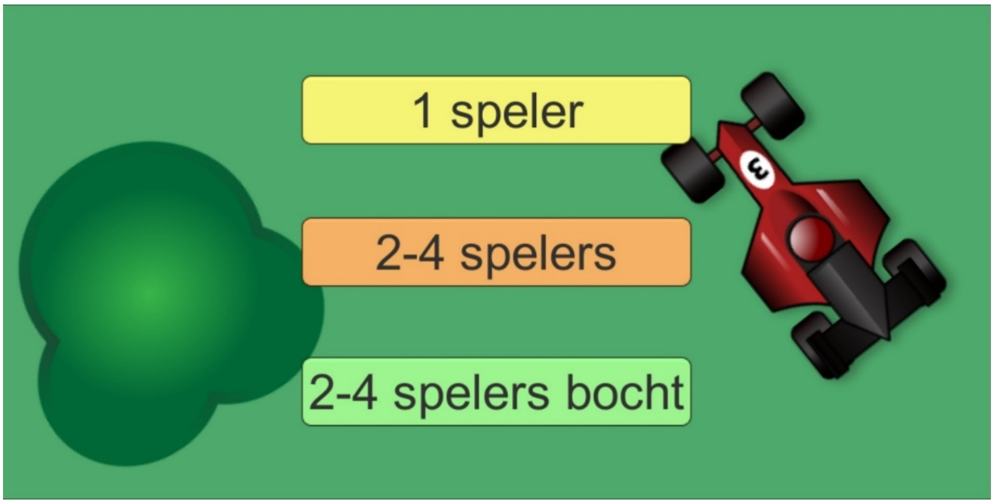

Figure 18. Race Game Menu

Three Different Systems

The current state is the game as in Figure 15. The adaptive version includes options for the size of the cars, which can be changed within Unity as of right now. It also includes different tracks: a straight track for fast running and a curved track for practising running and turning together. For the static version – a version without technology – I thought of creating a race track parkour in a gym, with obstacles and a finish line. The therapist could use a stopwatch to time children in running. He could also let the children have more variation in the race by making them crawl the parkour, or letting them walk backwards.

Paper.io

The idea for Paper.io is based on the original game Paper.io 2[14], depicted in Figure 16. The original game has many different colours as there are many players in this game. The initial idea is displayed

[14] https://play.google.com/store/apps/details?id=io.voodoo.paper2&hl=nl

in Figure 19, my interpretation for the game in Figure 20. This game initially only had four colours as the therapy sessions include a maximum of four children.

Figure 19. Gameplay Real Paper.io 2. Image retrieved from: https://play.google.com/store/apps/details?id=io.voodoo.paper2&hl=nl

Figure 20. Paper.io Initial Idea

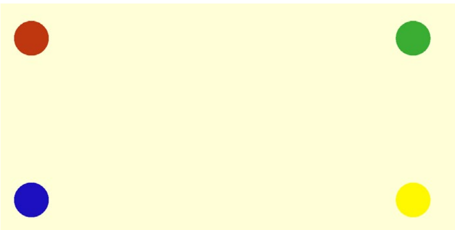

Figure 21. Paper.io First Colour Iteration

After a lot of trial and error, it became clear that it was not the best option to draw dots per frame count. I got stuck on this for a really long time. The supervisor gave the idea to search the web for tutorials on how this particular game was created. Luckily, there was a tutorial[15] that covered most of the basic game elements. Sometimes it can be beneficial to use an existing game early on after getting stuck, and change it slightly, to create a new game (Schell, 2015).

[15] https://www.youtube.com/watch?v=JzYqnqq6Hg4&list=PLv8eWYqL8247qpZqvTC5wdsSKl6PSB6n6&index=11&t=661s

Colours

The colours of my idea depicted in Figure 20 and Figure 21. were hard to see for someone with colour-blindness. The colours in Figure 22, Figure 23 and Figure 24 were more clear. The colours in Figure 25 and Figure 26 were even better.

Previously, I thought that the maximum amount of players would be four players. But, working on the tutorial used to create this game, I found out that there was a built-in AI opponent. This could come in handy during therapy sessions, as children could also team up to overpower the AI opponent. So I kept this in. The idea behind this is that now the therapist can choose how many children enter the game (out of 5) by letting them stand on the dots. The dots that are not selected by children will become AI opponents. This way the game can be played single-player as well as multiplayer.

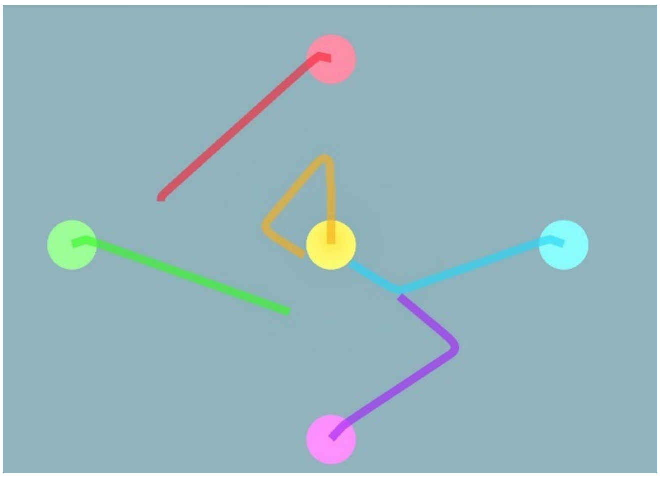

Figure 22. Paper.io Five Player

In Figure 21, the start of the game is depicted. Every player starts in their own circle. When they walk out of their circle, they leave a semi-transparent trail behind. Once they reach their own colour again, the area that they surrounded with their tail will be filled with their colour. This can be seen in Figure 22.

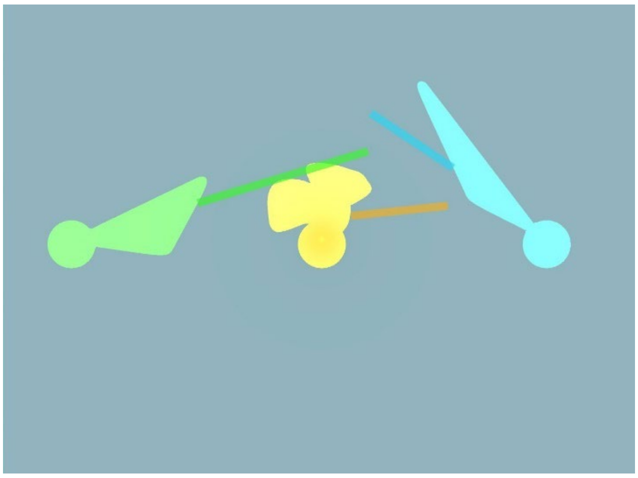

Figure 23. Paper.io Kills

Killing

In Figure 22 can also be seen that certain colours (red and purple) are not existing anymore. In the original Paper.io game, a player can kill another player by walking through its tail. If a player gets killed, their colour disappears. In real life, using the playground, this would probably be very demotivating for children. Also, children that got 'killed' will not be active in the game anymore, which we explicitly try to avoid. That is why I chose to remove the option to kill anyone in the game.

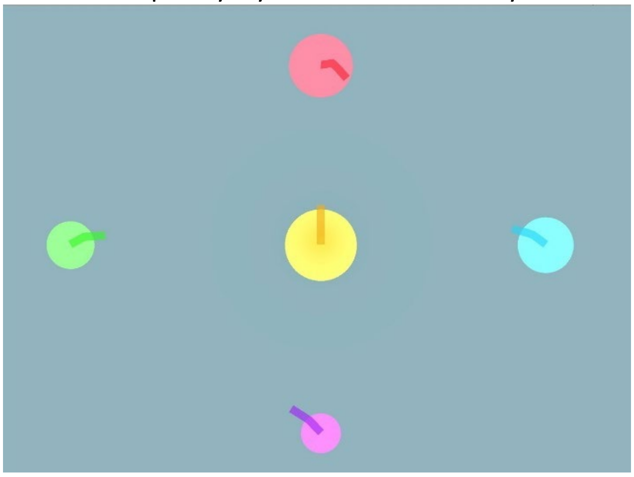

Figure 24. Paper.io Adaptive Settings

In Figure 24, it can be seen that settings were changed for each player. Some players start in a larger area, as others start in a smaller area. The therapist can change these settings depending on children's needs.

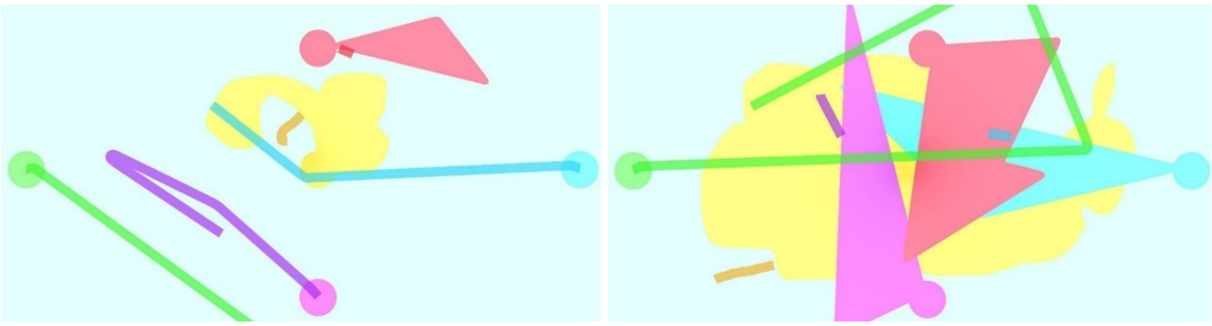

Figure 25. Paper.io Five Player Bright Background

After this, I changed the screen size, which can be seen in Figure 24 and Figure 25. I also made the background lighter to see how this works with the colours. However, after some testing, the darker variant worked better in my opinion.

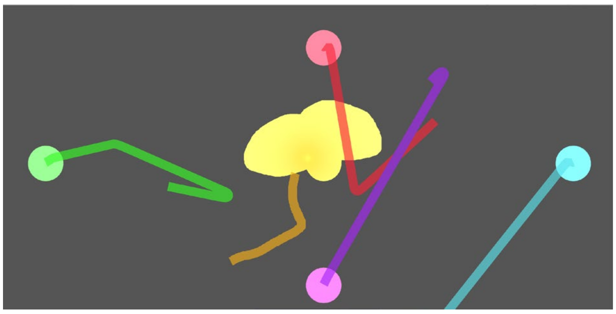

Figure 26. Paper.io Five Player Dark Background

Coding

I used a lot of tutorial code, but edited it to fit the idea better. Players' speed were set slower. Also, as mentioned above, players could not kill each other anymore, because killing would imply that a player would not be moving anymore. The camera was changed to world view, because it initially zoomed in and followed the (only) player. The perspective was also changed to top-view instead of 3D. The reason behind this was that the 3D version might be a bit confusing when displayed on the ground, as it shows 'walls' from a weird perspective depending on where a player is standing on the floor.

There are still some bugs within this game. Removing the killing part creates a void for what happens if players cross tails. Also, as of now, if one player decides to enclose the entire screen by walking around the edges, the whole screen turns their colour, and other players' colours are not visible anymore until they 'encapsulate' an area by connecting it to their own colour (which is not visible anymore). This might be tackled by giving players the option to 'kill' each other's tail. A player would walk over another player's tail, which then starts blinking and disappears. The other player has to get back in his colour area to get his tail back and conquer area again.

The last bug regards the area in percentages; I could not get my code to count the player area percentage. Also, right now people could walk out of the area (sometimes the AI opponent does this). A solution might be to create walls surrounding the playing field and a grid layer over the playing field, and then check for each square in the grid which colour it (mostly) has, count the squares per colour and then give an indication of which colour player has the largest area. This could be adapted in such a way that players work together to beat the AI opponents by conquering an x amount of the area.

Three Different Systems

For the three different systems within the Paper.io game, I thought of the current system as depicted in Figure 26. Children join the game by standing on a dot. The dots that are not selected, will become AI opponents. The adaptive version is likewise, but here the therapist can change settings in the Unity screen so that the starting area gets bigger or smaller per child. This way, children that need some extra help could start in a larger area, which makes the game more balanced when looking at average skills. For the static, non-tech system I thought of creating a field with hoops on the floor. Small coloured bags will be put in a basket on each hoop corner on the floor. Children use their own colour bag to conquer the hoops. When all hoops are conquered, the player with the most conquered hoops in their colour wins. I thought of a lot of variations for this: they could only carry one bag at a time, they could remove their opponents' bags from hoops, they could only fill hoops of their own colour, they have to throw the bags instead of bringing them to the hoops, they throw their bags on other coloured bags to conquer that specific hoop.

Chapter 7. Evaluation & Discussion

This chapter will focus on the evaluation of the two created games and presenting those to the client. It will explain the testing setup, the semi-structured video-interview and the results of proxy-testing. Ideas of the client for better implementation of the games will be discussed.

This chapter aims to answer the following research questions:

- *How does the interactive playground intervention enhance automated motivation compared to regular therapy sessions?*
- *To what extent do experts think children with DCD will experience more autonomous motivation towards physical activity through the use of*
  - *d) the current system (interactive playable games for the playground)*
  - *e) an adaptive system (supports adjustments of the player variables)*
  - *f) a static system (no interaction; projected virtual playing field)*

  of the interactive playground intervention?

Testing Setup

The evaluation of the games is an important part of this graduation project in order to answer the main research question. Due to COVID-19 restrictions, testing could not be done physically with the client and children with DCD. Therefore, testing was done via a structured video-interview with the client as proxy tester. The client was asked to use his expertise to answer how children with DCD would react. The audio of the video-interview was recorded, so the researcher had enough time to ask questions and get answers without having to put the answers on paper right away.

During this video-interview, the two games were shown via screen casting. The technical setup included a multi-touch device (phone) connected to a laptop via an USB cable, which was used as a remote for the games opened with the program Unity, displayed on an external screen. This way, within a Skype-call, screen casting with only the external screen was possible, while the laptop screen was used for the video sharing. The researcher used multi-touch on the phone remote to move the player objects in-game.

During the explanation of the two games, first, the current system of Race Game was showed. Then the current system of Paper.io. Then the adaptive system was showed, in which the researcher changed settings in Unity. Then the adaptive system for Paper.io was showed in a same way. The static version of both games was explained to the client during the video-interview.

The questions used in this structured interview can be seen in Appendix 2: Interview Client on Prototypes.

Proxy Testing Outcome

How does the interactive playground intervention enhance automated motivation compared to regular therapy sessions?

In order to be able to compare this, it should have a clear reference of what it is comparing with. Therefore I chose to ask the client (Dijkstra, Personal Communication, July 20, 2020) to answer questions based on autonomous motivation towards physical exercise on a scale of 1 to 10.

The client concluded:

- **Regular therapy** scores 6-7. Sometimes it scores an 8-9 if methods are really effective for a child, sometimes only a 4 if a child needs a lot of help and does not show any initiative. It really depends on the child, and if the child gets help in a more broad sense with multiple different specialists, such as speech therapists and ergotherapists.

- **Previous RE-Play project games** on the interactive playground score a 6, but only if the system works. There are a lot of technical difficulties which sometimes make it impossible to get it up and running. This doesn't add to children's motivation. Long-term, it probably won't work as well in increasing autonomous motivation.
- **Other projects** the client is a part of score an average of 7 in motivating children. Some projects work really well, while others don't help at all. It really depends on if the child gets help in a more broad sense with multiple different specialists and coaches in school.
- **Race Game** and **Paper.io** score a 7-8. They seem fast in motivating children right away: children will see the games and immediately want to try them out. It will work best short-term, because kids like to try new things. However, it has to be embedded in a larger program with parental help, coaching and lifestyle advice in order for it to have long-term effect. The RE-Play system is really strong in motivating children right away.

The client was really enthusiastic about the static system of Paper.io. However, during the interview, it became clear that the client did have a technology based version in mind for the static system. It was discussed what kind of version this could be. Based on the client's input, the static version should include some sort of projected floorplan that doesn't move on itself. The client concluded that this static version could have added value, because not much has to be set up for this version. It could save time, he thought.

To what extend does the client think children with DCD will experience more autonomous motivation towards physical activity through the use of

a) the current system (interactive playable games for the playground)
b) an adaptive system (supports adjustments of the player variables)
c) a static system (no interaction; projected virtual playing field)
of the interactive playground intervention?

The client thinks the adaptive system is the most promising in increasing autonomous motivation towards physical activity in children with DCD, because editing parameters based on a child's needs could balance the game in such a way that children will experience more competence and autonomy. It gets easier for the children that need it, which gives them more successful experiences.

According to the client, the static system gets second place. This is mainly because it combines attributes used in regular therapy with technology in the form of a displayed floor. This could create more autonomous motivation, as the floor could be set in a theme that fits the interest of the children. Within this static version, there is a lot of room for differentiating difficulty levels per child. This way, a child could experience more competence and autonomy, which will help with their view of self and could boost their self-esteem. Because the floor seems fun, and the exercises fit their needs, the children may experience more autonomous motivation for physical exercise. Lastly, this static version could also be used without the interactive playground system itself, through the use of multiple projectors.

The current system gets third place in increasing autonomous motivation in children with DCD, because the RE-Play is really strong in motivating children right away. However, some children need more help than others and have a need for the games to be less hard, else they would not experience successes. Games tend to work best if they are really easy to understand and could be played without extensive explanation. Some of the previous RE-Play project games need more explanation, which makes it harder for the child to experience motivation towards exercising. As moving is difficult for these kids, the games shouldn't also be mentally hard. So for the current system: children will like the games immediately and immediately feel autonomously motivated to engage in physical activity, but autonomous motivation levels will also immediately drop if a child has the feeling that he/she isn't good at it or can never win. Therefore, autonomous motivation for the playground's physically induced exercise could actually get lower.

Overall, the client preferred Race Game above Paper.io. Race Game will probably work the best. Paper.io seemed like less fun, according to the client, but that could also be because it felt less finished. The client concluded these interactive playground games would be a good addition to regular therapy, but should only be used as such – additional but not replacing regular therapy. The games should be used in that context, he said.

Remarks Client

The client said that if I made something so simple that children could understand it right away, I've done great. He thinks I did that with these games.

For Race Game, it would be nice to have a track on which children could run multiple laps. Maybe even with own lanes for each child. This way not only fast speed is being trained, but also durability and preciseness. The adaptive version should include bigger and smaller race cars and something should happen when they almost bump into each other. Also, let children compare their own rounds with their previous rounds. This way there is less competition amongst children and more competition within children. It would be nice if children could see that they are doing better than the previous round: they are x seconds faster.

For Paper.io, the client thought it was important to mention that the design specifically made sure that all children are included all the time (not 'killing' each other). It would work better when all kids are included. He also thought it would be better to display concrete words instead of percentages. He expects the children to understand concrete positive words better. For example, 'super big, mega large or ultra large' would be good terms. So, not exact values, but positive words about the sizes. The client also thinks some aspects might work less, because of the way the interactive playground senses children's positions. If children walk really closely together, sometimes the digital players switch or one player gets left out. This has to be taken into account.

Previous RE-Play project versions also included a wearable to track progress. The client expresses that this activity sensor could be used to check activity, for example for Race Game, at the beginning of an intervention (multiple sessions), at the middle and at the last session. Then you can check with the activity sensor if they got better. You can also check if children exercised more at home. For Paper.io, it is harder to check children's condition levels.

Reflection Testing

In this section, there will be reflected on playtesting, the interviews and some game aspects.

Due to COVID-19, physical testing wasn't possible. This had a huge implication on this project, as the initial goal of this project was to extensively test existing games using the interactive playground in combination with children with DCD. For more information on this, check out the COVID-19 chapter in Appendix 3: Ethical Analysis. Also, interviews were conducted with merely three experts, and playtesting was done with only the client, because the experts that were previously interviewed could not fit playtesting into their schedule at the time.

Although it was explained at the beginning of the interview how movement was simulated through multi-touch on a phone connected to the system, the client seemed to have forgotten this during explaining Race Game. He seemed really confused that there were multiple cars driving at the same time. This could have been explained better.

Originally, the intention was to answer research questions based on autonomous motivation beyond the scope of the RE-Play system. I chose to not include this 'beyond the scope of', because there is no way for me to test if this would really be the case. Longitudinal research would be needed in order to answer this type of question. Therefore, I kept it on autonomous motivation. Also, I generalised different forms of motivation into autonomous motivation, because I think it would be really hard to test such a thing without testing it with the actual children. Intrinsic motivation, for example, can be really different for each child, just like any other type of motivation state.

I chose to not include sounds for Race Game and Paper.io. At first, I wanted to include race car sounds for Race Game, but this would probably be really loud and chaotic in multi-player if each car makes a sound. Sounds if someone reaches the finish line would probably distract children when racing; if someone else finishes, that ping sound you hear means you have probably not finished first. If sound would be included, I think all parts of the game should have sounds, not just the finish or start.

Most of the transformational games, such as Race Game and Paper.io, are experimental. It is hard to say for sure that the games change behaviour. Out of the five levels of assessment, stated in 'The Art of Game Design' (Schell, 2015, p. 509), these two games fit the first three levels best: 'feels like it', 'Anecdotes' and 'Subject Matter Experts (SME) approval'. These assessment levels, aren't really proof that the two games are working well for increasing autonomous motivation in children with DCD, but it is, however, a strong indicator that they are on the right track.

Pro's and Con's Playtesting Using Smartphone

Playtesting with a smartphone can come in really handy. Here is a list of pros and cons for playtesting with a smartphone.

Con's

- A smartphone just represents the interactive playground. It implies artificial movement, as finger movement is different than mouse movement or body movement.
- It is hard to see what is going on for the client. Because the client couldn't see that I was moving multiple fingers on my phone's screen, he got confused to see multiple cars moving on screen at the same time. This could be tackled by also showing where you put your fingers on the screen. However, this is hard on a smartphone, because fingers will probably hide important game aspects, but this should work on a tablet.
- There is a big difference in resolution and visibility compared to the interactive playground. On a phone it is really clear, on the interactive playground it is probably less clear.
- There is a difference in detection of movement. A phone's finger detection is really precise and accurate. The interactive playground has some technical issues, for example when players walk too close to each other.

Pro's

- A smartphone is really easy to use.
- Testing can be done really fast.
- Hardly any set-up time. The Unity Remote 5 app works really well. Just click on play within Unity on your laptop, within 5 seconds the game will be displayed on your phone.
- There is instant feedback. Feedback can also be screen-recorded on the phone, as well as on the laptop screen.
- If something goes wrong, restarting the prototype takes mere seconds.

- No large slow computers needed for processing power.
- Testing from different locations, even at the other side of the world, is possible.

Chapter 8. Conclusion

This chapter will focus on answering the research questions an drawing conclusions from it. These sub-questions that will be answered below all help to answer the main question:

To what extent does a physiotherapist think children with DCD will experience more autonomous motivation[16] towards physical activity compared to regular therapy sessions, induced by the current, adaptive and static state of the interactive playground intervention games?

- *What are the implications of DCD on children's daily life?*

Developmental Coordination Disorder (DCD) is a chronic neurological developmental disorder that impacts motor skills. Children with DCD fail to reach certain developmental stages (American Psychiatric Association, 2013). Multiple studies showed low self-esteem and/or obesity as implications for children with DCD (Eggleston, Hanger, Frampton, & Watkins, 2012; Peens, Pienaar, & Nienaber, 2008; Farmer, Echenne, & Bentourkia, 2016; Pless, Carlsson, Sundelin, & Persson, 2001; Wagner, et al., 2011; Zhu, et al., 2014). DCD symptoms can be a factor for children to become obese, and obesity can be a factor for experiencing severe DCD symptoms in adolescence. Motivating children with DCD to become more physically active might be of great importance to tackle low physical fitness later in life.

- *What type of interventions are used for children with DCD?*
- *What do physiotherapists' and ergotherapists' interventions for children with DCD without the use of technological advancements such as the interactive playground look like?*

Physical health therapists aim to improve motor skills in children with DCD through motor training intervention. Often, the child will be helped by a team of experts: ergotherapists, physiotherapists, speech therapists, creative therapists and remedial educationalists. Treatment through interventions by physiotherapists and ergotherapists is mainly focused on specific requests for help, based on actions the child struggles with. First the team focusses on what goes wrong: does it have to do something with attention, coordination, balance or fear? Knowing this, the team can focus on helping the child. Most interventions for children with DCD that show improvement consist out of pure motor-based intervention, integrated psycho-motor intervention and/or psychologically based intervention, but a combination of these seems to be most effective (Peens, Pienaar, & Nienaber, 2008; Pless, Carlsson, Sundelin, & Persson, 2001). Interventions that aim at success instead of failure tend to work well within children with DCD, as these success experiences might enhance competence and self-worth (Ericsson, 2008; Peens, Pienaar, & Nienaber, 2008; Wilson, 2005). Motivating children with DCD seems to be an important part of therapy as it is needed to change behaviour.

- *What types of motivation are there?*

Motivating children with DCD seems to be an important part of therapy as it is needed to change behaviour. Motivation is defined as all brain processes that energise and direct behaviour (Michie, van Straalen, & West, 2011). When looked at from the Self-Determination Theory (SDT), a macro

[16] ***Autonomous motivation:*** *both intrinsic and some types of extrinsic motivation where people have identified with values of an activity in such a way it integrated into their sense of self* (Deci & Ryan, 2008)*. People get a feeling of self-endorsement of their actions if they are autonomously motivated.*

theory of human motivation and personality concerning inherent growth and innate psychological needs, it explains (intrinsic) motivation behind choices people make as a result of the basic psychological needs: autonomy, competence and relatedness (Ryan & Deci, 2020). Motivation can be divided into intrinsic and extrinsic motivation (Deci & Ryan, 2008; Ryan & Deci, 2020). Ryan & Deci (2020)created the Self-Determination Theory's Taxonomy of Motivation, in which extrinsic motivation is then divided in subsections: external regulation, introjection, identification and integration. It seems they created a scale on which amotivation turns into extrinsic motivation, and then from external regulation it crosses over into (internal) intrinsic motivation through internalization. Activities done for one's own sake or for inherent interest and enjoyment are seen as intrinsic motivation. Extrinsic motivation is often seen as the opposite as internal and intrinsic motivation and concerns activities or behaviour done for other reasons than one's own interest, but internalisation of motivation already happens during extrinsic motivation.

- *What is autonomous motivation?*

Motivation can also be divided into autonomous motivation and controlled motivation. Deci and Ryan (2008, p. 182) eloquently describe the nuances of autonomous and controlled motivation:

> ***Autonomous motivation*** *comprises both intrinsic motivation and the types of extrinsic motivation in which people have identified with an activity's value and ideally will have integrated it into their sense of self. When people are autonomously motivated, they experience volition, or a self-endorsement of their actions.*

- *How can technological advances be used to enhance motor skills in children with DCD?*

It has been found that different types of technology might positively influence symptoms as writing skills and balance (Klein, et al., 2008; Snapp-Childs, Mon-Williams, & Bingham, 2012; Stromer, Mackay, Howell, McVay, & Flusser, 1996; Sugasawara & Yamamoto, 2009). Also, motivation towards physical activity might be tackled with the use of (active) video games (Gonsalves, Campbell, Jensen, & Straker, 2014; Ju, et al., 2018). However, most state of the art mobile games and gaming applications do not use behavioural technology when creating their games, although when theory is used, games tend to have a larger effect (Tabak, Dekker-van Weering, van Dijk, & Vollenbroek-Hutten, 2015). Behaviour change techniques (BCTs) used in those reviewed mobile games and gaming applications were: prompt (specific) goal setting as a motivation strategy for engagement, provide feedback on performance, provide general encouragement (rewards) and provide opportunities for social comparison (competition) (Tabak, Dekker-van Weering, van Dijk, & Vollenbroek-Hutten, 2015). The BCTs on itself tend to work well based on literature (Abraham & Michie, 2008), although the use of it for gaming applications should be researched further. Overall, the use of behaviour change techniques may positively influence mobile gaming applications in such a way that technological advances can be used to enhance motor skills in children with DCD.

- *How can autonomous motivation be enhanced according to an adult diagnosed with DCD?*

Based on personal experience of an adult with DCD (Personal Communication, April 30, 2020), autonomous motivation could be enhanced by positive feedback, praise, expressing acknowledgement in someone's efforts, give extra time to complete tasks, break tasks down into small steps and a lot of repetition with successful experiences.

- *How do physiotherapists and ergotherapists promote motivation for physical activity in children with DCD?*

According to the people interviewed (Physiotherapist and Ergotherapists, Personal Communication, May 14, 2020; A. Dijkstra, Personal Communication, June 16, 2020), these things seem to be important in enhancing motivation amongst children with DCD:

- Use a child's interests in therapy sessions
- Breaking it down into smaller steps
- Start with things a child (knows it) can do
- Succesful experiences
- Let the child think about their own goals and reflect on them (Stop-Think-Do method)
- Repetition
- Rewards and praise

- *To what extent do experts think children with DCD will experience more autonomous motivation towards physical activity through the use of*
  - *the current system (interactive playable games for the playground)*
  - *an adaptive system (supports adjustments of the player variables)*
  - *a static system (no interaction; projected virtual playing field)*

  of the interactive playground intervention?

The client thinks the adaptive system is the most promising in increasing autonomous motivation towards physical activity in children with DCD, because editing parameters based on a child's needs could balance the game in such a way that children will experience more competence and autonomy. It gets easier for the children that need it, which gives them more successful experiences. According to the client, the static system gets second place. This is mainly because it combines attributes used in regular therapy with technology in the form of a displayed floor. Within this static version, there is a lot of room for differentiating difficulty levels per child. This way, a child could experience more competence and autonomy, which will help with their view of self and could boost their self-esteem. The current system gets third place in increasing autonomous motivation in children with DCD, because the RE-Play is really strong in motivating children right away. However, some children need more help than others and have a need for the games to be less hard, else they would not experience successes. Games tend to work best if they are really easy to understand and could be played without extensive explanation. Children will like the games immediately and immediately feel autonomously motivated to engage in physical activity, but autonomous motivation levels will also immediately drop if a child has the feeling that he/she isn't good at it or can never win.

- *How does the interactive playground intervention enhance automated motivation compared to regular therapy sessions?*

According to the client, previous **RE-Play project games** on the interactive playground are placed slightly below regular therapy sessions, but only if the system works. There are a lot of technical difficulties which sometimes make it impossible to get it up and running. This doesn't add to children's motivation. **Race Game** and **Paper.io** tend to score slightly higher than regular therapy, according to the client. They seem fast in motivating children right away: children will see the games and immediately want to try them out. It will work best short-term, because kids like to try new things. However, it has to be embedded in a larger program with parental help, coaching and lifestyle advice in order for it to have long-term effect. The client states that it could be used additionally, but not as therapy replacement. The RE-Play system is really strong in motivating children right away.

Chapter 9. Future Work

Even though the results of project seem promising, there is still some additional work that has to be done. The games should be implemented in and tested on the real interactive playground, as for now it is only tested using a smartphone.

Due to COVID-19, the games could not be tested on an actual interactive playground, with actual children with DCD. It is important that this is tested further in order to research if children actually experience more autonomous motivation regarding physical activity.

A wearable with an activity sensor could be used to check activity levels of children with DCD during interaction with the playground to check if children's activity levels improve during the intervention. The wearable can also be used at home to see if children are actually more involved in physical activity beyond the interactive playground. Preferably, this could be longitudinal and/or clinical research.

Regarding autonomous motivation, this project has used different types of motivation collectively, because without testing it with real users, it would be hard to conclude anything for these different types of motivation, as how children experience these types also differs. More clear implementation of behaviour change techniques could help. Therefore, it is advised to conduct tests more focussed on different types of motivational experiences, perhaps in another graduation project of someone with a psychological background.

There are also some additional features that could be implemented in future work. Sounds could be included and tested with children. Race Game could include a track on which multiple laps can be done. Paper.io needs a lot of extra work (see Chapter 6. Realisation: Paper.io). Also, sliders for parameters should be built in-game, so therapists can change settings easily. The static system is not worked out technically, but this could easily be done in ways that are explained in Chapter 7. Evaluation & Discussion. The static system could probably also work really well in different settings, for example in a classroom, sports club or during P.E. class. All of these small things add up to large changes that can be used as main input for another Creative Technology student's graduation project.

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Appendix

Appendix 1

Overview of Existing Games

Title	Description
Block Dodger	Blocks will come rushing towards the player at various speeds, with every level getting more intense. Quickly dart through the gaps until you have completed all six levels.
Buzz	The player(s) is/are dropped in the middle of the jungle, surrounded by bees. By catching the bees, players can compete to achieve the highest score.
Cat Game	Players are tasked with hatching as many bird eggs as possible, whilst scaring away the cats that are trying to get to the eggs first.
Coin Collection	While the game features various game modes, the general gameplay revolves around collecting more coins than the other players or the other team.
Dragons Dungeon	The Dragon’s Dungeon is a digitally augmented version of the classic playground game Red light, green light. As the dragon starts to wake up, the three areas on the field become off-limits in order of difficulty. The goal is to obtain the highest possible score, either individually or as a team.
Pong (DIPP)	An implementation of the old arcade classic; every player controls their own bar, which can be used to bounce the ball back to the other side. A variation exists in which two players have to work together to control a single bar.
Rock Paper Scissors	A digital version of the classic game of Rock, Paper, Scissors. As one of the three symbols moves towards the player, they must choose which response to pick before the symbol reaches the bottom of the screen.
SyncJump	Players must jump exactly when the game tells them to. Be careful to time your jumps carefully, however, as jumping at the same time as everyone else will reward the players with nice visual effects.
Tag	A digitally augmented game of the playground classic of the same name. One player is chosen to be *it*; this player will have a red circle, and their goal will be to touch another players circle in order to turn that player into *it*.
The Floor is Lava	Players compete for control of the various rock platforms scattered around the map, all while avoiding the lava as much as possible. Stand in the lava for too long, and you’ll temporarily get knocked out of the game.
Uncover	An image is hidden behind a dark layer. Help uncover the image before the times runs out, by removing the darkness as you walk across the playground.
Vote	A number of voting options are shown on the screen, such as PC vs Console and Introvert vs Extrovert. It is up to the players to give their vote on each of the choices, sparking dialogue between the players based on their choices.

Appendix 2

Semi-Structured Interview Scheme Ergotherapist and Physiotherapists

- Kun je kort iets over jezelf vertellen?
- Hoe ziet de behandeling van een kind met DCD er uit? (in het kort)
- Wat zijn belangrijke materialen die gebruikt worden?
- Vanuit welke theorie werk je?
- Ik vond in de literatuur dat er veel gewerkt wordt aan motivatie omtrent bewegen. Hoe ziet dit eruit tijdens de behandeling? Wat doe jij om motivatie voor bewegen te verbeteren?
- Wat zijn je meest effectieve behandelingsmethoden?
- Welke technologieën zet je in tijdens de behandeling?

To get an idea of the impact DCD has on one's life and what this does for motivation towards physical activity, an adult male (age 25-30) with the DCD diagnosis was interviewed. He got the diagnosis when he was 23 years old. He always thought he was just extremely clumsy. This part aims to answer the question: What are personal experiences regarding motivation during childhood for an adult diagnosed with DCD?

During his childhood he struggled a lot with motor skills. He always had bruises that he could not explain, and nearly every time he came home from playing outside he'd have wounds and was bleeding somewhere. Participating in physical activities was very hard for him. Even though he wasn't diagnosed as a child, teachers recognised his lack of motor skills and decided to give him extra personal attention by physical exercise interventions in their local gym. This didn't help him at all, because all the exercises they gave him were so hard for him he just wanted to run away. An example he gave was that he had to do a head roll, but even after seeing someone perform one and someone teaching him how to move, he wasn't able to do one and the teachers just didn't understand what was wrong so they gave up. This was also the same for swimming – after three years of swimming class, he never even got one diploma. He said that he could learn to 'swim' for a day, but if he has to repeat these motor skills the next day, he wouldn't know how to.

Writing was – and still is – something he struggles with. It took him way more time to finish writing assignments than his peer students. Because the writing movement didn't come natural, he always had sore hands after a writing exercise because "his muscles tried so hard". There was one year in elementary school where he got a few 10s as a grade for writing. He said that that was because he had an amazing teacher that gave him extra time and that could motivate him to do his best. But, after getting a new teacher, his grades for writing dropped again. The teachers didn't seem to understand him. Later, in high school, he was the first person in the entire history of the school that got a fail (grade: 4) for drawing class. The teacher got mad at him and told him he drew like a four-year-old. The teacher said that He couldn't be serious drawing those abominations, he probably thought He was making a fool out of him. This almost caused him to have to drop the gymnasium school he was in, but eventually they made an exception for him so he could continue the next year. Nowadays, He still struggles to read his own handwriting.

Even though He wasn't diagnosed with DCD until later in life, he got group therapy for his bad motor skills. At age 8 he was diagnosed with ADHD, this led him to have to participate in the group therapy for children with ADHD and/or Autistic Spectrum Disorders. He explained that he had to do some balance exercises and exercises that aimed at improving self-esteem. For one of the exercises, he had to pretend to be a tree. These group exercises were traumatic for him, He said he was definitely more aware of his bad motor skills because of it. This being more aware of one's motor skills was also found in literature for children of age 6-8 with DCD (Pless, Carlsson, Sundelin, & Persson, 2001)

(Farmer, Echenne, & Bentourkia, 2016). Luckily, he didn't have to participate in the group therapy sessions after that day. He did state that it made him realise that even though his motor skills were bad, there were a lot of children in that group that were even weirder than he was, which made him put his skills in perspective.

In high school, He just didn't went to physical education classes. He was really demotivated to exercise and he was ashamed others might find him weird if he participated. In his entire high school period, he went to classes around two times a year, and he always sat on the bench and never participated. He still doesn't play any type of sports.

Nowadays, He still struggles with a lot of motor skills. He types on a computer way slower than average, especially when he hasn't done that for a few days. He spills drinks and foods a lot, especially coffee. He once accidentally threw coffee on the highest boss at work. He spills coffee on his clothes a lot: "I have a coffee stain on my shirt right now, which you cannot see right now because I professionally put a shirt on over it". He also struggles with walking, especially when avoiding obstacles or having to stop walking suddenly, he concludes that he "tripped over air".

He also had some success experiences. He played the guitar for a while and got quite good because he was extremely motivated, but this only worked well when he kept playing every day, as he seemed to lose his ability to play when he didn't play for some time.

Since He got his DCD diagnosis, puzzle pieces seemed to fall in place. He always felt out of place and ashamed, and this caused him to have low self-esteem. Now he got an explanation for his uncoordinated behaviour. This diagnosis also helps others to understand him. At work, for example, he always explains to his colleagues that he is "just very clumsy". Colleagues mostly respond by telling him they are clumsy too, but then they get to experience that He's clumsiness is on a way different scale. When He knows people better, and his actions tend to seem weird to others, he tells them that he has DCD.

This interview gives a good example of the implications DCD has on daily life that were also found in literature: low self-esteem, avoiding physical exercise and struggling with daily life skills. It also shows that motivation is a big factor to do learn to do something.

Interview Client on RE-Play Interactive Playground games

Je hebt nu een paar keer gewerkt met de interactive playground.

- Met wat voor een doel gebruik je die?
- Hoe denk je dat dit kan helpen bij kinderen met DCD?
- De playground zou in moeten spellen op motivatie om te bewegen. Op wat voor motivatie? Intrinsieke?

Het doel van mijn project was eigenlijk om de interactive playground spellen zo aan te passen dat er drie versies waren:

  - Een statische versie (eentje die het altijd doet - maar niks meet en geen beweging detecteert)
  - Een dynamische versie: het spel past zich automatisch aan aan de kinderen
  - Een aanpasbare versie: adaptive system (hierin kan je zelf aanpassingen maken voor/tijdens het spelen)

- In voorgaande projecten zijn deze versies ook kort aan bod gekomen. Klopt deze insteek met wat jij hiervan verwacht?:

- Wordt er buiten deze projecten om ook gebruik gemaakt van de interactive playground? Hoe dan?
- Welke spellen werden het liefst gebruikt?
- Wat verwacht je van zo'n spel?

Interview Client on Top Three Games

Mijn doel is nu om zo'n spel te maken met die drie versies. Vanwege covid-19 kan ik dit niet fysiek testen, dus ik zal een applicatie maken die een soort nep-versie van de playground moet voorstellen. Hiermee ga ik mijn project dan testen - niet met kinderen maar met jou (en hopelijk een andere fysiotherapeut en ergotherapeut).

- Wat verwacht je van zo'n spel? Wat moet het kunnen? Hoe moet het eruit zien?
- Wat moet er NIET in zitten?
- Wat speelt er onder de kinderen? Wat vinden ze leuk? Wat motiveert ze?
- Wat willen de kinderen leren?
- Help je ook meisjes? Zijn er kinderen die kleurenblind zijn?

Spellen voorleggen:

  - Racewagensprint
  - Landje-pik (paper.io)
  - Sonar-tikkertje

Interview Client on Prototypes

- Je wilde graag drie versies:
  - Een spel modus (dynamisch)
  - Een therapy modus waarin je verschillende dingen aan kunt passen
  - Een versie van het spel die je altijd kan spelen, ook als de Interactive Playground niet werkt

- Voor het eerste spel (auto):
  - De spelmodus zoals die getest is
  - Een therapy modus: aanpasbaar --> grotere/kleinere auto's, andere banen
  - Een racebaan op de vloer: gebruik een stopwatch voor wie als eerste over de finish is. Dit kan ook met een uitgezette baan of een objecten-parcour, maar dan moet je wel uitkijken voor botsende kinderen.

- Voor het tweede spel (landje-pik):
  - De spelmodus zoals die getest is (maar dan zonder AI tegenstander)
  - Een therapy modus: aanpasbaar --> grotere/kleinere stippen, meer/minder spelers en tegenstanders, computer tegenstanders
  - Een spel waarbij er allemaal hoepels op de grond liggen. Kinderen hebben allemaal pittenzakjes in hun eigen kleur, die liggen in hun eigen begin mand (of hoepel) Als jij zegt START, dan mogen de kinderen één pittenzak per keer in een lege hoepel leggen. Als alle hoepels vol zijn dan wint degene met de meeste pittenzakjes. Variant: je mag ook een pittenzakje van een ander uit de hoepel weghalen, die leg je dan terug in de mand van de tegenstander. Variant: je mag ook gooien. Variant: je mag alleen hoepels van je eigen kleur vullen met jouw pittenzakje.

- Dit project ging natuurlijk helemaal om bewegen aantrekkelijker te maken voor kinderen, zodat op de lange termijn de motivatie omtrent bewegen verbetert.

- De volgende vragen gaan over het verbeteren van de motivatie omtrent bewegen.
    - Op een schaal van 1-10, welk cijfer geef je de verbetering in motivatie omtrent bewegen door jouw ingezette reguliere therapie?
    - Op een schaal van 1-10, welk cijfer geef je de verbetering in motivatie omtrent bewegen door AirPlay?
    - Op een schaal van 1-10, welk cijfer geef je de verbetering in motivatie omtrent bewegen door andere interventie projecten waar je aan deelneemt?
    - Op een schaal van 1-10, welk cijfer geef je voor verbetering van motivatie als je kijkt naar het inzetten van deze spellen?
- De volgende vragen gaan over de drie verschillende versies en de verhoudingen tot elkaar:
    - Wat is je mening over de dynamische versie (zoals deze voorgedaan werd)?
    - Wat is je mening over de therapy mode (zoals deze uitgelegd werd)?
    - Wat is je mening over de statische versie die werkt zonder de Playground?
- Wat is je algemene tevredenheid ten aanzien van deze drie versies?
- Wat zou je willen veranderen?
- Voorgaande projecten werkten met meetwaardes in het dagelijks leven. Waar zie je mogelijkheden bij deze spellen?

Appendix 3

Ethical Analysis

The following paper was written by me for Module 12 Reflection class (Winderlich, Ethical Analysis, 2020). It is an important addition to this bachelor thesis, as it explains how COVID-19 implications were taken into consideration during this project. It shows ethical risks that should be taken into consideration. It also explains a part of my personal motivation regarding this project.

Intro

> My graduation product is about positively influencing motivation towards physical activity of children with Developmental Coordination Disorder (DCD).
>
> During this graduation project I will develop a game for an interactive playground that can be used during therapy sessions that are intended to get children with DCD to participate in physical activities and ultimately help increase motivation of those children towards those type of activities and physical activities in general. Due to COVID-19 implications, this will happen without physical contact with kids/experts/supervisors and without using the interactive playground stationed at Roessingh Research Department (RRD) or at the Design lab. That is why I will create an app that serves as a mock-up for this interactive playground so I can test it with experts who will function as proxy testers.

Ethics in Tech Practice: a Toolkit

A method that can be used to reduce ethical risks is an Ethical Toolkit for Engineering/Design Practice (Vallor, Green, & Raicu, 2018), by using the following 7 steps:

1. Ethical Risk Sweeping
2. Ethical Pre-mortems and Post-mortems
3. Expanding the Ethical Circle (stakeholders)
4. Case-based Analysis
5. Remembering the Ethical Benefits of Creative Work
6. Think about the Terrible People
7. Closing the Loop: Ethical Feedback and Iteration

The following chapters are based on these 7 steps.

1. Ethical Risk Sweeping

A hazard is something that potentially can harm you, and a risk is the likelihood of a hazard causing harm.

Ethical risks – the choices that may cause significant harm or spark acute moral controversy – should be taken in consideration at all times, as many disasters from the past could have been prevented if ethical risks were taken into account. There are many reasons why foreseeable ethical risks get missed. Some of these reasons are that only material or economical risks are considered as causes of harm, some ethical risks are considered as for example economic or legal risks, the moral perspectives of all stakeholders aren't shared or that likely causal interactions that might lead to harm were not anticipated. The following points are potential risks regarding my project.

- Stakeholders

- Due to COVID-19 restrictions, children (that should've been stakeholders) were not included in designing and building the project prototype.
- Stakeholders/experts can be biased.
- Not enough stakeholders.
- Stakeholders might not be invested enough.
- Not taking the opinions of stakeholders seriously.
- Demotivated stakeholders.
- Will anything regarding children's motivation really improve by doing this graduation project?

▪ Proxy testing
  - Absence of physically testing the interactive playground.
  - Experts (physiotherapists and ergo-therapists) test the project. They might be biased in what they want the product to look like based on their expertise – children might not like it.
  - Lack of physical interaction may cause proxy-testers to act socially desirable.
  - Testing is an indication of how children would react – the outcome is not necessarily applicable to all users. Also, test results will not give any substantial answers to the main research question.

▪ Technology
  - In absence of being able to use the interactive playground, an app is made. Using a tablet/phone to interact with the project might result in more technological restrictions and different interactions with the product.
  - The app will be designed in a way that the game can be used for the interactive playground later on. Since it will not be tested on the interactive playground itself, it might fail significantly when it is used. Also, physical harm is possible when used on the interactive playground.
  - The product/game should work for three different types of the game: static, dynamic and therapy-mode. Technological limitations could negatively impact the product, especially if they weren't taken into account while designing.

▪ Design
  - Stakeholders might think something will be fun for children, while children can experience this very differently.
  - Experts want a therapy-mode in which they can set the difficulty level – children might experience the set difficulty as too high, which might negatively influence their motivation towards physical activity.
  - The product/game should work for three different types of the game: static, dynamic and therapy-mode. One of these types might be unintentionally be preferred when designing the game, which might result in 'bad' other types of the game.
  - Not taking the opinions of stakeholders seriously.
  - Designing for problems that aren't there.
  - Technological limitations could negatively impact the product if they weren't taken into account while designing.

2. Ethical Pre-mortems and Post-mortems

As this graduation project hasn't finished yet, there won't be any post-mortems included in this part.

COVID-19

Due to rules and restrictions regarding COVID-19, a lot of alterations had to be made regarding the graduation project. As mentioned before, physical contact with certain stakeholders was prohibited. Also, using physical objects that had to pass multiple hands was strongly discouraged.

Consent forms also had to be changed in a way that the COVID-19 rules and restrictions were followed.
For my graduation project, this meant that:

- My original GP proposal had to be radically changed, because for the original project idea I was supposed to adapt already existing games for the interactive playground and test these alterations with children with DCD.
- I cannot physically meet children and thus I cannot test the interactive playground games with children.
- I cannot physically use the interactive playground or let others use it.
- I can only contact people using e-mail/Skype/Teams/phone. Zoom was strongly discouraged by the UT based on a privacy leak.
- I had to be careful and understanding while contacting health care employees, because they might have a huge workload due to COVID-19 and are possibly unable to help me with my GP.
- I had to rewrite my research questions several times to include the changes that had to be made to follow the rules and restrictions due to COVID-19.

Solution

So, knowing all this, what can we put in place to reduce failure risk? The solution my supervisors and I came up with, was that I would build a new game instead of adapting one/multiple (which was originally the plan). This would be made using the same programs as intended for the interactive playground, but I have to export it as an APK (android app file) so it can be played/tested by others using their phone/tablet. Testing with children isn't possible, so I will proxy test with experts (physiotherapists, DCD coordinators and ergo therapists). They will test the app on their own device (phone/tablet), to avoid passing physical objects. As proxy testers, they will play the game as if they are the children with DCD playing it and as if it was situated on a real physical playground. This however does imply that my main research question could not properly be answered by this project, so I had to rewrite it and get it checked many times. The consent forms I digitally distributed to participants had to be adapted as well, my supervisor helped me fill it in. The UT ethics commission has approved my consent form and information folder.

3. Expanding the Ethical Circle (Stakeholders)

To expand the ethical circle means to ensure that the legitimate moral interests of the full range of stakeholders have been taken into account. In 'Value and Ethics for the 21st Century' (Boatright, et al., 2012), stakeholders are described as "any group or individual who can affect or be affected by the achievement of an organization's objectives". The ethical circle should be expanded in order to not fall victim to groupthink (too enthusiastic to think about downsides/risks), bubble mentality (lack of cognitive access to the broader social realities) or Friedman Fallacy (sidelined 'noble aims' to maximize shareholders' profit at the expense of others/environment).
Stakeholders are important in any business, that is why a stakeholder analysis – the process of understanding who has a vested interest in the project – is of importance. A list of potential stakeholders for my project can be found in Table 4.

Table 4. Stakeholders

Assumed instead of consulted?	Children with DCD (not consulted due to COVID-19)
Directly affected?	Me (Creative Technology student) Supervisor of Graduation Project Critical observer of Graduation Project Physiotherapists (proxy testers) Ergo therapist (proxy tester) ➔ Consulted through carefully conducted interviews and digital (phone) conversations
Indirectly affected?	Children with DCD (due to COVID-19) Parents of children with DCD

	Roessingh Research Department (usage of the interactive playground on the premises) University of Twente Schools of children with DCD Educators of children with DCD Coaches of children with DCD Design Lab (University of Twente) FitClinic (physical health center)
Not initially intended?	Children without DCD Siblings of children with DCD Friends of children with DCD Peer-students Schools School teachers P.E. classes
Substantial risk of harm?	Children with DCD (Not actually used in this project, but will be used in the near future) Physiotherapists Ergo therapists ➔ Carefully written information folders and consent forms were used, all approved by the University of Twente Ethics Commission
Least likely to buy/use, but strong opinions?	Technologically/computer illiterate people Technology opposers Conservative educators and therapists Media

Groupthink, as well as bubble mentality, is something that might definitely occur during my project. That is why my supervisor and I inform our critical observer in decisions. The critical observer is in close contact with multiple organizations and also invested in the project (on a lower level), but oversees the main aspects with a critical view. Also, in order to tackle bubble mentality, interviews with different physiotherapists from different organizations were conducted in order to minimize the one-sided mentality regarding therapy approaches for helping children with DCD. Originally I would also test my product with the children with DCD who would use the interactive playground during therapy sessions, but unfortunately this was canceled due to COVID-19. Friedman Fallacy doesn't apply here, as the product I am working on is not for sale, just for training and research. There is no profit to be made here, except for the mental and physical health of the children with DCD that might benefit from this product.

4. Case-based Analysis

Virtual Reality Health Risks in Children

Virtual Reality headsets are widely used for playing games in a digital environment. VR for children has been used by one of my indirect stakeholders, Roessing Research Departent, to help children with balance problems to ride a bike[17]. However, recent studies have found that virtual reality headsets could pose risks to children aged 8-12[18]. Risks include the trigger of eyesight and balance problems, as well as the ability to detect differences in distances, even after 20 minutes of VR headset usage. Not enough research has been done on the long-term effects of VR on children and their development.

Using Children in a Participatory Design Team

Children themselves have no legal rights concerning privacy and consent according to most national laws. However, Human-Computer Interaction does tend to use children in participatory

[17] http://www.rrd.nl/weekend-van-de-wetenschap/

[18] https://www.theguardian.com/technology/2017/oct/28/virtual-reality-headset-children-cognitive-problems

design, because it gives users a voice in designing technologies meant for them to use[19]. But what do children think of the ethical issues surrounding their past involvement? Most of the children that participated in the research answered that they were okay with it because their parents were (and they signed the consent forms), or that they gave permission during the sessions so it wasn't a problem. Some children, looking back on their involvement in the participatory design team, thought of the permission as acceptable – as long as their pictures weren't used in a judgmental context or weren't embarrassing. Also, almost all participants wanted to have some degree of anonymity. Participants did believe that their ideas were valued, they felt they were part of something important, and all participants looked back at the participatory design team as an important and motivating experience. It does lead to the question: do children themselves want to be credited for their participation and creative contributions, regardless of parents' consent?

5. Remembering the Ethical Benefits of Creative Work

Although it is extremely important to focus on risks, benefits should not be forgotten. After all, it is all about the positive outcome of the product – why else would we make it? Ethical benefits the creative work of this project are explained in Table 5.

Table 5. Ethical Benefits of Creative Work

Why are we doing this, and for what good ends?	The project is part of a larger organization that aims to help rehabilitate people with disabilities. This project specifically aims to create a fun learning environment that ultimately should affect children's motivation towards physical activity in a way that they themselves want to exercise more, which is beneficial for their health.
Will society/the world/our customers really be better off with this tech than without it? Or are we trying to generate inauthentic needs or manufactured desires, simply to justify a new thing to sell?	The interactive playground as a product will be used as an addition to traditional therapy for children with DCD, not as a replacement. It is intended to make physical activity more fun for the children by implementing digital and technological advances based on the technology children use in their daily life. There is a small desire for technological products to use during therapy sessions, as physiotherapists notice that children tend to experience these things as fun and desirable. Will the world be better with than without it? That is a hard question to answer. I don't think it's a necessity, but rather a fun implementation.
Has the ethical benefit of this technology remained at the center of our work and thinking?	The ethical benefit of this technology has remained at the center, especially because of the implications COVID-19 has on the world right now. For this project, it meant that the product could easily be missed in a society where social distancing is practiced. That is not something one'd like to admit as a designer. It wasn't easy to adapt the project to the expected new standards, as a lot of hard work and creative commitment needed to be adapted too. Luckily, all is not lost, because when COVID-19 rules and regulations get altered such that the project can continue, the product I designed can easily be implemented in the interactive playground so it can finally be tested with the intended user group. Unfortunately, I won't get a chance to experience this.
What are we willing to sacrifice to do this right?	In my case, a lot of motivation that I got from the intended course of action. I was so happy to find a graduation project that involved children, as I know I like working with children – why else would I have tried teaching primary school for three years? My whole project was intended to be around testing things with children and using their thoughts on and experience of the product to make it better. Now I have to build an app that won't even be tested with children. This actually made me quite sad. I have to keep reminding myself what I am doing it for – which is graduating, for now.

[19] https://web.stanford.edu/~mattm401/docs/2016-McNally-CHI-ChildrenOnEthics-Paper.pdf

6. Think about the Terrible People

"In reality, technology is power, and there will always be those who wish to use that power in ways that benefit themselves at the expense of others. And there will be those who use the power we give them for no rational purpose at all. If you are building or granting access to powerful things, however, it is your responsibility to mitigate their abuse to a reasonable extent." (Vallor, Green, & Raicu, 2018)

For my project, I also thought about the terrible people that could use it. This can be found in Table 6.

Table 6. Think about the Terrible People

Who will want to abuse, steal, misinterpret, hack, destroy, or weaponize what we built?	This is a hard question to answer. I do not think that this product will cause any physical harm in the future. I do foresee the ability to 'weaponize' it in the sense that it can be used for commercial purposes – for example to guide people into walking a certain way towards a certain store. Also, when used inside malls and other shopping areas, information storage of walking patterns might become a privacy hazard.
Who will use it with alarming stupidity/irrationality?	The product might get connected to the internet to store personal data. It is a quite expensive system, so when it is not stored or 'placed/hidden' correctly, it might tempt people to steal it for the money.
What rewards/incentives/openings has our design inadvertently created for those people?	Information on how people walk by, which way they are facing, what they are looking at. The possibility to sell that information to third party companies.
How can we remove those rewards/incentives?	I don't think there is anything we ourselves could do about the privacy issue, except for using different types of cameras in the system that do not make it possible to recognize people. Our system is not connected to the internet as far as I know, but there is no way we could prevent others from doing this and sharing the information they collected.

7. Closing the Loop: Ethical Feedback and Iteration

The ethical impact of technology is an ongoing process. To embed ethical feedback into company culture, these four steps are needed (Vallor, Green, & Raicu, 2018):

1. Remember that ethical design/engineering is never a finished task.
2. Identify feedback channels that will deliver reliable data on ethical impact.
3. Integrate the process with quality management and user support: make it standard.
4. Develop formal procedures and chains of responsibility for ethical iteration.

Conditions may have changed, users may have changed and technologies may not get used as intended. Ethical design/engineering is never a finished task, but a never-ending loop and we must treat it as such. For my project, this means that the terrible people and their possible abuse of my project as I came up with in step 6 weren't anticipated in step 1. The ethical considerations should therefore be added to the list of step 1, which also means that the pre-mortems should be expanded and the stakeholders reconsidered, and so on.

Appendix 4

Informed Consent Form

TOESTEMMINGSVERKLARING **(INFORMED CONSENT)**

Ptcpt no.

Betreft
De Universiteit Twente doet onderzoek naar het inzetten van een 'interactieve playground' bij kinderen met Developmental Coordination Disorder, zoals uitgelegd in de informatiefolder die bij dit formulier is gegeven.

Hoofdonderzoekers:
Robby van Delden (r.w.vandelsen@utwente.nl; van Loenshof 28, 7511HG Enschede; 0534893925), Monique Tabak, Verena Winderlich (v.winderlich@student.utwente.nl), Universiteit Twente

Contact informatie
Mocht u vragen hebben over dit onderzoek, dan kunt u contact opnemen met de secretaris van de Ethische Commissie (ethics-comm-ewi@utwente.nl secretaris Petri de Willigen, Zilverling Kamer 1051, Drienerlolaan 5, 7522 NB Enschede, 053 4892085). De Ethische Commissie bestaat uit onafhankelijk deskundigen van de universiteit en is beschikbaar voor eventuele vragen en klachten rondom het onderzoek.

Onderzoek: Interactive playground - Game Induced Exercise Promotion for Children with DCD

Het volgende is geldig voor het collegejaar 2019'2020:

☐ Ik verklaar hierbij dat ik volledig geïnformeerd ben over het onderzoek. Het doel van het onderzoek en de methodes zijn mij uitgelegd, waarbij ik de ruimte heb gehad om vragen te stellen.

☐ Ik begrijp dat ik mijn deelname op ieder moment, zonder opgaaf van reden, mag en kan beëindigen zonder dat hieraan enige consequenties verbonden zijn (ook later in het seizoen).

☐ Ik geef hierbij vooraf toestemming voor mijn deelname aan onderzoek tijdens seizoen 2019'2020 en voor het verzamelen en gebruik van anonieme gegevens zoals beschreven in de informatiefolder.

☐ Ik geef toestemming voor het publiek beschikbaar stellen van de *anonieme* onderzoeksmaterialen die zijn verzameld tijdens mijn deelname aan het onderzoek.

Beeld/audio-materiaal wordt enkel door betrokken onderzoekers bekeken en zal nooit openbaar gemaakt worden en/of vertoond worden aan derden voor demonstratie of rapportage. Al het onderzoeksmateriaal zal verwerkt en opgeslagen worden conform de regels en richtlijnen van de AVG. Alle data wordt voor een minimum van 10 jaar opgeslagen, conform de NVSU-richtlijn.

☐ Ik geef toestemming voor het maken van video/audio-opnames van de interviews voor onderzoeksdoeleinden.

☐ Ik wil graag benoemd worden voor mijn bijdrage aan dit onderzoek in de erkenningen van het onderzoeksverslag.

☐ Toestemming voor quotes enkel mits vermeld met initialen

☐ Toestemming voor quotes met volledige naam

Datum: Plaats:

Naam: Handtekening deelnemer:

………

The extra copy of this consent form is for you to keep.

Appendix 5
Information Folder

Achtergrond

Technologie speelt een steeds grotere rol in ons leven, het helpt ons beter te presteren en gezonder te leven. Ook tijdens het sporten wordt er steeds vaker gebruik gemaakt van technologische innovaties: van slimme digitale sporthorloges tot doellijn technologie voor de videoscheidsrechter in voetbal.

Aan de Universiteit Twente, in samenwerking met Roessingh Research Department, doen we onderzoek naar het inzetten van technologische innovaties tijdens therapiesessies van kinderen met Developmental Coordination Disorder (DCD). Op het moment zijn we bezig met de ontwikkeling van toepassingen voor een ***interactieve playground***, waarmee we beweging leuker kunnen maken met interactieve spellen voor kinderen die moeite hebben met bewegen.

Deze *interactieve playground* maakt gebruik van Kinect sensoren en projectie/beamers om kinderen in real-time van visuele feedback te voorzien over hun bewegingsprestaties. Zo worden er op de vloer spellen geprojecteerd die feedback geven met licht en geluid tijdens het spelverloop.

Het huidige onderzoek, geleid door de Universiteit Twente en Roessingh Research Department, is erop gericht om passende spellen te ontwikkelen om in te zetten tijdens therapiesessies. Om dat te kunnen doen, brengen we in kaart hoe een 'standaard' therapiesessie eruitziet; ontwikkelen we interactieve spellen en testen we deze met fysiotherapeuten en ergotherapeuten (hierna genoemd: experts). Zo ontwerpen we, samen met jullie, de therapie van de toekomst!

Onderzoeksprocedure

Door middel van interviews, observaties en video-opnames zal informatie verzameld worden over relevante therapie- en spelsituaties waarin de *interactieve playground* bruikbaar kan zijn.

In deze folder leggen we uit wat het voor jou betekent om aan het onderzoek mee te doen. Je beslist zélf of je deel wilt nemen aan het onderzoek. Voor vragen kunt je contact opnemen met Verena Winderlich via v.winderlich@student.utwente.nl of met de afstudeerbegeleider Robby van Delden (r.w.vandelsen@utwente.nl; van Loenshof 28, 7511HG Enschede; 0534893925).

Deelname

Deelname is geheel vrijwillig. Je kan op ieder moment, zonder opgaaf van reden, aangeven dat je niet meer wil meedoen met het onderzoek. Toestemming voor deelname hoeft slechts eenmalig verleend te worden en is daarna geldig voor de rest van het afstudeeronderzoek (tot 31-08-2020). Daarna word eventueel opnieuw gevraagd toestemming te verlenen.

Wat gebeurt er tijdens de activiteiten?

De activiteiten zijn met name bedoeld om te begrijpen hoe therapie wordt ingezet bij kinderen met DCD. Dit wordt gedaan om de meerwaarde van de *interactieve playground* in kaart te brengen en te onderzoeken hoe een interactieve playground ingezet kan worden tijdens therapiesessies. Onderzoeksactiviteiten zullen onder andere bestaan uit interviews en het testen van een app waarin interactie met de interactieve playground wordt getest. Experts hebben hierin een leidende rol: zij testen deze app door een

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Human Media Interaction.

inschatting te maken van hoe kinderen met DCD zullen reageren tijdens spelverloop.

Welke gegevens worden er verzameld?

Tijdens het onderzoek worden er video en/of audio opnames gemaakt van de interviews en de gebruikerstest van de app.

Hoe worden de gegevens bewaard?

De data en video/audio opnames worden veilig bewaard en anoniem verwerkt volgens AVG richtlijnen. Onderzoeksgegevens worden volgens VSNU richtlijnen minimaal 10 jaar bewaard.

Wie heeft er toegang tot de data?

De video-opnames, interviews en vragenlijsten zijn enkel toegankelijk voor mensen betrokken bij dit onderzoek. Een lijst met namen van mensen die toegang hebben tot het materiaal is beschikbaar en kan worden opgevraagd bij Robby van Delden.

Hoe worden de gegevens gebruikt?

De gegevens worden geanalyseerd voor wetenschappelijk onderzoek. Dit wordt gepubliceerd in wetenschappelijke artikelen en in de 'gewone' media, waarbij volledig *anonieme* resultaten op basis van de gegevens gepresenteerd worden. De gegevens worden mogelijk ook gebruikt door de onderzoekers van dit project voor vervolgonderzoek, passend binnen de kaders van deze brochure. Verder worden de resultaten gebruikt als inspiratie voor het ontwikkelen van nieuwe spellen voor de interactieve playground.

Worden er gegevens van mij publiek gemaakt?

Onderzoeksmaterialen waar je op te herkennen bent worden nooit publiek vertoond, ook niet voor demonstratie, promotiedoeleinden, of media.

Indien je als expert erkenning wil hebben voor het meedoen aan dit onderzoek, kun je dit aangeven op het consentformulier.

Kan ik mijn gegevens laten verwijderen?

Als je tijdens of binnen 24 uur na een activiteit besluit dat je niet (meer) wil meedoen worden al je gegevens van die sessie verwijderd. Als de onderzoeksmaterialen eenmaal anoniem gemaakt zijn kunnen ze niet meer aan jou gekoppeld worden en kunnen ze dus ook niet meer verwijderd worden.

Meer informatie en onafhankelijk advies.

Wil je graag onafhankelijk advies over meedoen aan dit onderzoek, of een klacht indienen? Dan kan je terecht bij de Ethische Commissie (ethics-comm-ewi@utwente.nl, secretaris Petri de Willigen, Zilverling Kamer 1051, Drienerlolaan 5, 7522 NB Enschede, 053 4892085). Deze bestaat uit onafhankelijke deskundigen van de universiteit en is beschikbaar voor vragen en klachten rondom het onderzoek.

Voor vragen kan je verder terecht bij de onderzoekers, contactgegevens op de voorzijde van deze folder.

Appendix 6

Checklist for Submitting a Research Proposal to the Ethics Committee

(See Chapter 3)

Checklist for the principal researcher when submitting a request to the EC or the EC member for an assessment of the ethical permissibility of a research proposal

1. General

1. Title of the project: Interactive playground - Game Induced Exercise Promotion for Children with DCD
2. Principal researcher (with doctoral research also a professor): Robby van Delden, Monique Tabak
3. Researchers/research assistants (PhD students, students etc. where known): Verena Winderlich
4. Department responsible for the research: HMI
5. Location where research will be conducted: digitally at participants' homes/workplace
6. Short description of the project (about 100 words): Research on an interactive playground by a mock-up application for phone/tablet that can be used by physical therapists during therapy for children with Developmental Coordination Disorder. No children will be involved. Physical therapists will be used for proxy-testing.
7. Expected duration of the project and research period: Feb. 2020 – Aug. 2020
8. Number of experimental subjects: around 6
9. EC member of the department (if available): Dennis Reidsma, temporary replacement Randy Klaassen

2. Questions about fulfilled general requirements and conditions

1. Has this research or similar research by the department been previously submitted to the EC?

   ☐ Yes,

   ☒ No

   If yes, what was the number allocated to it by the EC?

   Explanatory notes:

2. Is the research proposal to be considered as medical research (Also see Appendix 4)

   ☐ Yes

   ☒ No

   ☐ Uncertain

   Explanatory notes: The standard research of HMI poses questions which are not of a medical nature. In general, the questions are concerned with the normal interaction between healthy humans and an app on their own devices.

3. Are adult, competent subjects selected? (§3.2)

   ☒ Yes, indicate in which of the ways named in the general requirements and conditions this is so

☐ No, explain

☐ Uncertain, explain why

Explanatory notes: Minors are not directly involved. However, experts are asked questions on how minors could/would react. Subjects are screened insofar as it is necessary to guarantee that the random sample is representative of the research population.

4. Are the subjects completely free to participate in the research, and to withdraw from participation whenever they wish and for whatever reason? (§3.2)

   ☒ Yes

   ☐ No, explain why not

   ☐ Uncertain, explain why

   Explanatory notes: Subjects are not put under any pressure to participate and can withdraw at any given time.

5. In the event that it may be necessary to screen experimental subjects in order to reduce the risks of adverse effects of the research: Will the subjects be screened? (§3.4)

   ☒ Screening is not necessary, explain why not

   ☐ Yes, explain how

   ☐ No, explain why not

   ☐ Uncertain, explain why

   Explanatory notes: It is unlikely there are adverse effects ; the people that are asked are also already filtered through our contact persons, making it less likely that additional risk (e.g. overburdened) plays a role.

6. Does the method used allow for the possibility of making an accidental diagnostic finding which the experimental subject should be informed about? (§3.6 and Appendix 4)

   ☒ No, the method does not allow for this possibility

   ☐ Yes, and the subject has given signed assent for the method to be used

   ☐ Yes, but the subject has not given signed assent for the method to be used

   ☐ Uncertain, explain why

Explanatory notes: Accidental discoveries are not applicable in a medical sense.

7. Are subjects briefed before participation and do they sign an informed consent beforehand in accordance with the general conditions? (§3.2, §3.3, §3.7, §3.8)

   ☒ Yes, attach the information brochure and the form to be signed

   ☐ No, explain why not

   ☐ Uncertain, explain why

   Explanatory notes:

8. Are the requirements with regard to anonymity and privacy satisfied as stipulated in (§3.8)?
   ☒ Yes

   ☐ No, explain why not

   ☐ Uncertain, explain why

   Explanatory notes: Research data of persons is made anonymous at the earliest possible stage right up until the research report. The only exceptions to this are when the person concerned has given their expressed permission to de-anonymize their information. Consent form gives option for 'anonymity' or to 'be acknowledged'.

9. If any deception should take place, does the procedure comply with the general terms and conditions (no deception regarding risks, accurate debriefing) (§3.10)?
   ☒ No deception takes place

   ☐ The deception which takes place complies fully with the conditions (explain)

   ☐ The deception which takes place does not comply with the conditions (explain)

   If deception does take place, attach the method of debriefing

   Explanatory notes: decisions and handling parts of the system are explained beforehand

10. Is it possible that after the recruitment of experimental subjects, a substantial number will withdraw from participating because, for one reason or another, the research is unpleasant? (§3.5)
   ☒ No

   ☐ Yes, that is possible

   If yes, then attach the recruitment text paying close attention to what is stated about this in the protocol.

   Explanatory notes:

3. Questions regarding specific types of standard research

Answer the following questions based on the department to which the research belongs.

11. Does the research fall ***entirely*** under one of the descriptions of standard research as set out in the described standard research of the department? (Chapter 4)
   ☒ Yes, go to question 12

   ☐ No, go to question 13

   ☐ Uncertain, explain what about, and go to question 13

   Explanatory notes: Although no example is known of distributed interviews using a send app, it does follow other aspects of standard the Department Human Media Interaction (HMI) research in 3.11.

12. If yes, what type of research is it? Give a more detailed specification of parts of the research which are not mentioned by name in this description. (for example: What precisely are the stimuli? Or: What precisely is the task?)
Research on: human-computer interactions, interface design, user experience. & Specific type of standard research:
Questionnaire-based research (field research): Respondents individually fill in answers electronically, to questions about themselves, their environment or others in their environment. The real purpose of the research is however always explained to the participant during the debriefing. Completing the questionnaire should not take longer than 1 hour. No physical discomfort or health and safety risks are involved. Frequently asked questions in questionnaires relate to: user experience, usability, cognitions, and behaviour in social interaction.
Laboratory research (interaction between subject and app in their own environment): Participants are exposed to settings involving virtual or real human-human or human-computer interaction, alone. Their behaviour during interaction is measured by behavioural and/or physiological assessments. Subjects also sometimes have to make choices, pass judgment or perform short tasks. In addition, participants have to fill in questionnaires in which, in principle, the same questions can be asked as those named under standard research "Questionnaire-based research". Only the researcher and his/her staff have access to the identifiable data. Audio and video recordings are not made available to third parties without informed consent. Recordings in which subjects are identifiable are carefully stored for 5 years and are destroyed when no longer needed for the purposes of the research.

13. If no, or if uncertain, give as complete a description as possible of the research. Refer where appropriate to the standard descriptions and indicate the differences with your research. In any case, all possible relevant data for an ethical consideration should be provided.

ADDENDUM

4. Why is your work COVID-19 proof?

Note: choice with * requires explanation

14. Do you add additional face-to-face contact?
☒ No, I only work in distributed fashion over phone, survey, or telco (Skype, Canvas, Teams, etc)
☐ *No, only existing face-to-face contact, explain below who and how many you include as already breaking within 1.5m guidelines,
☐ *Yes, explain
Explanatory notes:

15. * Do you add indirect physical contact? For instance, sharing a tangible device, please explain why and what actions will be done with the device.
☒ * No,
☐ * Maybe,
☐ * Yes.
Explanatory notes: Participants will use an app that can be downloaded online. No physical contact with products. Participants use their own devices.

16. * Do you put additional burden on people from the care sector that are under pressure?
☐ * No, I work people from another field, explain
☒ * Maybe,
☐ * Yes

Explanatory notes: Participants include physical therapists. They have limited client consults due to COVID-19 and most consults are done without face-to-face contact. They do not have more clients than before COVID-19.

17. * Give a thorough explanation, why you consider your research can be considered COVID-19 proof include any considerations you discussed with your supervisor to address contingency of any additional risks you identified. Explanatory notes: I will not use physical objects that might be hazardous to anyone’s health as I only make use of digital components that participants will use on their own devices. I will conduct digital interviews and user tests with physical therapists. They are explained beforehand on how much time interviews/tests will take and are able to withdraw from this research at any given time, also when they think it will (negatively) affect their workload. Thus, I think that my work is COVID-19 proof.

Appendix 7

Race Game Code

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UIElements;

public class ControlScenes : MonoBehaviour
    {
        private AssetBundle loadedAssetBundle;
        private string[] scenePaths;

        public void LoadSceneMain(string Scene_Name)
        {
            SceneManager.LoadScene(Scene_Name, LoadSceneMode.Single);
        }
    }
```

```
using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UIElements;


public class Main : MonoBehaviour
{
    // Start is called before the first frame update

    public Sprite[] sprites;

    public float carX;
    public float carY;
    public float margin;
    public Vector3 scale;



    void Start()
    {
        Debug.Log(sprites[0]);

        for (int i = 0; i < sprites.Length; i++){
            GameObject car = Instantiate(Resources.Load("GameObjects/Car",
typeof(GameObject))) as GameObject;

            SpriteRenderer renderer = car.GetComponent<SpriteRenderer>();
            renderer.sprite = sprites[i];

            RectTransform rt = car.GetComponent<RectTransform>();
            rt.localScale = scale;
            Debug.Log(sprites[i]);
            car.transform.position = new Vector3(carX, carY + i*margin, -2);
            car.name = "Car " + i;
        }
    }
}

using System.Collections;
```

```
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UIElements;

public class Touch2 : MonoBehaviour
{
    [SerializeField]
    private Transform finishPlace;
    private Vector2 mousePosition;
    private Vector2 initialCarPosition;
    private Vector2 carPosition;
    public Vector2 carAngle;
    private float deltaX, deltaY;
    public static bool locked;
    //public static int width;
    //public GameObject collisionGameObject;

    // Start is called before the first frame update
    void Start()
    {
        initialCarPosition = transform.position;
        locked = false;  //auto is nog niet bij de finish
        carAngle = transform.eulerAngles;
    }

    float AngleBetweenTwoPoints(Vector2 a, Vector2 b)
    {
        return Mathf.Atan2(a.y - b.y, a.x - b.x) * Mathf.Rad2Deg;
    }

    // Update is called once per frame
    private void Update()
    {
        foreach (Touch touch in Input.touches)
        {

            //Debug.Log(transform.position);
            if (Input.touchCount > 0 && !locked)
            {
                //Touch touch = Input.GetTouch(0);
                Vector2 touchPos = Camera.main.ScreenToWorldPoint(touch.position);
                carPosition = transform.position;
                float carAngle = AngleBetweenTwoPoints(touchPos, carPosition);
                Debug.Log(touchPos + "," + carPosition + "," + carAngle);
                transform.rotation = Quaternion.Euler(new Vector3(0f, 0f, carAngle));

                //transform.right = (mousePosition - carPosition);
                transform.position = touchPos;

                switch (touch.phase)
                {
                    case TouchPhase.Began:
                        if (GetComponent<Collider2D>() ==
Physics2D.OverlapPoint(touchPos))
                        {
                            deltaX = touchPos.x - transform.position.x;
                            deltaY = touchPos.y - transform.position.y;
                        }
                        break;

                    case TouchPhase.Moved:
```

```
                        if (GetComponent<Collider2D>() ==
Physics2D.OverlapPoint(touchPos))
                        {
                            transform.position = new Vector2(touchPos.x - deltaX,
touchPos.y - deltaY);

                        }
                        break;
                }
            }
            if (locked)
            {
                Debug.Log("locked is troeee");
                deltaX = 0;
                deltaY = 0;
            }
        }
    }

    //float AngleBetweenTwoPoints(Vector2 a, Vector2 b)
    //{
    //    return Mathf.Atan2(a.y - b.y, a.x - b.x) * Mathf.Rad2Deg;
    //}


    private void OnTriggerEnter2D(Collider2D collision)
    {
        Debug.Log("TRIGGERED!!!");
        locked = true;

        //if (Input.GetMouseButton())
        //{
        //    Debug.Log("Mouse is stuk");
        //}
    }

    //private void OnMouseDown()
    //{
    //    if (!locked)  //als de auto nog niet bij de finish is wanneer klikken
begint, update positie auto met positie muis
    //    {
    //        deltaX = Camera.main.ScreenToWorldPoint(Input.mousePosition).x -
transform.position.x;
    //        deltaY = Camera.main.ScreenToWorldPoint(Input.mousePosition).y -
transform.position.y;
    //    }

    //    else if (locked)
    //    {
    //        Debug.Log("locked is troeee");
    //        deltaX = 0;
    //        deltaY = 0;
    //    }
    //}

    //PointerDownEvent

    //private void OnMouseDrag()
    //{
    //    if (!locked) //als de auto nog niet bij de finish is tijdens klikken, update
positie auto naar positie muis
    //    {
```

```
    //        mousePosition = Camera.main.ScreenToWorldPoint(Input.mousePosition);
    //        transform.position = new Vector2(mousePosition.x - deltaX, 
mousePosition.y - deltaY);
    //        //Debug.Log(transform.position);
    //    }
    //    else if (locked)
    //    {
    //        transform.position = transform.position;
    //        Debug.Log("AUTO staat stil");
    //        //locked = true;
    //    }
    //}

    //private void OnTriggerEnter2D(Collider2D collision)
    //{
    //    Debug.Log("TRIGGERED!!!");
    //    locked = true;

    //    //if (Input.GetMouseButton())
    //    //{
    //    //    Debug.Log("Mouse is stuk");
    //    //}
    //}
}

using System.Collections;
using System.Collections.Generic;
using UnityEngine;
using UnityEngine.UIElements;


public class Car5Rotate : MonoBehaviour
{
    [SerializeField]
    private Vector2 mousePosition;
    private Vector2 initialCarPosition;
    private Vector2 carPosition;
    public Vector2 carAngle;
    private float deltaX, deltaY;
    public static bool locked;

    void Start()
    {
        initialCarPosition = transform.position;
        locked = false;  //auto is nog niet bij de finish
        carAngle = transform.eulerAngles;
    }

    void Update()
    {
        //Debug.Log(transform.position);
    }



    private void OnMouseDown()
    {
        if (!locked)  //als de auto nog niet bij de finish is wanneer klikken begint, 
update positie auto met positie muis
        {
            deltaX = Camera.main.ScreenToWorldPoint(Input.mousePosition).x - 
transform.position.x;
```

```
            deltaY = Camera.main.ScreenToWorldPoint(Input.mousePosition).y -
transform.position.y;
        }

        else if (locked)
        {
            Debug.Log("locked is troeee");
            deltaX = 0;
            deltaY = 0;
        }
    }

    //PointerDownEvent

    private void OnMouseDrag()
    {
        if (!locked ) //als de auto nog niet bij de finish is tijdens klikken, update
positie auto naar positie muis
        {
            mousePosition = Camera.main.ScreenToWorldPoint(Input.mousePosition);
            carPosition = transform.position;
            float carAngle = AngleBetweenTwoPoints(mousePosition, carPosition);
            Debug.Log(mousePosition + "," + carPosition + "," + carAngle);
            transform.rotation = Quaternion.Euler(new Vector3(0f, 0f, carAngle));
            transform.position = mousePosition;
        }


        else if (locked)
        {
            transform.position = transform.position;
            Debug.Log("AUTO staat stil");
            deltaX = 0;
            deltaY = 0;
            //locked = true;
        }
    }

    float AngleBetweenTwoPoints(Vector2 a, Vector2 b)
    {
        return Mathf.Atan2(a.y - b.y, a.x - b.x) * Mathf.Rad2Deg;
    }

    private void OnTriggerEnter2D(Collider2D collision)
    {
        Debug.Log("TRIGGERED!!!");
        locked = true;

        //if (Input.GetMouseButton())
        //{
        //    Debug.Log("Mouse is stuk");
        //}
    }
}
```