RE-Play: An exploration of game induced exercise promotion in clinical use

Bachelor thesis

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Creative Technology

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Abstract

Children with motor deficiencies often find themselves unable to take part in physical activities with their peers. As a result of this, these children will often become less active overall than neurotypical children, which can in turn cause additional health problems. The Roessingh Centre for Revalidation provides these children the opportunity to take part in a group-based rehabilitation program, where the children can play and be active during weekly therapy sessions. Outside of these weekly sessions, however, the children often remain inactive.

This research is aimed at investigating the opportunities provided by combining wearable sensors with an interactive playground, to create a system that is able to respond to the physical activity measured during the week before the therapy session in such a way that it can be used during the therapy sessions to evaluate and encourage physical activity.

Two existing games have been adapted to better suit these therapy sessions, in addition to a new third game being developed. This new game is able to analyze and respond to data recorded by the wearable sensors during the week prior to the therapy session, and reward players for achieving their activity goals for that week. An evaluation session with the target users revealed that while all three games were entertaining and encouraged physical activity during the therapy sessions, the children had difficulties relating their own physical activity to the game's response. This made the game ineffective in stimulating physical activity outside of the therapy sessions.

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1 Introduction

1.1 Motivation

Almost everyone reading this will remember vague notions from their childhood; memories of playing in the school yard, chasing their childhood friends around the playground, or going on adventures in the neighbourhood. For all but the most talented of us, these memories will also include that *one* activity you just could not quite master. Whether it was soccer, gymnastics, or even drawing, your body simply refused to cooperate and the end result was always not quite what you expected it to be. Luckily, this would often be limited to just one or two activities, perhaps three if it was a particularly bad day. However, this is not the case for all children. For children with a developmental coordination disorder (DCD), it is the exception rather than the rule that their bodies respond exactly as they expect them to. As per the American Psychiatric Association (2013), these children possess substantially worse acquisition and execution of coordinated motor skills than peers of similar age and with comparable opportunities for learning. These problems in turn manifest themselves as slow and imprecise performance of motor skills, resulting in poor executions of daily tasks, chores, sports, and leisurely activities. Similarly, children afflicted with cerebral palsy (CP) also suffer from sub-par motor skills, resulting in difficulties executing a spectrum of tasks ranging from the mundane to the more intensive. As per Richards and Malouin (2013), motor control during simple tasks such as walking and grasping is disturbed by involuntary spastic and irregular movements. Due to their impaired motor skills, functioning completely independently is neigh impossible for children affected by DCD or CP. Both DCD and CP are relatively common disorders in children, with DCD being diagnosed in 6% of Singaporean children aged five to eleven years old (Wright & Sugden, 1996) and CP being diagnosed in 0.31% of children aged eight years old from various areas of the USA (Christensen et al., 2014).

1.2 Background

Various methods aimed at helping rehabilitate children with DCD have been designed, however, due to the relatively small amount of research present in the field, it is difficult to determine which approach yields the best results. According to an analysis by Pless and Carlsson (2000), the most effective approach focuses on specific skills within a group structure, among other variables that are out of scope for this section of the paper. The difficulty herein, lies in the fact that there is a large variation of capabilities within the target group, making it exceptionally difficult to produce a group based task that is challenging though manageable for all of the groups participants. Kirby and Sugden (2007) show this variation of capabilities in their study, which found that 25% of Canadian children diagnosed with DCD could also be diagnosed for attention deficit hyperactivity disorder (ADHD) and dyslexia. A system

that is thus not designed with the user needs of children with DCD, ADHD, and dyslexia in mind, is at risk of not accommodating the specific requirements of 25% of its target group. Current generic rehabilitation methods are simply not flexible enough to accommodate for such a large discrepancy in user performance and abilities. It is possible to customize an existing rehabilitation method to a specific group with the help of a therapist, but this is a rather time consuming and manpower intensive process. It is for this reason, that these methods can not be effectively applied as a universal tool to help treat children with DCD or CP. To help circumvent this inflexibility, this research project is an exploration in the opportunities offered by the development of ambient intelligence and wearable sensors.

Ambient intelligence (AmI) is a field of research that pertains to developing systems that are able to adapt and respond to its user's actions and emotions, or as Aarts and Wichert (2009, p. 244) put it; "Ambient Intelligence (AmI) is about sensitive, adaptive electronic environments that respond to the actions of persons and objects and cater for their needs.". By making use of these adaptive environments, it becomes possible to develop systems that are capable of adapting themselves to the specific needs of their users. It is possible to create such an ambient intelligent system by gathering all relevant user data through a number of sensors, based upon which possible alterations can be made to the system by itself. In order to acquire this user data, wearable sensors appear to be a prime candidate. These wearable sensors provide a way for the system to acquire relevant user data unobtrusively before the user comes into contact with the system, allowing the system to optimize itself for its specific user without any human intervention. This technology could be applied to new or existing DCD and CP treatment methods, in order to significantly improve the systems flexibility. By optimizing itself to a broad range of users, a system could be designed to be able to cater to a much more significant portion of those affected by DCD or CP without any human intervention in regards to optimization or customization. This could in turn lead to a system that is able to effectively support treatment of groups of children with varying degrees of capabilities at the same time.

To create such a system, a number of serious games will be developed or improved for an existing interactive playground. This interactive playground is a system consisting of six Kinects and two projectors fitted into the ceiling of a room, all of which are connected to a computer. By using this setup, physical interactions with the images projected onto the floor can be measured by the Kinects, which will then send these measurements to the computer so that these physical interactions can then serve as the primary user input for the games. Regarding the activity sensor, each participant will be given a MOX physical activity monitor[1]. This wearable activity monitor will measure the amount of steps taken by the participants throughout the day, and send this data to the RRD database. This database can then in turn be accessed by the computer to receive the participants' data, which can then be used to analyze

[1] https://www.maastrichtinstruments.nl/portfolio/mox-physical-activity-monitor/

and react to the player's activity data.

1.3 Challenges

There are a number of challenges that are expected to appear during the course of this project. First of all, working with a number of existing components, in this case the database, playground, and games, means that any new developments will have to based upon the foundation laid by these pre-existing components. Should any issues be encountered with these components, it will be much more complicated to solve these issues than it would be when developing a system from scratch, as the original developers might no longer be affiliated with the project or might not have time to provide extensive support. Additionally, developing for a unique system such as the interactive playground means that testing and debugging the software will be more complicated than it would otherwise be when simply developing for PCs or laptops, as access to the playground will be much more limited than access to basic consumer electronics. Furthermore, working with children diagnosed with DCD or CP could prove a lot more challenging than working with neurotypical children due to their condition(s), both in regards to direct communication with the children and the ethical documentation required to actually work with them.

1.4 Goal

The main goal of this project will be to create and adapt a number of games that can be used in a therapy setting by children aged 8-12 years old that have been diagnosed with either DCD or mild forms of CP. We adapt two existing games to better suit the context of a therapy session, and create a completely new game, which will feature the wearable integration as part of its game mechanics.

1.5 Research questions

The research question can thus be defined as:
How can a wearable sensor provide added value when integrated with an interactive playground regarding the rehabilitation of children with motor deficiencies?

To help answer this research question, the following sub-questions will need to be answered first:
What requirements should be taken into account when designing a system for children diagnosed with DCD or CP?
How can the data from a wearable activity sensor be integrated into an existing interactive playground?
In what way does playing a game that is able to react to this data facilitate the therapy sessions?

1.6 Report outline

Following this introduction, chapter two of this report will go into more depth in regards to the current state of the art within the fields of DCD, CP, AmI, and interactive play. In this second chapter, available literature within these fields will be examined in order to provide insight into the current opportunities provided within these areas, as well as possible problems and challenges related to the target group that will have to be taken into account during the project. The third chapter contains the design methodology, and will finish up by answering the first sub-question of the research question using the information found in chapter two. In the next chapter, the ideation process that will lead to the design of the final system will be described, as well as the underlying assumptions these design decisions will be based on. The second sub-question, regarding the integration of the activity data, will be answered in this chapter. The fifth chapter will further specify this design idea based on feedback from the client. Following this, the sixth chapter will describe the realization of the system, as well as the final product and its implications. The seventh chapter will describe the methods used to evaluate the new system, as well as the results of said evaluation, which will then be used to answer the third and final sub-question. The eighth chapter will be used to discuss the end result, as well as any problems or limitations that may have been encountered during the project. Furthermore, the eighth chapter will also cover suggestions for future research opportunities. The ninth and final chapter will then make use of all the aforementioned information to answer the research question and draw a conclusion. Based on this conclusion, recommendations for further research will then be made.

2 Background

2.1 Existing components

While already briefly mentioned in the introduction, an overview of the existing components of the system will be discussed at the beginning of this chapter in order to familiarize the reader with the initial state of the project. These components consists of the interactive playground, the already existing serious games, the MOX activity sensor, and the RRD database.

2.1.1 Interactive playground

Two different instances of the interactive playground will be used during the course of this project. One of these instances is located at the DesignLab at the University of Twente, and the other one is located at the Roessingh Centre for Revalidation. While both systems are very similar, there are some differences that should be noted; the playground version found at Roessingh makes use of six Kinects and displays games at a resolution of 1920 by 2160, whilst the playground found in the DesignLab uses four Kinects and features a resolution of 1920 by 2400. Furthermore, the playground found at Roessingh has both the beamers and the Kinects connected to a single pc, whilst the DesignLab variant uses two computers; one for the beamers and one for the Kinects, with the Kinect computer sending all tracking data to the beamer computer, which also hosts the games.

The concept behind the interactive playground is relatively simple; the beamers are used to project the games onto a floor, rather than displaying the games on a screen. Rather than having the players interact with the games using a controller, the playground turns the players themselves into controllers by having the players walk around on the projected surface. This movement is then measured by the Kinects, which send the measured data back to the game to be used as input. The game then responds to this input by moving the player's icon, granting the player points, et cetera.

This system is not without its limitations, however. The most important of these is that it is not uncommon for the software to mix up players if they are standing too close to each other. This should be taken into account when designing a game in which specific players need to be tracked throughout the play session. Furthermore, all these devices can take quite a toll on the computers, especially in the case of the system found at Roessingh Centre for Revalidation, since only one computer is used here. The Kinects and beamers have to be carefully distributed over the various USB hubs to prevent start-up issues or freezes from occuring.

2.1.2 Serious games

A number of serious games have already been developed for the interactive playground. These games have typically been developed by students as a way to help answer their research questions as part of their graduation projects,

not unlike the game that will be developed during this project. As these games have been developed for other graduation projects, however, they are generally not designed with a clinical user context in mind, and are instead more often focused on a general public setting. This in turn means that these game are usually not directly applicable in a therapy session. During this project, two of these existing games will be adapted to better fit into such a context.

Aside from these student games, a game template on the basis of the tag game by Moreno, van Delden, Poppe, Reidsma, and Heylen (2016) is also available. This template contains all the code required to translate the incoming movement data as measured by the Kinects into player movements on the screen. This template can thus be used as a basis for further development of a new game.

2.1.3 Wearable

The wearable sensor that will be used during the course of this project is the MOX physical activity sensor. This activity sensor is able to measure counts of physical activity from its wearer and upload this data to the database in real-time. These counts of physical activity can also be calculated into step counts, making the data much more relatable for the average user. All of this can be done wirelessly, as the sensor can send relevant data to a host device, such as a smartphone, using Bluetooth technology. This makes it a lot more user friendly than similar wired sensors, as the MOX sensors are less obtrusive and do not require users to bring cables with them.

2.1.4 Database

All of the relevant user data is currently already being stored in the RRD database. Within this database, every user has their own storage of activity data, which can be accessed at any point in time by an authorized user by sending an HTTP request to the REST/JSON webservice developed for the database. The webservice will then respond with the moment at which the data was stored, and the amount of physical activity that was performed at that point. The same webservice can also be called to determine what the daily goal for a specific user was, allowing for the game to compare the user's step goal with the actual amount of steps counted.

Of course in order to access this data, the system that is running the game will require a constant internet connection, otherwise it can not request data from the webservice. This can be solved by extending the playground with a USB-based WiFi adapter, allowing the playground to connect to the guest network at the Roessingh Centre for Revalidation. Furthermore, the physiotherapist coordinating the game during a therapy session will somehow have to confirm that the game should have the authorization to access the player's data, without this process being too complicated or the process interrupting the therapy session.

2.2 Literature research

Before development can begin, it is important to first read and summarize relevant literature regarding DCD and CP, ambient intelligence, and wearable sensors. The aim of this research will be to explore to how ambient intelligence and wearable sensors can be combined in order to create adaptive interactive systems for the treatment of children diagnosed with DCD or CP. To help answer this question, the initial focus of the research will be to determine how children diagnosed with either DCD or CP are affected in regards to their ability to perform tasks. Following this, the literature review will answer how significant the differences in both physical and mental performance between various children diagnosed with DCD or CP are, as this will help determine the range of capabilities that can be expected from the target group. It will then be investigated how effectively ambient intelligence and wearable sensors can be combined into a single adaptive and interactive system.

2.2.1 Definition and impact of DCD and CP

Both the American Psychiatric Association (APA) and the World Health Organisation (WHO) have specific criteria regarding the diagnosis of DCD. The APA (2013) describes DCD as a motor disorder, in which "the acquisition and execution of coordinated motor skills is substantially below that expected given the individual's chronological age and opportunity for skill learning and use." (p. 74). In addition to this, DCD is likely to result in decreased performance in sports related activities and unclear handwriting. This definition is dependent on the condition that these symptoms can not be attributed to another medical condition such as CP or mental retardation. The WHO (2004) maintains a more objective definition than the APA, describing DCD as a condition where, on a standardized test of motor impairment, the individual in question would achieve a score at least two standard deviations below the mean. In addition, it should interfere with their academic performance or daily activities. Furthermore, these symptoms should not be accountable to any other diagnosed neurological disorder, and the individual should have an IQ of at least 70.

CP on the other hand, is defined by Rosenbaum et al. (2007) as "a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occured in the developing fetal or infant brain." (p. 9). It is further stated that "the motor disorders of CP are often accompanied by disturbances of sensation, perception, cognition, communication, and behaviour, by epilepsy and secondary musculoskeletal problems." (p. 9). This updated definition is a response to the, at the time of the report, common definition proposed by Bax (1964), which defined CP as a disorder of movement and posture due to a defect or lesion of the immature brain. Note how the older terminology describes CP as a single disorder, whereas the more modern definition describes CP as an umbrella term for multiple motor disorders.

Whilst these symptoms paint a clear picture of the direct results of these

conditions, it is also important to determine the long lasting effects of both DCD and CP. For instance, adolescents diagnosed with DCD have an increased risk of mental health difficulties when compared to their neurotypical peers, as suggested by Harrowell, Hollén, Lingam, and Emond (2017). In addition to this, a further study by Harrowell, Hollén, Lingam, and Emond (2018) aimed at investigating the effects of DCD in adolescents gives an indication of the significance of the role that DCD can play in the lives of those affected: while the control group of neurotypical adolescents would achieve a median of five passing grades on their National Certificates of Secondary Education (GCSEs), adolescents diagnosed with DCD achieved a median of two passing grades on their GCSEs. Due to research in this field being hard to quantify in tangible numbers, this comparison makes the impact of DCD much more relatable to the average person. Furthermore, Colver et al. (2015) report findings suggesting that adolescents diagnosed with CP have more difficulties with forming and maintaining social connections. It should be noted however that since this last report is based on self-reported data, further research using a more objective method might be necessary before it should be taken as fact.

Considering that, based on the aforementioned reports, these effects are already present by the time individuals diagnosed with DCD or CP become sixteen years of age, it is important to treat children as soon as possible to help mitigate said effects. Analysis by Smits-Engelsman, Jelsma, Ferguson, and Geuze (2015) describes that while initial motor skills of children diagnosed with DCD are lacking compared to neurotypical children, there is no significant difference between the rate of motor learning of the two groups. In fact, at the end of the ten week period, the group diagnosed with DCD was achieving scores similar to those achieved by the neurotypical group after the seventh week. With the important caveat that the analysis was based on medium term learning that spanned five weeks, and is thus not necessarily representative of long term learning, this could be indicative of the fact that given enough time and support, children diagnosed with DCD could perform comparably to neurotypical peers. It should be noted that these results do not correlate with the aforementioned study by Harrowell et al. (2018), however, suggesting that there might be differences based on subject matter or the duration of the learning process.

The definition for DCD that will be used moving forward is the one maintained by the WHO, due to it being much more objective and quantifiable than the definition used by the APA. The impact of DCD is assumed to be primarily physical of nature, with those diagnosed with DCD performing noticeably worse in motor related tasks. This does not mean that there are no mental factors to be taken into account however, as issues related to mental health and academic performance are more common when compared to neurotypical peers.

Similarly, the definition for CP that will be used from this point onward is the definition proposed by Rosenbaum et al. (2007), as it takes into account insights discovered related to CP after the publication of the definition proposed by Bax. The impact of CP will be assumed to be both physical and mental,

with the areas affected by the condition ranging from perception and cognition to communication and behaviour. Furthermore, the increased prevalence of social problems should be taken into account.

2.2.2 Variations between diagnosed children

Now that the symptoms of DCD and CP as isolated conditions are known, the next step is to determine to what degree the physical and mental capabilities of those affected by either condition can vary on an individual basis in order to determine to what extend this can be compensated for in the to be designed system. A study by Alloway (2007) quantified the performance of children diagnosed with DCD by creating descriptive statistics for working memory measures, attainment, and IQ, based on verbal and visuospatial testing, as well as tests focused on literacy and numeracy skills. Across all of the test statistics, the smallest standard deviation consisted of 16% of the mean, while the largest standard deviation amounted to 24% of the mean. Skills related to literacy and verbal short term memory would generally find themselves on the higher end of this range, while visuospatial skills and skills related to the working memory would find themselves on the lower end of this range and thus be more consistent among various participants. As for CP, research based on the Cerebral Palsy Registry of Norway by Andersen et al. (2008) reveals that, in Norway, severely impaired vision and hearing was present in 5% and 4% of children diagnosed with CP. Furthermore, active epilepsy was found in 28%, mental retardation in 31%, and severely impaired or no speech in 28% of the children. While children with co-existing conditions of this severity are currently not included in the therapy sessions, this could potentially change in the future. Furthermore, it is still important to consider these conditions should some of the children show minor forms of these conditions.

In addition to these variations within the degrees of severity of DCD and CP itself, children diagnosed with either of the two conditions will frequently get diagnosed with other disorders, such as ADHD (Hellgren, Gillberg, Gillberg, & Enerskog, 1993), autism spectrum disorder, dyslexia (Albaret, Barré, Biotteau, et al., 2015), or even depression (Lingam et al., 2012). Specifically the combination between DCD and ADHD seems to be common, with Kirby and Sugden (2007) reporting that 25% of children diagnosed with DCD could also be diagnosed with ADHD, and Kaplan, Wilson, Dewey, and Crawford (1998) reporting that, in their test group, this percentage reached 41%. Dyslexia and other reading disabilities are also very common, with Kaplan et al. (1998) also stating that, again within their test group, 56% of children diagnosed with DCD could also be diagnosed with a reading disability.

As a result of these differences, both within DCD and CP, and due to common coexisting conditions, a group of randomly selected children diagnosed with DCD or CP can possess a rather large range of capabilities and needs. Due to the limitations of this research, design decisions should be based around a target group consisting of children with DCD or CP, with the strong possibility of ADHD and dyslexia also being present in the target group. This will

ensure that the majority of target users are taken into account during the design process, while still being feasible with the time and resources available to this project.

2.2.3 Ambient intelligence and wearable sensors

As described by Augusto, Callaghan, Cook, Kameas, and Satoh (2013), "An Intelligent Environment is one in which the actions of numerous networked controllers (controlling different aspects of an environment) is orchestrated by self-programming pre-emptive processes (e.g., intelligent software agents) in such a way as to create an interactive holistic functionality that enhances occupants experiences." (p. 1). This means that based on the information the system receives through the connected sensors, it should be able to make its own decisions in order to maximize the benefit for its user, without a human operator having to intervene in the decision making process.

In order to obtain the information required by the system so that it can make its own decisions, the user will have to be continuously monitored during their interaction with the system, and preferably even beforehand so that the system can prepare appropriately. In the case of the interactive playground, this would be setting the complexity and physical intensity of the game to an appropriate level based on the amount of physical activity performed beforehand. This data gathering is an ideal application for wearable sensors due to various factors. First of all, the user is not required to be physically close to the rest of the system in order for data to be gathered, as can be seen by the use of wireless wearable sensors by Brady, Carson, O'Gorman, Moyna, and Diamond (2006). In addition, every user within a group can be individually monitored by providing every user with their own wearable sensor, allowing for personalized customization interaction with the system. Furthermore, users are not at risk of leaving a detectable area within a system due to the sensor being physically attached to the user. The wearable sensors can then be used to sense various physiological parameters with wearable sensors, which can then in turn be used to determine various states of the users body such as high physical activity, as shown by Mukhopadhyay (2015).

Due to their physical flexibility, wearable sensors will allow the system to track its users without interruptions, even before or after the user has interacted with the interactive playground. This in turn will allow the playground to customize itself based on the specific needs of the user at that point in time, even if the user has not interacted directly with the system yet.

2.2.4 Summary

Now that the various components have been researched, it can be determined how ambient intelligence and wearable sensors can be combined in order to create adaptive interactive systems for the treatment of children diagnosed with DCD or CP. It is important that any system aimed at providing a comprehensive treatment method is designed to adapt to the specific needs of every

user. While children appear to benefit more from group based treatment than an individual variant, it is important to recognize that it is very unlikely that all group members will show identical or even similar symptoms. For this reason, the system should be able to distinguish the individual users within the group, and adapt their individual experiences to align closely with their capabilities. The data required to do so should be, at least in part, gathered before the users interact with the system, so the system can preemptively customize itself to reflect the needs of its users. In order to achieve this, using wearables appears to be a viable solution; due to the wearable being attached to the user throughout the day, the system can gather data without requiring the user to be physically present at a specific location. In addition, since every user has their own wearable, the system can track every user individually without the risk of mixing up some of its users during rapid movement, making sure that the system adapts the correct areas of the playground for the related user.

2.3 Input from the client

During the exploration phase of the project, two pilot sessions were held at RRD with regards to the use of the existing interactive playground and its role in rehabilitation sessions. These pilot sessions were attended by the client, Mattiene van der Kamp, a researcher at RRD, as well as a Allard Dijkstra, a physiotherapist at RRD. Whilst part of a different project, these sessions were attended in order to gain first hand experience into how the target group interacted with and responded to the interactive playground. Furthermore, these sessions provided a moment to discuss the wishes of the client, as well as any suggestions they might have had based on the existing games available to the playground.

2.3.1 Typical therapy intervention

Before any therapy sessions take place, a meeting is organized between the physiotherapist, the child's parents, and the children themselves, in order to gain more insight into their specific problems. Following this, an initial test is organized to determine the current state of the children's activity. After this, the children attend a one hour therapy session for ten weeks. Currently, these therapy sessions are based on groups of roughly four children and largely consist of performing various exercises not unlike those seen in primary school playgrounds, under the supervision of a physiotherapist and a movement therapist. Examples of these exercises include playing indoor soccer, playing tag, and bouncing a ball off the walls. These games tend to be team based, but can be individually tuned by the physiotherapist to suit every child. Following these ten weeks, the child has to retake the initial test, so any improvements or differences can be determined. The results of this test are then discussed with the parents in a final meeting.

The problem with this current situation, according to Dijkstra, is that while the children certainly improve over the span of the therapy sessions, they quickly relapse into their initial behaviour and slowly lose all of the progress gained from the therapy sessions. Because of this, it is important to not only create a physically active game, but also a game that the children can carry on playing after the therapy sessions end, so that they remain active.

2.3.2 Client's wishes

First of all, the client wished for the game to be multiplayer if possible, since the pilot groups will consist of roughly four children. While it is possible to have the children play games individually, this creates a scenario where the majority of children are idle in between turns, which is something to be avoided. Furthermore, the client wished for a "therapy mode" to be implemented, in which the therapist is able to directly control a larger portion of the game than is possible in the default mode, so that the game can be fine tuned based on the specific group of users. In addition to this, Dijkstra stressed how easily confused and distracted the target group is, demonstrated by some

group members already being confused by the relatively simple *Rock paper scissors* game, explained later on in detail, a confusion that was compounded by some of the children having their trackers switched around. Any new game should strive to have one or two basic rules, any more could lead to the children not understanding the game. Lastly, the client wished for the game to require little to no instructions on behalf of the children, so that it becomes possible to play various games interchangeably without having to interrupt the session for instructions.

2.3.3 Follow-up meeting

A few weeks later, another meeting was held at RRD. This meeting was attended by van der Kamp, Dijkstra, van Delden, and Folkertsma, among others. The purpose of this meeting was to discuss the progress of the project, as well as to discuss any additional design requirements. During the meeting, it was confirmed that the MOX activity sensor should be used as the wearable component of the system. This should allow the game to be integrated with the app used by RRD more easily, as all data gathering for the app is also done with the MOX activity sensor. Possible ethical concerns arise from this however, since the tracking used in the interactive playground is not perfect, and could lead to users, and thus user data, to get mixed up between the various players. To prevent this, it was suggested to link the game to the account of one specific user, rather than every participating member. Furthermore, the client expressed interest in a game mechanic that would allow children to set their own difficulty dynamically whilst playing, rather than having the therapist set it beforehand.

2.4 Related works

In order to learn from previously developed systems and help to avoid any problems that the developers of said works may have come across, it is important to create an overview of what similar works have been created in the past. This section of the report will describe what these works are, what the advantages and disadvantages of each work are, and what can be learned from the work so that it can be applied to this project. This list of related works is inspired by a previous overview made by Ahovi (2018).

2.4.1 Related playgrounds

LUMOplay
The *LUMOplay*[2] is an interactive display software that can be used to make displays interactive. It is developed by Lumo Interactive Inc. It is not a typical interactive playground, in the sense that it allows users to apply the software to their own surfaces, sensors, and computers. Because of this, it does not have a defined hardware setup.

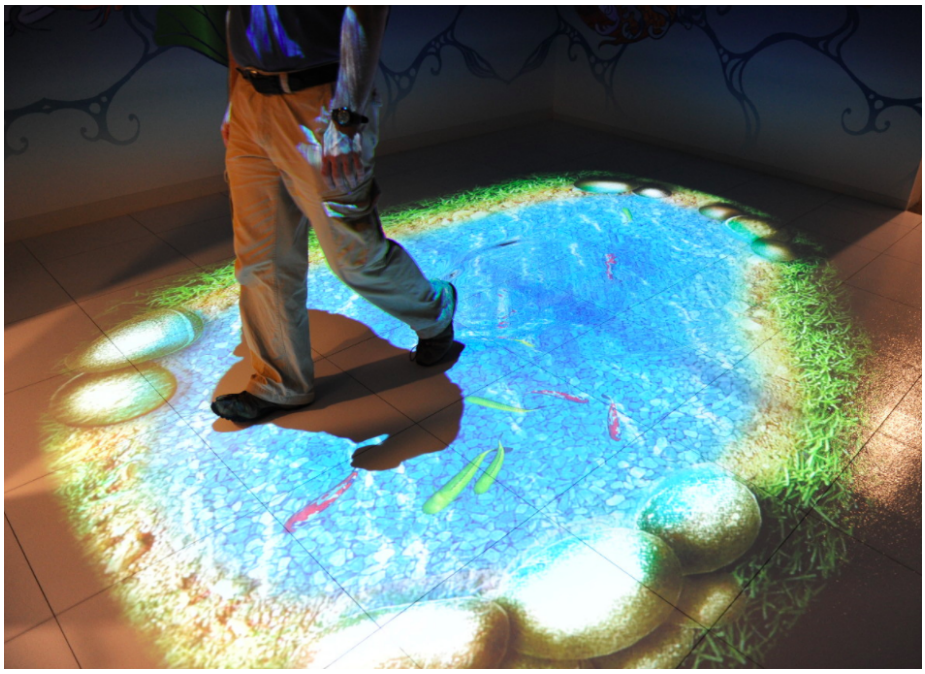

Figure 1: An interactive surface made using *LUMOplay*. Image reprinted from Project Mapping Central[3].

The downside of the *LUMOplay* is that the system uses its own format for

[2]https://www.lumoplay.com/

games, an example of which can be seen in Figure 1 above, resulting in all existing games developed for the current playground being incompatible with the *LUMOplay*. The current interactive playground used at the university on the other hand primarily makes use of games created in Unity[4], which can also be played on computers making use of a different playground setup.

BEAM

BEAM[5] is an interactive playground designed for children and families, developed by *EyeClick*. The various tracking, sensing, and projecting components are all located within a single ceiling mounted hardware kit. This creates an easy to install system that only takes up a small amount of space, and can thus be installed in a larger variety of rooms than a larger, more decentralized playground would fit in.

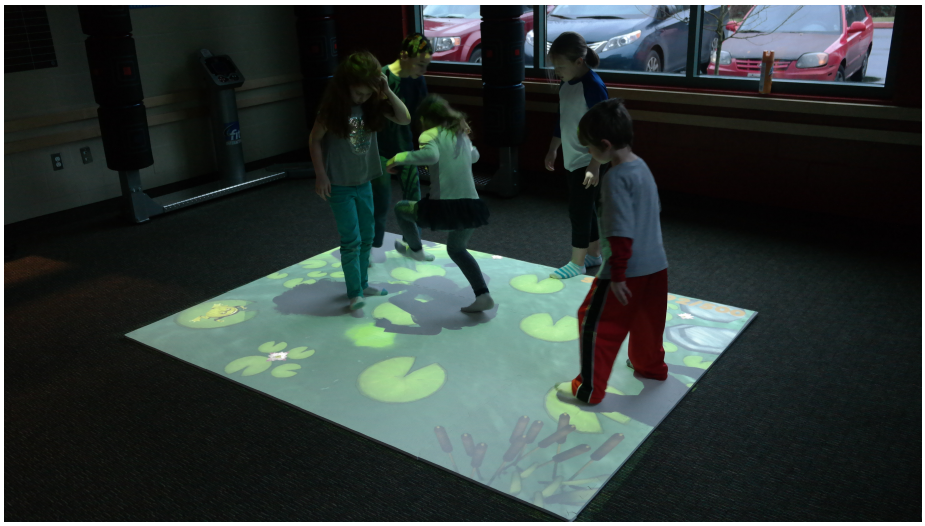

Figure 2: The *BEAM* being used by a group of children. Image reprinted from Motion Fitness[6].

The downside of the integrated nature of the *BEAM* is that the system can not be expanded with additional projectors, so the projection surface is quite limited, as can be seen in Figure 2 above. Because of this small projection surface, the use of the *BEAM* is limited primarily to young children, as they take up less space. Furthermore, the small surface area limits the amount of games that can be played on the *BEAM*, as there is simply not enough surface area for kids to run around in for games such as tag .

[4]https://unity.com/
[5]https://joinbeam.com/

Wisdom well
The *Wisdom well*, seen in Figure 3 below, is also known as the *WizeFloor*[7]. It is an interactive floor application created by Iversen, Kortbek, Nielsen, and Aagaard (2007) consisting of four glass tiles, four projectors, four webcams, and a laptop. The webcams are managed by a tracking manager running on the laptop so that they can be used to track the users.

Figure 3: The floor component of the *Wisdom well* as seen by its users. Reprinted from Iversen et al. (2007, p. 117)

The main difference between the *Wisdom well* and the interactive playground consists of the fact that the tracking devices are placed below the floor, rather than above it; the webcams are placed three meters below the interactive floor itself, with users being tracked through the glass floor. The advantage of this is that the system can detect exactly where the users are touching the floor, without the line of sight of the various tracking components being blocked. The downside of this however is that the *Wisdom well* has to be placed over a three meter deep hole in the floor, making its placement much more expensive and permanent than a system tracking its users from above.

MagixFloor
The *MagixFloor* is a commercially available interactive playground made by *MotionMagix*. The system consists of a ceiling mounted *MagixFloor* unit, a device combining computer, projector, and tracker components, and a gaming floor, upon which the *MagixFloor* unit can project the various games available on the device, as seen in Figure 4 below.

[7] https://www.wizefloor.com/

Figure 4: The *MagixFloor* as seen on the product page. Image property of *MotionMagix*

The unique characteristic of the *MagixFloor* is that all the various electronics are housed within a single unit placed above the projection surface. This allows for easier installation and more flexible placement, since less ceiling space is required. The downside to this is that the various tracking components are concentrated in a central position; this results in tracking of moments along the edges of the game floor being performed at a significant angle, reducing their accuracy.

Funky forest
The *Funky forest* is an interactive ecosystem created by Watson and Gobeille[8]. The primary components of the ecosystem are two desktop computers, three projectors, ten infrared lights, and two CCTV cameras. Unlike the previous two systems, these projectors are also able to project images onto the walls of the system, this can be seen in Figure 5 below.
Due to its ability to project onto both the floor and the surrounding walls, the

[8] *http://www.muonics.net/site_assets/41/files/funkyForest_setup.pdf*

Figure 5: The *Funky forest* can project images onto multiple surfaces at once. Image property of Emily Gobeille and Theodore Watson.

Funky Forest creates a complete digital environment that its participants are able to step into and be fully immersed in. The downside to this is that in order to provide this experience, a number of lamps need to be added along the entire length of the bottom of wall. This adds a lot more electrical components that could potentially break down, and also significantly increases the time and effort required to initially set up the installation. In this sense, the *Funky forest* is a stark contrast to the previously discussed *MagixFloor*, with the former being properly integrated into the room, resulting in a more immersive final product, while the latter is much easier to set up and move to a different room, but creating a much more limited experience.

Boundary Functions

Boundary Functions[9] is an interactive artwork that is projected onto the floor and responds to people's movement, and can be seen below in Figure 6. The artwork consists of a computer, an overhead projector, and a floor with a retroflective surface. If a vertically mounted camera is not available, a mirror is placed at a 45 degree angle in front of the projecter to reflect the light onto the floor. It was created by Scott Snibbe as a way to visualize how personal space responds to the people around us, and how it can be influenced by factors outside of our power.

[9] https://www.snibbe.com/projects/interactive/boundaryfunctions/

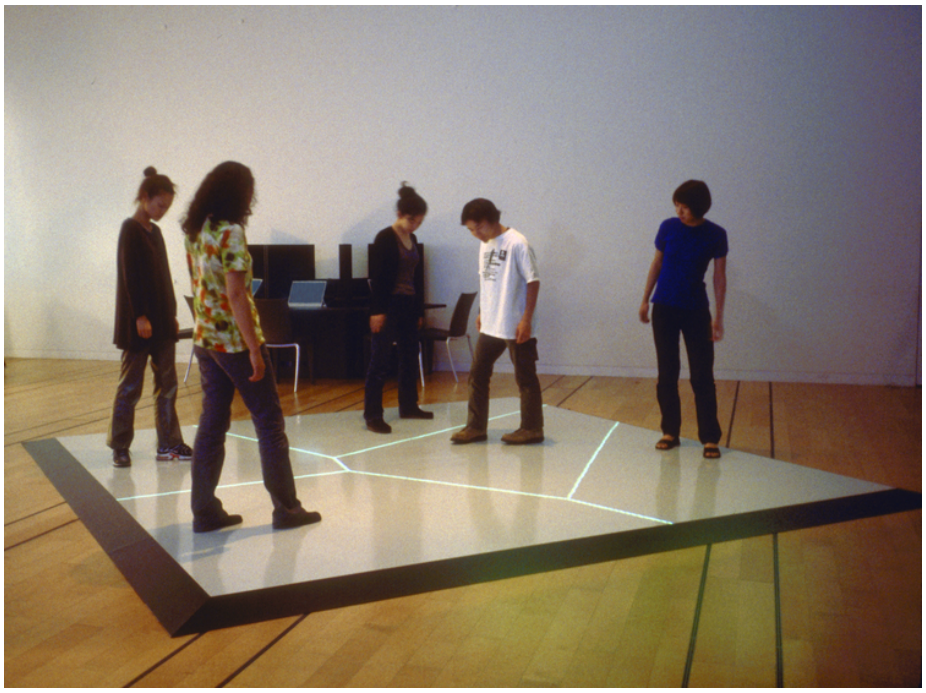

Figure 6: *Boundary Functions* being used by five people. Retrieved from Snibbe's portfolio site[3].

The use of a mirror to reflect the projection is a clever way to increase the flexibility of the system, as it allows for both horizontally and vertically mounted projectors to be used for the installation. Furthermore, *Boundary Functions* can not be interacted with by a single participant. While this is an interesting exploration of team-based play, this is not a desired characteristic of the playground games that will be developed for use at the Roessingh Centre for Rehabilitation, as this would render the games unusable if only one participant shows up to a therapy session.

Fear

Fear is another interactive exhibit developed by Snibbe and Raffle (2009), seen in Figure 7 below. It was designed to explore the science of being scared, and to incorporate a design principle Snibbe calls *social scalability*. This principle dictates that an interactive installation should support as many users as it can physically fit. *Fear* makes use of the player's shadow to incorporate the players into the game without requiring physical contact with the system. The players are tasked with gathering as much fruit as they can, but should be careful to do this only whilst the jaguar is not looking. If the jaguar spots a moving player, their shadow is pounced on and attacked, removing that player from the game.

Figure 7: Three children interacting with *Fear*. Reprinted from Snibbe and Raffle, (2009, p. 5)

The concept of *social scalability* is an interesting one and certainly applies to the games that will be developed for the interactive playground. Since the playground has enough space for all four children to run around in, this should be an expected scenario and should thus be accounted for when developing new games.

In addition to this, Snibbe cleverly uses game design to guide the player's behaviours. First of all, the fact that the player's actual outlines in the form of their shadows are used creates a more personal connection with whatever is happening on the screen, making the players more invested. Furthermore, by removing shadows from the game after they have been pounced on, Snibbe urges people to move on after they have lost the game, allowing for new players to join in as the previous ones leave.

Üno

The *Üno* is an interactive playground developed by Lü[10], with its primary components consisting of a camera module, a light and sound module, and a projector module. Unlike the previously mentioned related playgrounds, the *Üno* is only capable of projecting images onto walls, rather than floors, as can be seen in Figure 8 below.

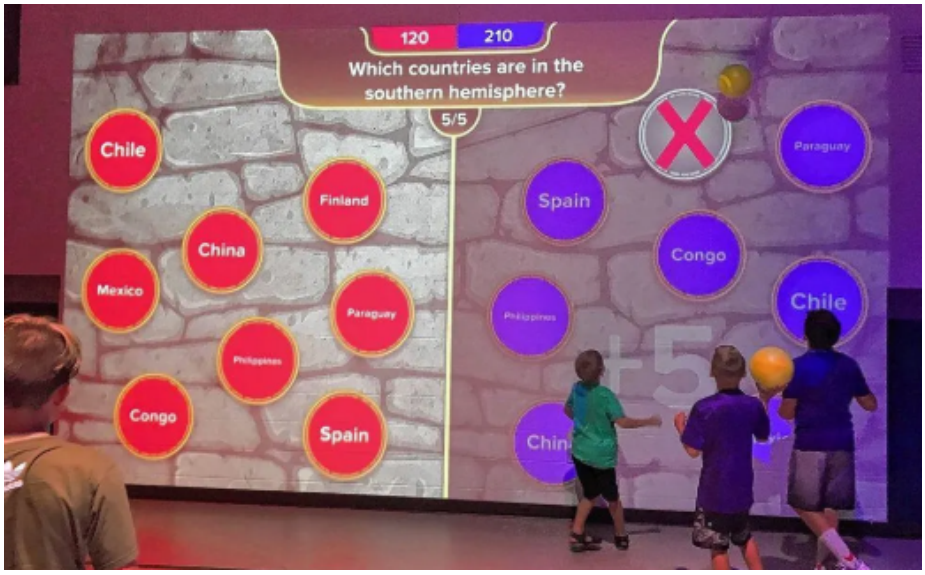

Figure 8: Children using the *Üno* interactive playground. Image property of *Lü*.

Similarly to the aforementioned *MagixFloor & BEAM*, the *Üno* has all of its various components located in a central position. There are much fewer obstructive elements that could interrupt the tracking software, as it is designed for use on walls rather than floors. Because of this, the drawbacks of the angled tracking are limited. The new orientation comes with its own drawback however; users are unable to interact with the higher parts of the interactive surface directly due to their limited reach. This especially affects children due to their smaller stature. While this can be remedied by using external objects such as balls or sticks, using these objects introduces more complicated motor skills to the interaction, which could be a disadvantage considering the target group for this project.

[10]https://www.play-lu.com/

2.4.2 Related games

A number of related games will be discussed in this section, all of which have been developed by students for the same interactive playground that will be used during the course of this project. Because of this, these games are a good indication of what is technologically feasible and appropriate for the target group, both in terms of visuals and game mechanics.

Rock paper scissors
Rock paper scissors (RPS) is a game specifically developed for children with motor impairments, by Markova (2018). It features a singleplayer and a multiplayer mode, allowing for groups of various sizes to play the game simultaneously.

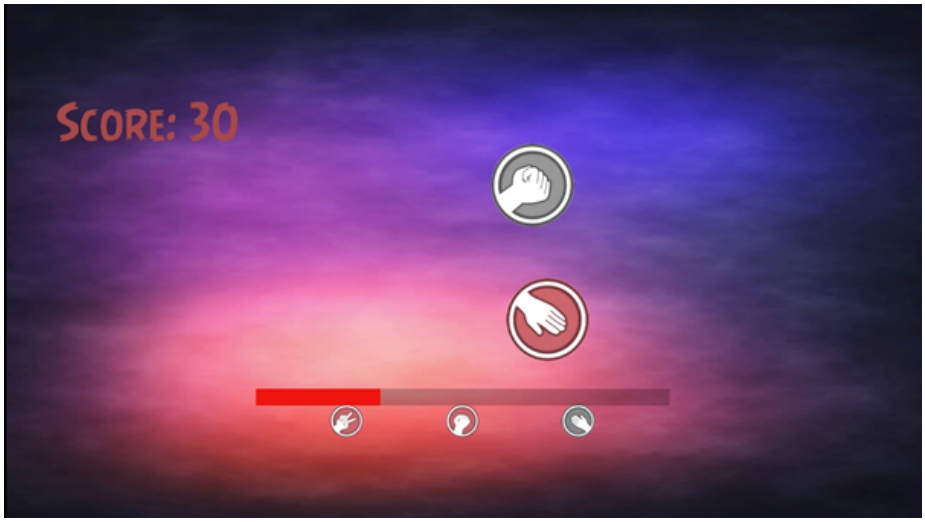

Figure 9: Image of a singleplayer *RPS* game. Adapted from Markova, (2018)

As can be seen in Figure 9 above, the multiplayer mode features two sides, allowing for children to play the game against each other. Furthermore, the visuals show the hand gestures typically made for all of the three moves in the game, informing the users on how they would be able to play the game without the help of the interactive playground, outside of their therapy sessions.

Tag

Tag is a game developed by Moreno et al. (2016) that can be played by two or more players. While not specifically designed for children with DCD or CP, it was designed for children in general.

Figure 10: Young adults playing *Tag*. Reprinted from Moreno et al. (2016)

The goal of *Tag*, as seen above in Figure 10, was to analyze how traditional analog games can be enhanced by technology without eroding the social or physical characteristics of said games. Furthermore, the game was able to adapt to players of various skill levels; the longer the tagger was unable to tag another player, the larger their tag circle would become. This in turn would make it easier for the tagger to tag other players they would previously have difficulties reaching.

Tag was later adapted to include cosmetics (van Delden, Moreno, Poppe, Reidsma, & Heylen, 2017) as a way to entice players to perform certain actions, by rewarding them with pleasant visual changes if they played a more active role in the game. This technique could be considered as a way to encourage active participation from users in this project as well.

Uncover

Uncover is a game developed by Ahovi (2018), based around cooperative multiplayer. In *Uncover*, players are presented with a black screen, covering an image unbeknownst to them. Players are able to uncover the image by walking across the black screen, erasing the black layer covering the image where-ever they go, as seen in Figure 11 below.

Figure 11: An image partly discovered in *Uncover*. Reprinted from Ahovi, (2018, p. 24)

By removing the competitive element between players, the game is more approachable for newer players, since they do not have to compete directly with more experienced players. The downside of this however is that this also removes a stimulus to actively participate and improve in the game, possibly making it less engaging overall.

An advantage of the game is that the game mechanics are very simple and easy to understand, to the point that no instructions are required. There is also no definite beginning or end to the game, as *Uncover* will simply keep looping through various images until the game is closed. As Ahovi intended, these two factors combined result in a game that allows passers-by to step in and play at any time.

Block Dodger

Block Dodger is a singleplayer game developed by Knuppe (2016), in which the player has to avoid the incoming blocks by moving through the gaps in the patterns. As the player completes more waves, both the music and the gameplay will start to get more intense as the blocks move faster and faster. Halfway through the waves, the blocks will have reached their maximum intensity whilst the music will keep getting more intense, allowing for researchers to analyze what effect the intensity of game audio has on the perceived difficulty of the game. An adult can be seen playing *Block Dodger* in Figure 12 below.

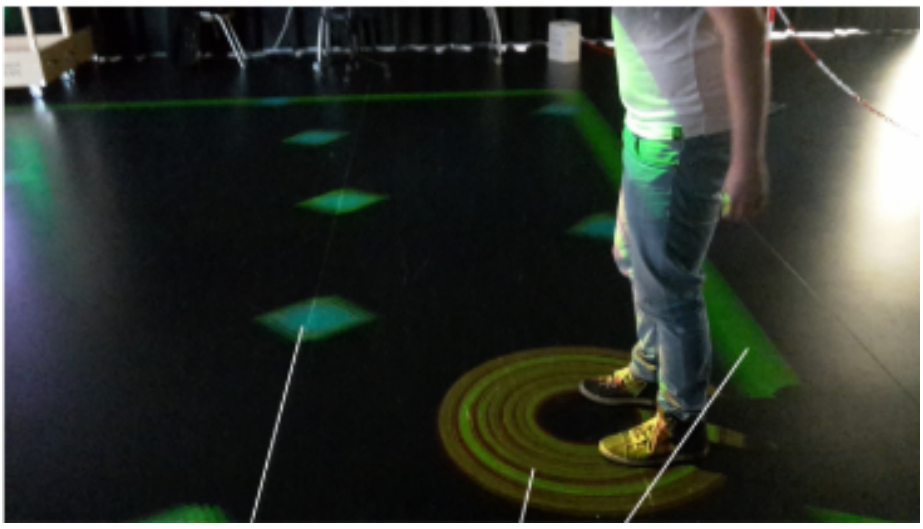

Figure 12: An adult playing *Block Dodger*. Image cropped and reprinted from Knuppe, (2016, p. 2)

The game promotes constant movement as there are only very short breaks between each wave, which will mostly be spent getting back into position for the next wave. While the game does get more difficult over time, this increase in difficulty is very gradual, so the players are eased into becoming more and more active. Furthermore, the only penalty for getting hit is the reduction of the players score multiplier, resulting in a lower final score. Aside from this, the player does not experience any negative effects.

A downside of the game is that the blocks will only spawn from the same edge of the screen throughout the entire game, and will do so in a limited number of patterns. This makes the game somewhat repetitive and predictable. Furthermore, the player technically only has to move along one axis to avoid the blocks, allowing the player to move along one line rather than having to use the entire area of play to avoid the blocks.

Buzz

Buzz is another game developed by Ahovi (2018), with a focus on competitive rather than cooperative multiplayer gameplay by virtue of displaying every players score on the screen. This can cause players with a below average performance to feel bad, but it can also motivate them to take a more active stance and catch up to the other players.

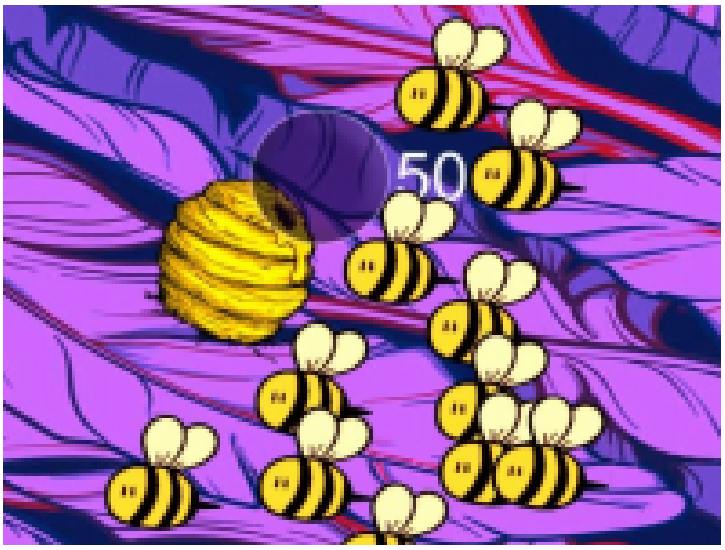

Figure 13: Screenshot of *Buzz* during gameplay. Reprinted from Ahovi, (2018, p. 25)

Players are placed on a nature-rich environment, as seen in Figure 13 above, and receive points for catching bees. This is done by touching the bees, after which the bee disappears from the screen. Similarly to *Uncover*, the game mechanics are very simply and intuitive, such that instructions are not required. There is also no definite beginning or end to *Buzz*, as players can enter and exit the game whenever they please. This encourages potential users to at least try out the game, before either moving on or playing it for a longer period of time.

3 Design methods and requirements

Before the ideation phase can take place, it is important to determine exactly how this design process should take place. For this purpose, this chapter will outline the design methodology that will be followed throughout the ideation, as well as the various design requirements that should be taken into account.

3.1 Design methodology

The design method that will be used is based upon the design process for Creative Technology as described by Mader and Eggink (2014); the design process will be broken down into three distinct phases. These phases can be described as the *ideation*, *specification*, and *realization* phases. At the end of this design process, the resulting product should be evaluated in the *evaluation* phase. An overview of this design process can be seen below in Figure 14.

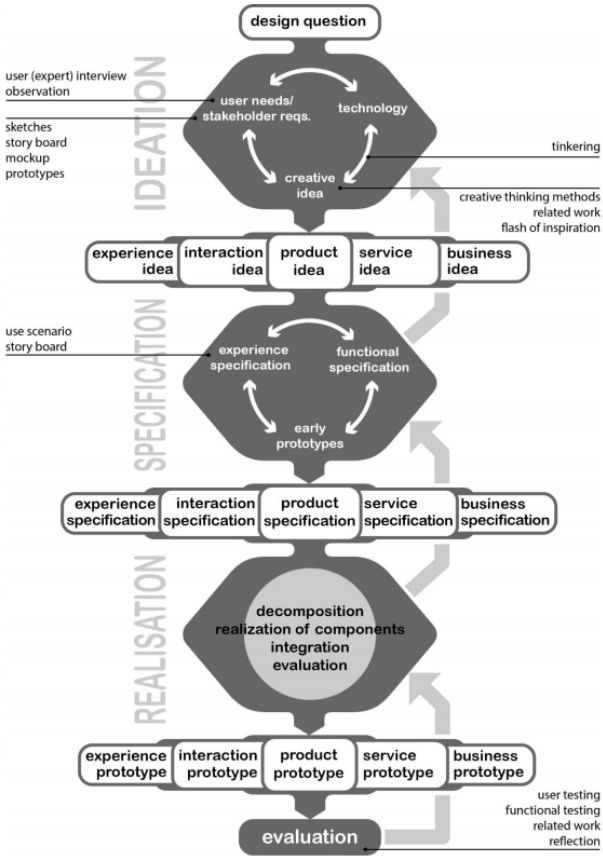

Figure 14: A systematic overview of the Creative Technology design method. Reprinted from Mader and Eggink, (2014, p. 3)

This design method incorporates elements of user centred design and iterative design into a more tradition prototype based design process, allowing for more direct feedback from the target group and the possibility of incorporating said feedback into the end product in early stages of development.

3.1.1 Ideation

The first phase of the design process can be described at the *ideation* phase. The goal of this phase is to gain insight into the domain related to the design questions, and then generate potential product ideas that can later be further expanded upon. As can be seen in Figure 15 below, the phase is cyclical in nature, creating a feedback loop that can be used to refine the product ideas before moving on to the next phase.

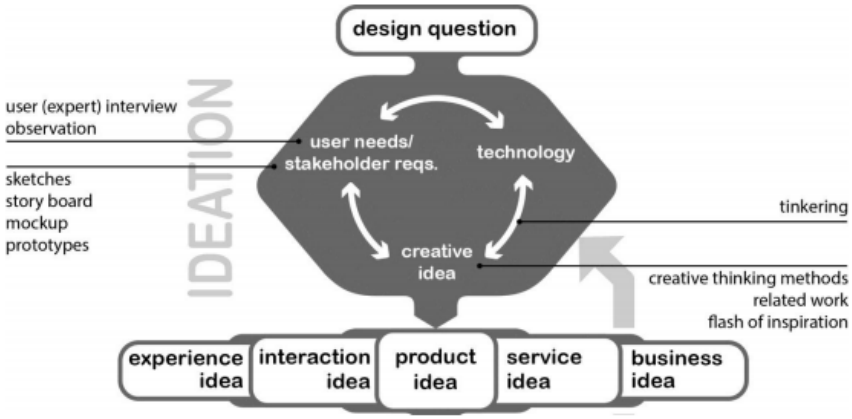

Figure 15: A systematic overview of the ideation phase of the Creative Technology design method. Adapted from Mader and Eggink, (2014, p. 3)

The starting point of this phase consists of the design question. Based on this design question, the first step is to analyze a number of traditional playground games using the various design requirements that will be specific later on in this chapter. From this exploratory process, one or multiple product ideas can be defined based on which traditional playground games would be the best match for a therapy session based on the design requirements, which can then be presented and discussed with the client using mock-ups. It these same meetings, the various existing playground games will also be discussed to give the client more insight into the various games and to determine which games would best suit the therapy sessions. The feedback gained from these sessions can then be carried over to the *specification* phase to further refine the product idea(s).

If multiple ideas are still being considered at the end of the *ideation* phase, a decision should be made together with the client to either pick one of the

ideas, or merge multiple ideas into one based on the user requirements and the feedback gained during the client meetings.

3.1.2 Specification

The second phase of the process is the *specification* phase. During this phase, a number of meetings regarding the use cases of the product ideas are held to quickly evaluate the basic principles used in the idea by either the client of other experts. Following this evaluation, a short feedback loop is applied in order to create a product ideas based on the lessons learned in these meetings. An overview of this phase can be seen in Figure 16 below.

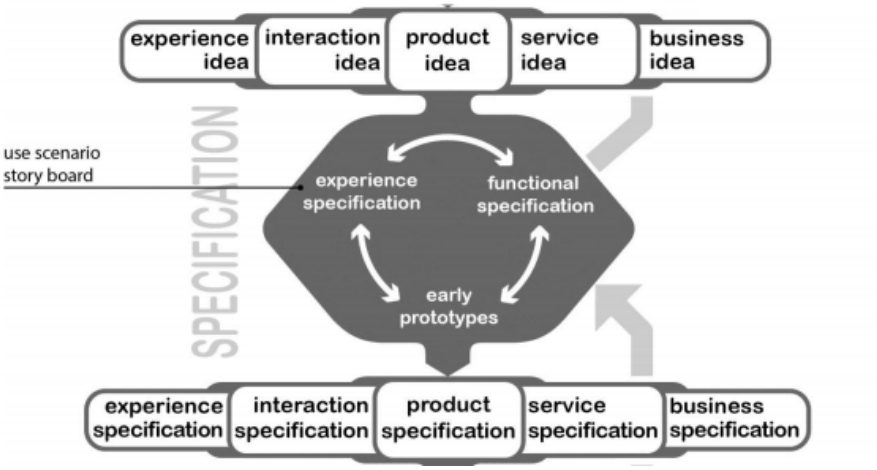

Figure 16: A systematic overview of the specification phase of the Creative Technology design method. Adapted from Mader and Eggink, (2014, p. 3)

The feedback gained from the client during the end of the ideation phase will be used to pick two existing games to be redesigned so they can be better integrated into the therapy settings. After selecting these two games, they will be discussed with the client to determine exactly what has to be changed about the games. Similarly, the new game ideas will be iteration upon based on the client feedback. These ideas will then be presented again to the client, after which the client will make a decision on which game to further develop. Finally, the expert in charge of the RRD database will be asked about the various options regarding the database integration, one of which will be picked based on the practical and ethical implications the various options would bring along with them.

3.1.3 Realization

The third phase of the design process is the *realization* phase, during which the actual products will be made based on the product specification. In the early stages of this phase, the existing games will be iterated upon using the knowledge gained in the specification phase. This will not only make the games more suited for therapy sessions, but it will also allow the developer to gain more insight into how the tracking component works and how it has been integrated into games previously. After this, the product specification of the new game will be broken down into its various components, each of which will be developed separately. When all of the various components can function independently, they will be integrated into a single functioning system, resulting in the final product prototype. An overview of this process can be seen in Figure 17 below.

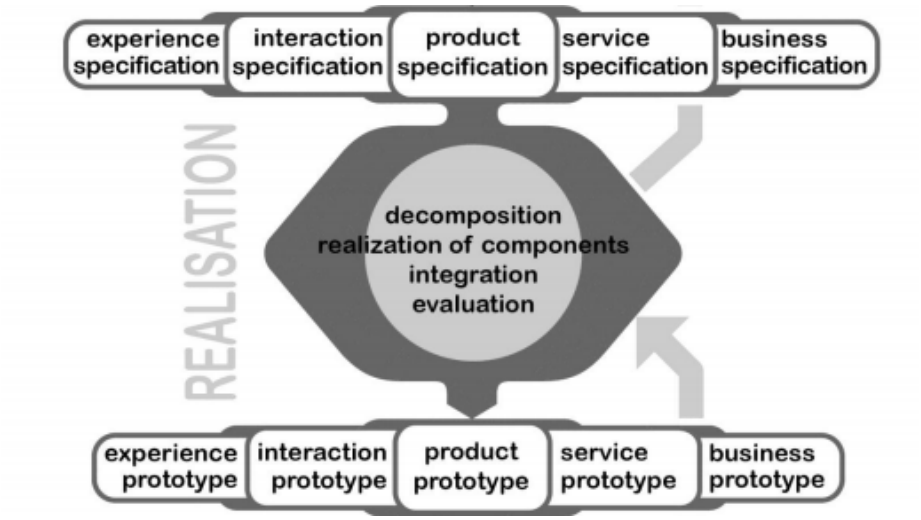

Figure 17: A systematic overview of the realization phase of the Creative Technology design method. Adapted from Mader and Eggink, (2014, p. 3)

Once these product prototypes are done, they should closely align with the product requirements and the wishes of the user group. The prototypes will then be presented to the client, who will be able to give feedback on the various games and specify desired improvements. After implementing these improvements, a pilot test will be held with students in order to detect and remove as many technical issues as possible. The feedback gained from this pilot test will be used to create a third and final iteration of the prototype, which can then be used to enter the *evaluation* phase.

3.1.4 Evaluation

The fourth and final phase of the design process is the *evaluation* phase. During this phase, a user test will be conducted to determine whether or not the final product meets the user requirements set out throughout the design process, as well as the requirements determined by the client. Furthermore, the user test should also be used to help answer the initial design question, which should now be possible to answer based on the information gathered throughout the entire design process. During this phase, the designer can also evaluate the design decisions made during the process, and reflect upon the design process as a whole. From this process, the designer can determine which new lessons have been learned during the project.

3.2 Design requirements

The various requirements that should be taken into account during the ideation project, as determined in the previous chapter, can be broken down into three categories; *user requirements*, *client requirements*, and *project limitations*. These three categories will first be discussed individually, including a table mapping their severity and the accompanying rationale, after which an overview will be given of the most important requirements.

3.2.1 User requirements

The *user requirements* can be defined as the requirements related specifically to the users, in this case children aged 8-12 with either DCD or CP. These requirements can be physical, but can also be related to other aspects such as game mechanics or ethical concerns. If these requirements can not be met, it can have direct effects on the effectiveness of the system. Each requirement has been assigned a severity based on the scale seen in Table 1, resulting in the *user requirements* overview below in Table 2. The reasoning for each severity can also be found in Table 2.

Severity	Description
1	A minor requirement, should be considered if possible
2	A major requirement, should always be considered
3	A vital requirement, must be accounted for at all times

Table 1: The scale used to document the severity of the requirements.

Requirement	ID	Severity	Reasoning
The game should not require any fine motor skills	U1	3	Children diagnosed with DCD or CP are by definition diagnosed with sub-par motor skills. Any game that does require the use of such skills is thus by definition unplayable for the target user.
The game should not include bright flashing lights	U2	3	A common co-occurring disorder in children diagnosed with CP is epilepsy; any bright flashing light in the game could trigger seizures for people diagnosed with this condition.
The game should not make use of words with more than three syllables	U3	2	A common co-occurring disorder in children diagnosed with DCD or CP is dyslexia. It can not be assumed that all users are able to quickly read complicated words on the screen, especially considering the age of the target group. Any information displayed in words on the screen aside from simple words are thus not likely to be interpreted correctly.
The game should not feature complex decisions that require the children to think more than two actions ahead	U4	2	From observing the user group during a therapy session, it became rather obvious that the target users do not possess the attention span to consider complex decisions. As such, these decisions should not be required to take part in the game due to the risk of children getting confused and leaving the game.
The game should accommodate various skill levels	U5	2	As mentioned during the state of the art, there are very significant discrepancies in the skill levels of the various individual target users. The game should be designed in a way that allows for all of these users to enjoy the game.
The game should be based on a child friendly theme	U6	1	It should be remembered that the target group consists for children aged 8-12, and are thus very impressionable. For this reason, while not vital to the game's functioning, the game should feature a child friendly theme.

Table 2: The user requirements sorted by severity.

3.2.2 Client requirements

The *client requirements* consist of the requirements set by the client that are not directly related to the user group. While not directly related to the functioning of the product such as the other two categories of requirements, these requirements will generally cover the ability to integrate the system effectively into existing treatment methods. This in turn will impact the feasibility of the actual use of the final prototype. An overview of these *client requirements* can be seen below in Table 3.

Requirement	ID	Severity	Reasoning
The game should be playable by at least two players at once	C1	3	The game should be playable by at least two players at once, in order to ensure all group members get to play the game in a timely fashion. If this requirement can not be met, the game will not be able to fit into a therapy session due to time constraints.
The game should be able to integrate data gathered through the app	C2	3	The goal of this project is to explore the use of wearables in combination with the interactive playground. If this requirement is not met, the project did not complete its goal.
The game should be playable by at least four players a once	C3	2	While it is preferable that the group as a whole can play the game at the same time, it is also acceptable for the game to be played by two users while the other group members do something else. Because of this, a separate requirement exists for including four players instead of two.
The therapist should be able to alter the difficulty of the game	C4	2	In order to effectively make use of the system in a personalized therapy method, the therapist would like to be able to modify the difficulty to suit specific group needs.
The game should require little to no explanation to play	C5	2	To avoid having to halt the play session and get attention from all of the children, the game should require little to no explanation to play.
The therapist should be able to alter the duration of the game	C6	1	Similarly to the requirement to be able to modify the difficulty, the therapist would like to be able to customize the game duration. In this case however, it would still be possible to run the game multiple times in case a longer game is desired, so it can be given a lower priority.
It should impossible for players to be unable to play the game for long periods of time due to game mechanics barring them from play	C7	1	The game should not stimulate gameplay which forces players to not take part in the game for long periods of time due to being somehow removed from the game. This could lead to players getting bored and doing something else to enjoy themselves or get attention, reducing the effectiveness of the therapy session and potentially affecting other players.

Table 3: The client requirements sorted by severity.

3.2.3 Practical requirements

The *practical requirements* are the requirements placed upon the product due to practical limitations of the project. These requirements can effectively considered as constants, due to the limited influence that the designer is able to assert over them. If these requirements can not be met, they will have a severe impact on the technical feasibility of the product. An overview of these *practical requirements* can be seen in Table 4 below.

Requirement	ID	Severity	Reasoning
The game should be playable on a 16 square meter surface area	P1	3	If the game can not be played on the surface area currently available to the system, the game can not be tested nor played.
Game mechanics should not include keeping track of individual players	P2	2	Due to the system's tracking components sometimes confusing players, the game should not use mechanics related to keeping track of individual users. Previous observations showed players getting very frustrated if this happened, sometimes resulting in the player quitting the game.
The game should account for people walking out of the play area	P3	2	Due to the unpredictable nature of kids, it is not uncommon for users to leave the play area and re-enter it later. This should be taken into account when creating the game.
The game should be playable regardless of the surface area	P4	1	Should the game be positioned elsewhere than the current setup, the game should still be playable regardless of the new surface area. While useful, this is not necessary for the execution of this project.
The game should not be based around vertical movement.	P5	1	As the tracking components of the system are not meant to track movement along the vertical axis, and shows serious limitations as determined by Kok (2018) vertical movement could have unintended consequences for the accuracy of the tracking.
The game should avoid the use of external items such as balls.	P6	1	This would make the game more reliant on external factors, as these additional objects may not always be present. Furthermore, additional moving objects could cause issues related to tracking.

Table 4: The practical requirements sorted by severity.

4 Ideation

As stated in the previous chapter, the first phase of the design process is the *ideation* phase. During this phase, a number of game ideas will be generated based on a number of more traditional playground games. For each of these games, a digital mock-up will be created to help visualize the idea. These mock-ups will then be presented to the client in order to receive feedback on the idea and the execution. Based on this feedback, a decision will be made in regards to which idea will be further explored during the project.

4.1 Traditional games

Before an augmented version of a traditional game can be created, a list of existing playground games should first be created to draw inspiration from. These lists can then be used to determine which games, or combinations of games, can be used to create a new game for the interactive playground. As stated in the requirements, the game should allow for at least two players to play the game at the same time, but this does not mean no game mechanics can be used from traditional single player games. Similarly, while asymmetrical gameplay will quickly become too complicated for the target user, this does not mean features of these games can not be used in the final design. For these reasons, the traditional games have been sorted based on the nature of their multiplayer interaction.

4.1.1 Single player games

A number of traditional physical single player have been compiled below in Table 5, along with whether or not the ideas meet the requirements as stated in chapter 3. Due to their nature as single player games, these games can already not pass the client's requirement that at least two players can play the game at once. Any game that meets all other client requirements has thus been colour coded as orange instead of red.

Game title	Meets user requirements	Meets client requirements	Meets practical requirements	Missing requirements
Hopscotch				C1*, C3*, P5
Solitaire				U4, U5, C1*, C3*, C4, C5, C6
Sudoku				U4, C1*, C3*, C5
Bean bag toss				U1, C1*, C3*, P6
Where's Waldo				U5, C1*, C3*

* Is a multiplayer requirement

Table 5: Traditional single player games compared to the project requirements. Red more than two requirements are not met, yellow means all but one requirement is met, green means all requirements are met. The multiplayer requirements do not count towards this total

Both *Hopscotch* and *Where's Waldo* only have one missing requirement, ex-

cluding the multiplayer requirements. *Hopscotch* can not conform to the practical requirements, due to the central role jumping plays in the game. Because of this, this jumping element would have to be replaced with something else in order to create a *Hopscotch* inspired multiplayer game, as the tracking software is not designed to deal with vertical movement and could thus run into problems. *Where's Waldo* on the other hand does not conform to the user requirements, as it is not able to adapt itself to users of various skill levels. This could relatively easily be resolved in a digital version however, by creating different levels of varying difficulties, or by introducing an element of competitive multiplayer.

Out of the two games, object finding games such as *Where's Waldo* seems to provide a stronger base for a multiplayer game than games guiding the movement of players along a pattern similar to *Hopscotch*, due to the fact that its core mechanics do not have to be reworked in order to adapt the game into a digital version. The game is also not based around having the player moving to specific locations, aside from the game objective, and thus is likely to cause less issues in regards to players having to move to the same physical location on the field of play. This in turn reduces the chance of the tracking system mixing up various users, as the various tracking objects will be in contact with each other less often.

4.1.2 Asymmetrical multiplayer games

Asymmetrical multiplayer games are games in which different players can play different roles with different rules and goals at the same time, rather than having every player playing the same role. These games provide an interesting opportunity, as the asymmetrical nature of its gameplay provides the chance to create two variations of the same game within the game itself, resulting in more replayability. The flip side of this however, is that it tends to complicate the game rules by creating multiple sets of rules that have to be taken into account during play. This has the unfortunate result that most of these games will, in their default state, be too complicated for this project. This does not mean that they are all automatically rejected for the project however, as visual and audio cues could be added in a digital version to provide more support to the players during play. An overview of some asymmetrical games investigated during the ideation phase can be seen in Table 6 below.

Game title	Meets user requirements	Meets client requirements	Meets practical requirements	Missing requirements
Jump rope				U1, P5
Red light, green light				C7
Musical chairs				U5, C7
Simon Says				C4
Hide and seek				C7, P1, P4, P6

Table 6: Traditional asymmetrical multiplayer games compared to the project requirements. Red more than two requirements are not met, yellow means all but one requirement is met, green means all requirements are met.

Out of the reviewed asymmetrical games, *Red light*, *Green light* and *Simon Says* are the best fit for the various design requirements set out in the previous chapter. The issue with regards to *Tag* is that it requires the players to remain immobile for extended periods of time, which goes against the purpose of these games. Failure to adapt the game's mechanics to account for this could lead to the children being much less active when compared to other game options. For *Simon Says*, however, the therapist is unable to directly affect the difficulty of the game for all players. Due to the competitive nature of the games, making the game easier for one side would make the game harder for the other. This makes it very difficult for the therapist to set a difficulty that all group members are happy with.

Despite *Simon Says* being a better fit for purposes of this project, *Red light*, *Green light* should definitely still be considered, as it has the potential to promote a more active form of play than *Simon Says*, due to the relatively short distances the children will have to walk to reach the various colours in *Simon Says*.

4.1.3 Symmetrical multiplayer games

Symmetrical multiplayer games are generally easier to understand than their asymmetrical counterparts, as the players all only have to remember one rule set, and do not have to play according to different rules based on their current role. An overview of some of these symmetrical games can be seen in Table 7 below.

Game title	Meets user requirements	Meets client requirements	Meets practical requirements	Missing requirements
Twister				U1, U5, C7, P2
Horse				U5, C5, P2
Tug of war				U5, C6, P6
Scavenger hunt				U5, P2
Relay race				C7, P1, P4

Table 7: Traditional symmetrical multiplayer games compared to the project requirements. Red more than two requirements are not met, yellow means all but one requirement is met, green means all requirements are met.

A common issue with the reviewed symmetrical multiplayer games is that since all players follow the same rules, it is often not possible to adapt the game based on the various skill levels of the participants. Rather, one uniform level of difficulty has to be used. The notable exception to this rule appears to be the *relay race*, since players can be paired up in such a way that the average skill levels of the teams balance out. Furthermore, players could potentially have to complete different parts of the race, with the more capable players having to complete the longest or most difficult parts, and vice versa. The downside to the *relay race*, however, is that the playground is simply not large enough to host any sort of race, as they would have to start slowing down already before even getting to their top speed. Furthermore, all but one of each team's members would have to remain idle at all times while the other two players compete.

The game with the least missing requirements is the *scavenger hunt*. This game also has issues with accounting for the various skill levels within the various players, though this can be slightly offset by the degree of luck involved in the game. Furthermore, the only other issue is that the individual users would have to be tracked to log their individual score.

Due to the physical limitations regarding the *relay race* being harder to overcome than the game mechanic issues present in the *scavenger hunt*, it would be more realistic to focus on developing a digitally augmented version of the latter.

4.2 Existing interactive playground games

In addition to creating a new game for use in therapy session aimed at rehabilitating the target group, the client has also asked for two of the already developed games available on the interactive playground to be modified for use in a therapy session. An overview with quick summaries of these existing games for the interactive playground can be seen in appendix A. In order to determine which of these games should be further developed, four sessions were held during which the children could try out the various games for an hour per session. Based on these session, the children's interest and excitement regarding each of the various games could be estimated.

By combining these observations with the client's expectations of how the various games would fit into a therapy session structure, two games were prioritized to be further developed. The first game chosen was *Uncover*, due to its potential to be expanded into a game that could be used to both stimulate physical activity in the children and encourage the children's problem solving skills. The other game we chose was *Block Dodger*, as it showed a lot of promise as a game to stimulate physical exercise for the children due to their enthusiasm for the game.

4.3 Initial ideas

Based on the previous comparisons between existing games and the design requirements, three traditional games have been chosen to serve as the basis for the new games. The first of which is *Red light, Green light*, which has been combined with the item collection elements of the aforementioned *Buzz* game. The second game that we chose is a combination of *Where's Waldo* and *Scavenger hunt*, which challenges its players to look for a specific item to collect rather than collection as many items as possible. Finally, the third game that we chose to expand upon was *Simon Says*, in which the players will have to replicate the pattern created by the leader.

4.3.1 The Dragon's Dungeon

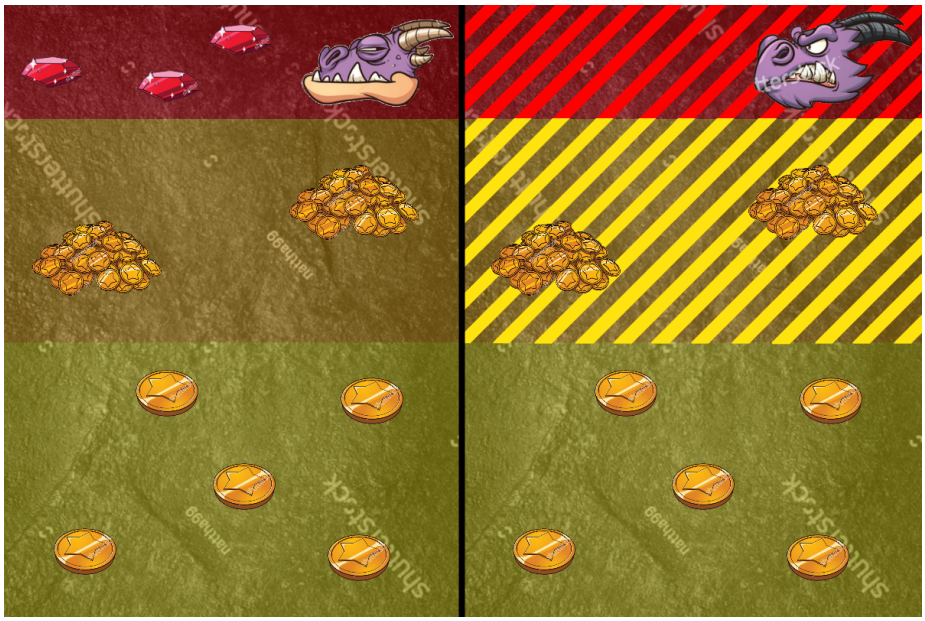

Figure 18: Mock-up of *The Dragon's Dungeon*'s base state and agitated state. Dragon and treasure images by *Shutterstock* user *Memo Angeles*[a], stone background image by *Shutterstock* user *natha99*[b].

[a] https://www.shutterstock.com/g/memoangeles
[b] https://www.shutterstock.com/g/natthamon++yanasing

The Dragon's Dungeon, seen above in Figure 18, is a digitally augmented version of the classic playground game *Red light, green light*. It aims to familiarize users with the main concept of the playground game in a playful manner, so that users might be able to play *Red light, green light* in their own time without use of the interactive playground. One of the main focuses of the game is to

allow the users to pick their own difficulty while playing, without interrupting play. This should allow users of various skill levels to play as a group without restricting the game for players on either side of the skill spectrum.

The main gameplay mechanic is similar to that of *Red light, green light*; as the dragon starts to wake up, the three areas on the field become off-limits in order of difficulty, as can be seen on the right side of Figure 18. The upper area of play is the smallest and becomes off-limits the earliest, but also provides the most rewards. By contrast, the lower area of play is the largest and receives lots of forewarning before it becomes off-limits, but provides the least score. The goal of course, is to obtain the highest possible score, either individually or as a team.

As the dragon starts to wake up, the upper area will become covered in yellow lines; this will be an indication that the area will soon become off-limits. When the dragon further wakes, the lines will turn red and the area will become off-limits. Any player still present in the area will have to stay still to avoid detection from the dragon. If the player is detected due to too much movement, they will be spotted by the dragon, resulting in a point deduction. When the first area is off-limits, the second area will be covered in yellow lines, et cetera. After all areas are off-limits and all players have to remain immobile, the dragon will go back to sleep and revert the playing field to its initial stage.

Data integration

Furthermore, the game will be linked with a data gathering app developed by Roessingh Research and Development (RRD). Based on the user's improvement according to the data available through the app, the users will be able to acquire in-game bonuses to help boost their score. If the data obtained through the app shows that the user was active outside of the therapy sessions, the players can obtain score multipliers and increased delays between phase changes. This will allow the players to achieve higher scores than if they were inactive, and thus give them better chances of placing well on a potential leaderboard.

Relation to the traditional game

When compared to the source material, *The Dragon's Dungeon* differs a lot from *Red light, Green light*. Rather than using one large field of play, *The Dragon's Dungeon* splits the area into three different zones. While this might make the game more flexible in terms of difficulty, it does reduce the similarities between the original game and the digital variant. Furthermore, the goal of the game was changed to be grabbing as much treasure as possible rather than reaching the opposite end of the area, in order to encourage the children to move along both axes rather than run along the straight line.

4.3.2 I Spy

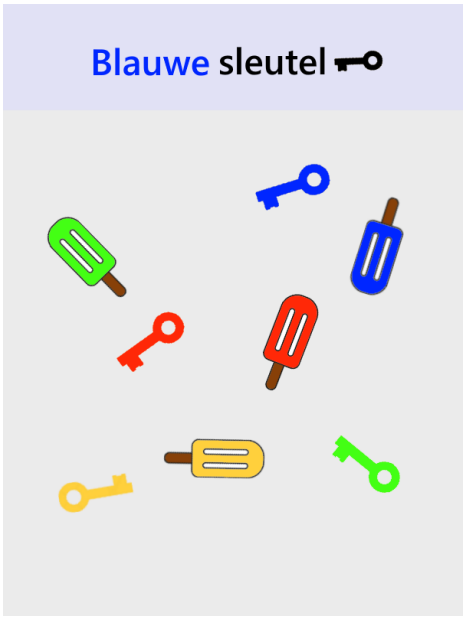

Figure 19: Base state of *I Spy*. Ice cream image by *Shutterstock* user *Skeleton Icon*[a], key image by *Shutterstock* user *Dzm1try*[b].

[a] https://www.shutterstock.com/g/rudiak
[b] https://www.shutterstock.com/g/dimas911

I Spy, seen above in Figure 19, is a combination of the traditional children's games *Where's Waldo* and *Scavenger hunt*. The game is similar in concept to *Buzz*, in the sense that it allows players to join the game whenever desired. *I Spy* is a much simpler game than *The Dragon's Dungeon*, which was done intentionally in order to represent various options in this regard. Furthermore, it still a free-for-all competitive element in its gameplay as a way to motivate the users to actively take part in the game. Because of this, most of the difficulty will be derived from the various users themselves competing with each other, rather than an intrinsic game mechanic.

The playing field is split into two segments; the top part of the field is used to display what item the players are currently looking for, while the bottom part of the field contains a collection of random items, including the objective. The first player to reach the objective item will be given a point, with the player with the most points in the end winning the round. Once a player reaches the objective, a new objective will be generated, along with new random items.

Data integration
In regards to integration with the app, *I Spy* takes an approach similar to that

of *Tag*. Rather than providing in-game advantages that could potentially give players unfair advantages, *I Spy* provides users with cosmetic changes based on their activity outside of therapy sessions in an attempt to motivate users to be active outside of therapy sessions. Various levels of activities will unlock a larger variety of items, as well as various visual effects once a player reaches the objective, such as fireworks.

Relation to the traditional game
Despite being a combination of two existing games, *I Spy* is still very similar to its sources of inspiration, as less core features had to be adapted in order to make the game suitable for use with the interactive playground, when compared to *The Dragon's Dungeon*. The downside, however, is that the original games do not feature active physical activity, so the impact on the amount of physical activity performed by the children as a result of replicating the game outside of therapy sessions might be limited.

4.3.3 Simon Says

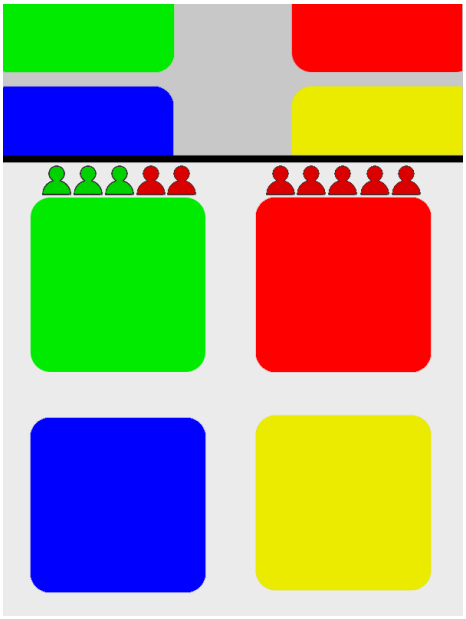

Figure 20: A *Simon Says* mock-up where the group has three lives remaining.

Simon Says, seen above in Figure 20, is an augmented digital version of the children's memory game of the same name. The game is designed to feature asymmetrical gameplay, with one person competing against the rest of the group. This asymmetrical gameplay element could add to the replayability of the game, as users have two separate roles to try out in the game. Similarly

to *I Spy*, the difficulty of the game will primarily be derived from the various players, though the player's activity in-between therapy sessions will also play a role.

The group of players is divided into two parts; one individual will be in charge of dictating the game, while the rest of the group will have to follow their lead. The field of play will be divided into two parts in a similar fashion; the smaller upper area will be available to the *leader*, where they can decide the pattern that should be followed in the lower area by the *followers*. The *leader* can input a pattern of increasing complexity as time goes on, after which the followers will have short intervals of 3-5 seconds to stand on the correct colours. Once the timer runs out, the *followers* will lose a life for each member that is not standing on the correct colour, after which the interval will start again for the next colour in the pattern.

Data integration
In regards to the data integration, the measure of activity in-between therapy sessions will grant the *leader* slight gameplay advantages; before the round starts, the *leader*'s activity will be analyzed by the system. If the *leader* has reached their activity goal, they will receive a slight advantage. These advantages are not enough to make major differences in gameplay, but could give that slight edge in situations that might otherwise result in a loss. These advantages includes a slightly reduced time interval for the *followers* or an increase in the sequence length. This could motivate the users to be active outside of therapy sessions in order to gain a slight edge in the game.

Relation to the traditional game
Similarly to *I Spy*, *Simon Says* has remained very similar to its source material, as not much has changed compared to the original game other than the fact that it can now be played by multiple people at once. Also similarly to *I Spy*, however, the original source game is somewhat limited in terms the amount of physical activity that is required of the user.

5 Specification

5.1 Game improvements

After the end of the *ideation* phase, the client was asked for their input on the current state of *Uncover* and *Block Dodger*. This feedback, along with the feedback given on the three new game ideas, would form the base of the *specification* phase, during which this feedback will be used to determine the various changes that might have to be made to the games.

5.1.1 Uncover

Uncover was designed to be a relatively simple game with few rules and limitations, so that new players can enter during a play session without having to wait for the next round or having to listen to extensive instructions. Because of this, the amount of possible changes is somewhat limited without adding new features that would go against the design philosophy of the game. Regardless, the client noticed several points of interest that could be improved upon while observing the children interacting with the game.

First of all, the client desired the addition of an optional therapy mode into the game, which can be enabled by pressing a specific button. This would allow the client to switch to the therapy mode when required while still maintaining the option of playing the game without having to specify a number of variables for each round. In addition to this, the client would like to replace the default game images with more child-oriented ones. These images should be edited to include a number of letters scattered around the image that can be combined to create a word related to the image. The purpose of this would be to give the children a goal to work towards, as they will have to uncover enough letters during the round to make a guess as to what the word on the image is.

Within the therapy mode, the client would like to have the option to specify the amount of seconds each round should last. Once the amount of seconds has been specified, the round should then start automatically. During the round, the children will have to uncover as much of the image as possible to reveal the various letters hidden in the image. Once the timer runs out, the children will be unable to reveal any more of the image.

The children will then be asked to attempt to solve what the word is. Once an answer has been given, the physiotherapist should be able to press a button to reveal the entire image to evaluate the answer. After doing so, the physiotherapist should be able to indicate to the system whether or not the correct answer was given. Following this, a new round should start and the physiotherapist will be asked to input the round timer again. The game should also keep track of the total score achieved by the players.

5.1.2 Block Dodger

Similarly to the feedback given regarding *Uncover*, the client would like a dedicated therapy mode in which the physiotherapist gains more control over

the various variables dictating the game's difficulty. Unlike *Uncover*, however, *Block Dodger* does not have dedicated rounds of play. It does include six different levels, but these will generally last longer than those found in *Uncover*. Because of this, allowing the physiotherapist to only change the variables between levels will provide less additional flexibility than it would in *Uncover*.

As a result of this, it was decided to merge the default mode with the therapy mode, where users can alter the game's difficulty during levels via the system's keyboard if they desire. This way, the game will still play in its default mode if no changes are made, but can also accommodate the wishes of the client.

Using the keyboard, the direction of the incoming enemies should be changeable. This change results in enemies moving along both the horizontal and vertical axes depending on their spawning location, creating a necessity for the player to also move across both axes if they wish to avoid the enemies. This increases both the difficulty of the game, and the amount of physical activity required to achieve a high score within the game. In addition to this, the client also desired a way to increase the movement speed of the various enemies shown on the screen to help customize the game for players of various skill levels. This could be introduced by allowing the user to set the enemy speed from anywhere between 50% and 200% of the default enemy speed during that level using the keyboard.

Furthermore, the score shown on the screen was shown in a very small font, which made it hard to read properly when projected onto the floor as part of the interactive playground. For this reason, the font size of the score counter should be increased significantly.

5.1.3 Summary

For both games, the goal is to create a therapy mode that allows for a larger degree of customization so that the therapist can tweak the game to suit the needs of the specific user group during therapy sessions. How to achieve this differs between the two games, as *Uncover* is divided into distinct, short, rounds with defined phases as part of each round, such as the reveal and the evaluation, while *Block Dodger* features somewhat constant gameplay. Either way, the goal will be to give the physiotherapist more influence over the various variables that contribute to the game's difficulty in a way that does not negatively affect gameplay.

5.2 Idea specification

As previously stated, the client was also asked for their thoughts on the three new ideas discussed previously. This feedback will also be used to determine which of the three new ideas, or which combination of the ideas, will be further developed into the new game. Additionally, this feedback will be used to determine what possible improvements can be made to the game concept before the start of the *realization* phase.

5.2.1 The Dragon's Dungeon

The Dragon's Dungeon was received the most enthusiastically by the client. In particular, the fact that the children are able to choose their own difficulty while playing was very well received. The theme was also well received, as it would provide a healthy amount of suspense to help immerse the user group into the game setting, thus hopefully making them more likely to take the game seriously. The client suggested adding audio cues to the game as well, to help reinforce this effect, and to provide another way for the players to realize that the dragon is waking up.

The main concern regarding the game is that children of a lower education level will not fully understand the game, and will instead simply run around trying to collect as many coins as possible. To help prevent this, the game should contain enough visual and audio cues to guide the player. It should be taken into account that the game is not too realistic however, as this could frighten the children and suppress the risks they would otherwise be willing to take.

Furthermore, the client would like a therapy mode similar to the ones discussed regarding the existing two games to be implemented as well. Within this therapy mode, the physiotherapist should be able to trigger the next stage of the dragon waking up. It would also be useful to be able to alter the length of the various stages in this therapy mode.

5.2.2 I Spy

I Spy on the other hand was, rightfully so, considered a much simpler and easier to understand game. The client imagined the game to be more likely to be used as an introduction to the interactive playground for the children, than a game than would routinely be used in a therapy session.

The main concern regarding *I Spy* is that unlike *The Dragon's Dungeon*, there are few elements aimed at keeping the game exciting throughout multiple sessions. Whereas *The Dragon's Dungeon* has an exciting theme to keep the children interested, *I Spy* has a relatively clean and simple layout in order to make it easier for the children to spot the object. Other than the changing objects, the game essentially remains the same, in the sense that the children should simple find a copy of the image seen at the top, which could lead to the children getting fed up the game over time. This could in part be alleviated by having the children compete to obtain the highest score, but this would introduce the tracking issue (see requirement P2 in Table 4) to the game. Another option would be to provide the children with a puzzle rather than a copy of the image, but this might result in the children standing still a lot whilst solving this puzzle. Overall the game would be very dependent on the amount of variation between the different items, and even then the game mechanics do not offer enough ways to keep the game exciting.

A suggestion was made by the client in order to make the game more interesting; instead of competing to find one item, the children could all be tasked

with finding a different item. Whoever finds a certain number of items first, wins the round. This idea could be extended by having the children drop each item off at one of the corners of the playing field in order to increase the amount of physical activity. A therapy mode could also be implemented, in which the physiotherapist could alter the amount of object on the screen, and the amount of time the players have to find said object.

5.2.3 Simon Says

Simon Says was found to be simpler in terms of physical activity than *The Dragon's Dungeon* and *I Spy*, but more complicated in terms of mental activity. The game would likely be used as a way to stimulate the players mentally, and as a short physical break between multiple physically intensive games. The asymmetrical gameplay element was well received, as it provided some variation in the gameplay.

The main concern was that children with less mental capacity would have a hard time competing in the game, which would end up in them dragging down the team or making the game too easy for the other players, both of which are not desirable scenarios.

The client suggested changing the four colours into four other images such as animals. This would make the game visually more interesting for the children, and could provide an opportunity for relevant audio cues to be added for each of the four options as well, making the game more immersive and more intuitive.

Due to the players controlling much of the game's pacing, a therapy mode is not as feasible in this game as it is in the other two ideas. On the other hand, the physiotherapist could instead take the role of the *leader*, playing against the children and influencing the pace of the game that way.

5.2.4 Conclusion

Overall, *The Dragon's Dungeon* was rated the highest, followed by *Simon Says* and then *I Spy*. On the other hand, *I Spy* also received the most in-depth suggestions to improve the game, which could end up making the game much more interesting to play. The three ideas would all fill different roles within a therapy session, with *The Dragon's Dungeon* potentially being used as a core game, *I Spy* being used early on as an introduction to get children used to the playground, and *Simon Says* being used as a way to let the children rest up while still remaining engaged.

Out of these three options, *The Dragon's Dungeon* will likely offer the most replayability, due to the excitement created by the theme and the tension of having to decide which risks to take. Furthermore, the fact that the players are able to decide how difficult to make the game for themselves also makes it easier for groups of children to play the game at the same time, without the game having to be altered to better suit the group's needs. Additionally, the

relatively large amount of different gameplay elements provides a large variety of possible implementations for the user data retrieved from the database. Because of this, as well as the game's flexibility in terms of difficulty and its more dominant role within a therapy session, *The Dragon's Dungeon* will be further developed for this project.

While all of the three games provided players different rewards for reaching their activity goals, the client did not specifically comment which reward structure was preferred. Because of this, we decided to use the reward structure described in the initial concept of *The Dragon's Dungeon*, as this is assumed to have been considered when grading the various concepts. As such, the data integration will move forward on the basis that if the player has reached their activity goal, the game will replace the collectibles with more valuable variants, so that the players can reach a higher final score.

5.3 Database integration

In order to realize the connection between the game and the sensor database, a software developer at RRD, Dennis Hofs, was contacted for their expertise and insight into the subject. Hofs, being the developer of the related mobile app, suggested three distinct options of establishing a connection between the game and the database. These options will be discussed in more detail below.

5.3.1 Option 1: Log-in system

The first option suggested by Hofs encompassed the creation of a log-in system within the game, where users would have to enter their own username and password in order to establish a connection with the database. This connection would be broken when the game was closed, so this step would have to be repeated whenever the game was used in combination with the database during a therapy session.

While this method resulted in the least amount of ethical concerns, since the developer of the game would not require any additional rights or privileges to access user data, the method is also by far the most obtrusive in terms of gameplay. This is due to the fact that the children would have to enter their username and password every time the game would be played. Keeping in mind the possible mental and physical restrictions of the target users, it is even possible that users would be unable to perform this step, thus preventing use of the feature.

5.3.2 Option 2: Temporary account

The second option suggested by Hofs consisted of the creation of a temporary account for the developer of the game, which would have to be given permission to access user data without requiring the accompanying password. The account would have to be given these privileges on an case-by-case basis, in order to prevent possible abuse of these privileges.

While the ethical concerns are still limited in this case, due to the permissions having to be granted on a case-by-case basis by the system administrator, it does remove the necessity for the game's players to enter any sensitive information during the therapy sessions. The downside of this option is that it will require more maintenance than the aforementioned option, as any new member of the therapy sessions will have to be manually added to the list of accounts that can be accessed. Furthermore, the temporary nature of the account means that the game mechanic will no longer be available after the deletion of the account at the end of the research period, unless a new account is created.

5.3.3 Option 3: Private/public key pair

The third and final option suggested by Hofs amounted to the creation of a private/public key pair, which would give the developer of the game unlimited access to the data of all users within the RE-Play project. This would fulfill a similar role as the previous option, while removing the requirement for constant maintenance as new members of the RE-Play sessions would not require any additional permissions to be granted. Furthermore, this option would also result in a more permanent solution that can be used even after the research project has ended.

The downside to this solution is that there would be little oversight regarding the handling of sensitive user data, which would make the system prone to abuse. This would apply not only to the developer of the games, but also to anyone else that gained access to the private key one way or the other.

While it would be possible to only allow the data integration to work during specific, pre-determined, times in order to increase the data security, this would only be possible through the game as it would take too long to implement these options into the database itself. This would in turn either limited the therapy sessions to only certain times, or require the physiotherapists to somehow set these times themselves within the game, making the system much more complex to use.

5.3.4 Conclusion

It was decided that the interruptions of play caused by the log-in system were too impactful on the general flow of the therapy session. This is compounded by the fact that many users might not even be able to make use of the log-in system due to physical or mental limitations. Because of this, it was decided that the log-in system was not a realistic option in this use case.

Between the higher maintenance cost of the temporary account and the ethical concerns of the private/public key pairing, it was decided that granting the permissions on a case-by-case basis was preferable to having reduced control over what data can be accessed. This is especially the case since the account will only last for the duration of this project, which will only be evaluated with four children, and thus only four permissions will have to be granted. Should

the client desired to keep the game functional after the project is over, a new account can always be created.

6 Realization

This chapter will describe the process of creating *The Dragon's Dungeon*, as well as the improvements made to *Uncover* and *Block Dodger*. In order to make sure each of the main components of *The Dragon's Dungeon* are able to function independently, the process has been broken up into three segments; the game design, the actual code, and the database integration. Once all three of these segments are able to function independently, they will be integrate to create the first iteration of *The Dragon's Dungeon*. After this, an initial user test will be performed on students in order to diagnose any possible errors or possible improvements that can be made before the final user test with the target user group.

6.1 Uncover

The first game that was worked on is *Undercover*. The changes that are required in order to make the game work in a therapy setting can be divided into two categories. One of these are the visual changes that will have to take place in order to improve the availability of information, as well as the different images in order to make the game more child friendly and allow for more goal-based gameplay. The other category consists of the technical changes made to the game in order to create a therapy mode in which the physiotherapist has more control over the game.

6.1.1 Visual changes

One of the visual changes that has taken place while improving *Uncover*, is that the user interface has been made a bright red colour, and that it has been moved to the upper left corner of the screen. This makes the score and timer text much more noticeable, so that the players can quickly find this information without stopping their play.

Furthermore, all images now include a number of scrambled letters, which, when placed in the correct order, will spell out a word related to the object or activity seen in the picture. This gives the players a goal to work towards while uncovering the image, whereas the game previously lacked a true purpose to work towards, especially since the game was designed in such a way that the players barely had time to look at the image once it was uncovered.

Lastly, the background images have been changed to more child-friendly images related to physical activity, such as soccer nets and bicycles. This was done at the request of the client, in order to make the game more in-line with its environment and the target users. Furthermore, the images are more recognizable for the target users, which should make solving the word puzzles more intuitive.

For a comparison between the new and old visuals of the game, as well as an example of how the letters can be seen on the new images, please refer to Figure 21 below.

Figure 21: Before and after screenshots of *Uncover*, with the older version shown on the left and the new version on the right.

6.1.2 Therapy mode

As per the specification chapter, a therapy mode has been added to the existing game, granting the physiotherapist significant control over the game progression when this is required. During the therapy mode, the game progression is broken down into five stages. During each of these five stages, a different component of the round is executed.

At the initial stage, the players are not able to interact with the game. The physiotherapist, or similar supervisor, however, can press one of four buttons in order to determine the time that the players will have next round to uncover the image. We decided to use this multiple choice approach rather than an incremental approach in order to limit the amount of button presses required per round, at the expense of some flexibility. This is not seen as an issue, as ten seconds is already estimated to be enough time to uncover the entire image with three to four players, let alone twenty secods. After pressing one of these buttons, the game will progress to the next stage.

During the second stage, the players are able to interact with the game the same way that they would in the default mode of the game. As the players remove more and more of the black layer hiding the image, they will start to find letters, which they will need later. Once the timer runs out, the next stage will automatically start.

Once the game enters the third stage, the players can start combining the letters they found during the previous stage in order to spell out a word related to the image they have uncovered. Once the group has given a definitive answer, the physiotherapist can press a button on the keyboard to reveal the entire image. Once the button is pressed, the next stage will start.

After the image is revealed, both the physiotherapist and the players will be able to see the entire image, including all of the hidden letters. This way, the physiotherapist can determine whether or not the group gave the right answer, and press the accompanying button to inform the system whether or not they

should get a point. After pressing the button the point will be awarded if required, and the game will move on to the final stage.

During the final stage, the game will reset itself and pick a random new image out of the list of remaining images that it has yet to show to the group. Should all images have been shown, the list will be filled again with all possible images so that the game can continue. After doing this, the game will automatically start the first stage again with the new image.

For a systematic overview of the various keyboard interactions during the five stages, as well as the transition requirements for each stage, please refer to Table 8 below.

Stage	**Nr.**	**Keyboard interactions**	**Transition**
Time input	1	H - Set timer to 5 seconds J - Set timer to 10 seconds K - Set timer to 15 seconds L - Set timer to 20 seconds	As soon as either of the four buttons is pressed.
Play	2	N/A	Automatically once the timer runs out.
Reveal	3	P - Reveal the entire image	Once P is pressed.
Evaluation	4	F - Mark the answer as false G - Mark the answer as correct	Once either F or G is pressed.
Reset	5	N/A	Automatically once the new image has been chosen.

Table 8: The five stages of the *Uncover* therapy mode

6.2 Block Dodger

The second game to be worked on is *Block Dodger*. Similarly to the *Uncover* section, the changes required to make *Block Dodger* function in a therapy setting can be divided into two categories; visuals changes and functional changes. While some visual changes were made to the game's user interface in order to improve the readability, the vast majority of time was spent on the functional changes; adapting the game's code in order to give the physiotherapist more input in the difficulty and flow of the game.

6.2.1 Visual changes

In the previous version of *Block Dodger*, the score text on the screen was so small that many children and even the physiotherapist were not aware of its existence. In order to draw more attention to the score and allow players to view their score at a glance without distracting them from the game, the font size has increased substantially. The font colour has also been made a brighter shade of white, in order to create a stronger contrast between the text and the black background. A comparison between the old and new visuals can be seen in Figure 22 below.

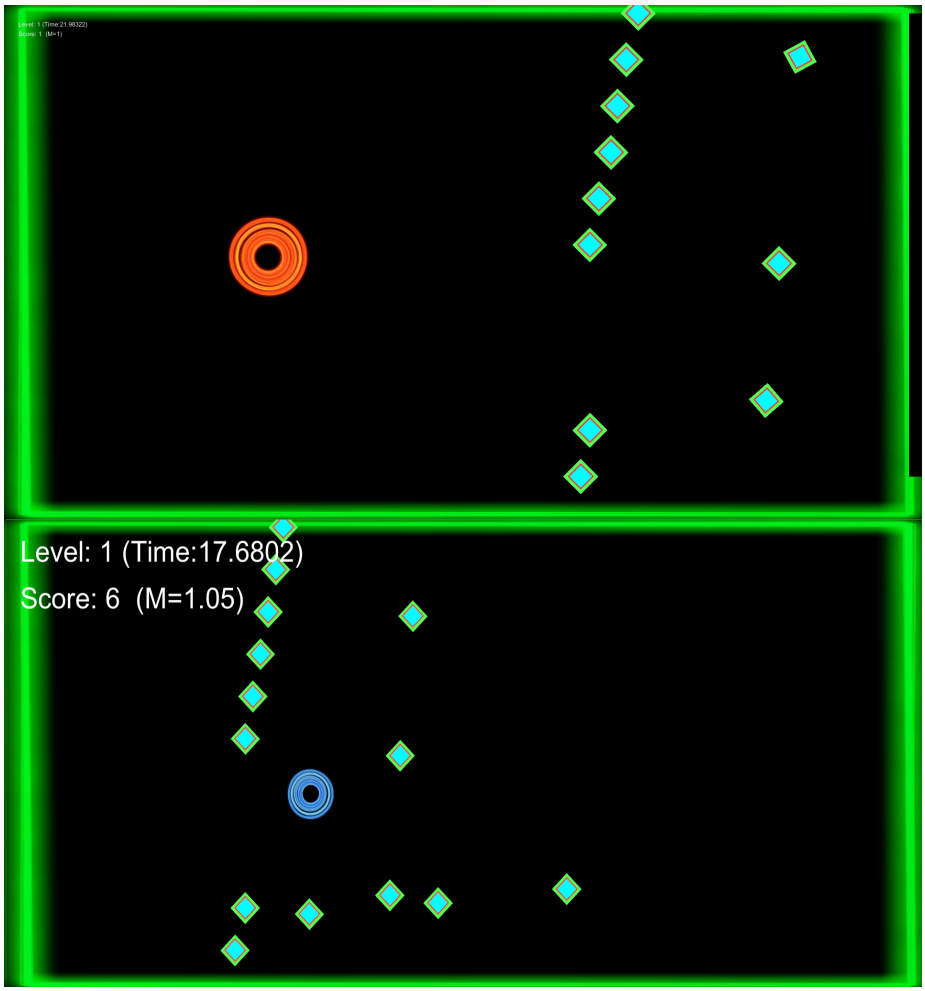

Figure 22: Before and after GUI of *Block Dodger*, with the older version shown above and the new version below. Note the increased GUI font size for the information shown in the top left corner of the pictures.

6.2.2 Functional changes

The primary functional change is that it is now possible to change the spawn direction of the enemies to any of the four cardinal directions. By pressing the S and A keys, the physiotherapist can now rotate the enemy spawn direction clockwise and counterclockwise respectively. This change has resulted in a significant change in gameplay, as players must now move along both axes in order to avoid the incoming enemies, resulting in a more physically demanding game.

Furthermore, it is now possible to alter the movement speed of incoming

enemies from anywhere between 50% and 200% of their original movement speed. This change gives the physiotherapist the ability to better tune the game to the capabilities of the player, without reducing the amount of enemies.

6.3 The Dragon's Dungeon

6.3.1 Design

From a visual perspective, final execution closely resembles the initial mock-up created during the ideation phase. The background has been exchanged for a similar one, with the exception of the watermarks. Aside from this, the same icons were used for the collectibles and the dragon's status. In addition to this, a score counter has been added to the top left corner of the screen. A template based on the tag game by Moreno et al. (2016) was used for both the visuals and the code used for the player tracking components of the game. Two screenshots of the final design of *The Dragon's Dungeon* can be seen in Figure 23 below.

Figure 23: *The Dragon's Dungeon*'s base state and agitated state. Dragon and treasure images by *Shutterstock* user *Memo Angeles*[a], background image by *Pxhere* user *DownTownApocalypse*[b].

[a] https://www.shutterstock.com/g/memoangeles
[b] https://pxhere.com/en/photo/169703

As can be seen in the screenshots, a rock-like background is used to suggest that the players are indeed in some sort of cave or dungeon. This background is divided into three areas by yellow, orange, and red semi-transparent overlays. These overlays indicate the three subsections of the playing field, with yellow and red indicating a safe and very risky area, respectively, and orange

representing something somewhere inbetween these. Furthermore, the yellow diagonal stripes indicate that the area will become off-limits in the next stage of the dragon, while the red diagonal stripes indicate that an area is already off-limits.

The dragon itself has been kept in cartoon style as can be seen in Figure 24 below, in order to prevent the children from potentially getting scared by the dragon.

Figure 24: The dragon's four phases. Images by *Shutterstock* user *Memo Angeles*[a].

[a] https://www.shutterstock.com/g/memoangeles

The various dragon images are all part of the same set made by *Shutterstock* user *Memo Angeles*[11], in order to make sure that the looks of the dragon did not change significantly between the various phases.

In keeping with this style, the collectibles, seen in Figure 25 below, also have a cartoonish look to them. In fact, the images were also found in a set of images created by *Memo Angeles*[10]. This was done in order to maintain a consistent style, and to make the items easily distinguishable from the darker, more realistic background.

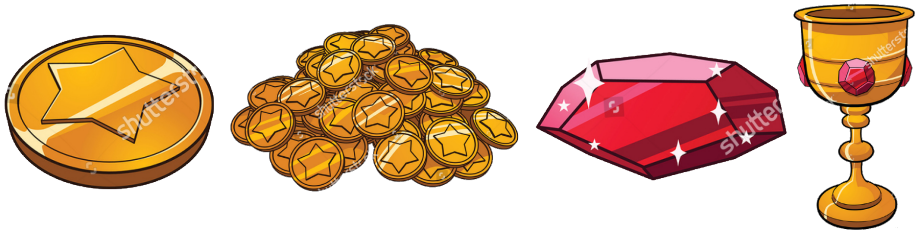

Figure 25: The four different collectibles. Images by *Shutterstock* user *Memo Angeles*[11]

6.3.2 Game mechanics

The goal of the game is to gain as many points as you can by taking the dragon's treasure. These treasures are spread out across the bottom, middle, and top of

[11] https://www.shutterstock.com/g/memoangeles

the screen, with the treasure becoming more valuable the higher you go. The dragon knows this however, and will keep a close eye on his most valuable treasure.

The dragon has four different phases, ranging from slumbering to angry, which it will cycle through periodically. As the dragon becomes more watchful for the players, sections will start becoming off-limits, starting at the top. These sections will be marked with yellow stripes before they become off-limits, and red once they actually are, so players should strive to run away from the area once they see the yellow stripes. An example of these warnings can be seen in the right screenshot in Figure 23 above. Should an unfortunate player be caught inside an off-limits are, they should try to remain as immobile as possible; the dragon will only see them if they move. If the dragon does see a player, the group will start losing points until the player either stops moving or leaves the off-limits area.

In addition to the yellow and red stripes serving as visual cues, the dragon will also start growling more intensely as it switches between phases, until calming down again once half of the map has been off-limits. This should provide the players with a warning that they should check their surroundings in case they haven't been paying attention to the dragon.

6.3.3 Database connection

If the player's combined activity goal of the past week has been reached, the collectible spawns will change. The bottom area will contain stacks of coins, the middle area will contain gems, and the top area will contain golden goblets with gems. Passing their goal will thus allow the player to reach higher scores in the game, motivating them to perform enough physical activity in a playful way. It also allows the physiotherapist to review whether or not the patient has reached their goal without interrupting the play session.

The RRD database contains all the information required to make the game adaptable based on the amount of physical activity performed by the user. This data can be reached through a REST/JSON webservice by sending it HTTP requests. The first of these HTTP requests should be a log-in request, which will return an authentication token if the user has provided the correct log-in details. This authentication token should then be included in the header of each subsequent HTTP request to authorize the request; without this token, the request will not be given the desired response and will instead return an error. These subsequent requests could for instance be a request for a patient's step count during the past five days.

This entire database component of *The Dragon's Dungeon* is locked behind a password; the first time the user tries to open the database input, they will be prompted to enter the password. This password check has been included so that unauthorized people can not access the patients' personal data. If this password is correct, the user will be able to enter the patient's ID in order to send a query to the RRD database asking for the patient's activity related data of the past week. The game will then receive a response from the RRD

database containing said activity data, which is then trimmed down to just the step count values for each day. After this, the game will send a similar request to receive the user's automatically and manually determined step goals. The manually entered values will take priority, after which any missing data is filled up with the automatically generated goals. This allows the game to compare the patient's step count to the goal set for the user, so the game can determine whether or not the goal has been reached for this week.

6.3.4 Integration

All of the various dragon, collectible, and background assets were created before scripting work started. The same holds true for the various audio assets used to indicate the changing dragon phases in the game. This meant that once the construction of the game had started in Unity, as well as the accompanying scripting work, there were no interruptions. The construction of the game started with a game template provided by van Delden; this template consisted of the functional player tracking code, and a framework upon which the game could be built. As the database connection was only programmed at the final stages of the realization, switching between the default and the improved reward game modes for testing purposes was done by pressing a button. When the game was fully functional without the database connection, this connection was developed separately from the rest of the game. Once the database component worked on its own, several functions were added so that it could be accessed by the other parts of the game, resulting in the combined project. This project was then turned into a standalone game using Unity's build feature, creating the first prototype that could then be used for the initial play test with students.

6.4 Client feedback

After finishing the integration, a meeting was organized with Van der Kamp to gain feedback on the first iteration of the final product from a clinical perspective. Van der Kamp was positive about the changes that had been made to the existing games, as well as the first iteration of the first game. The control given over *Uncover*'s pacing through the new therapy mode was particularly well received, as it allows physiotherapists to better implement the game into a therapy session. Other features that were mentioned in particular included the versatility provided by the new *Block Dodger* gameplay features, and the database integration used in *The Dragon's Dungeon*.

Furthermore, Van der Kamp explained that turning *Block Dodger* into a multiplayer game would increase its usefulness in a therapy session, as otherwise it would not be feasible to have the children play the game one by one. In addition to this, Van der Kamp stated that the children were unlikely to notice that they are losing points or that the dragon's phase is changing based on visuals alone; audio cues signalling these events would aid in this regard. Lastly, Van der Kamp stated that a therapy mode similar to the one now found

in *Block Dodger* would be a good addition to *The Dragon's Dungeon*, with the physiotherapist being able to change the amount of collectibles spawning and the duration of the various dragon phases.

6.5 Second iteration

Based on Van der Kamp's feedback, another iteration of the games was created. In this new iteration, both *Block Dodger* and *The Dragon's Dungeon* received significant changes in order to function better within a therapy setting. *Uncover* was not updated during this iteration.

6.5.1 Block Dodger

When it was initially created, *Block Dodger* had been designed and programmed for use by a single user. For this reason, the code concerning the tracking of said player was not designed to easily be expanded to accommodate a larger amount of players. Thus, in order to turn *Block Dodger* into a multiplayer game, this entire section of code had to be scrapped and replaced by the tracking code found in the same template used for the tracking component of *The Dragon's Dungeon*. While this initially had some incompatibility issues, these issues were eventually resolved, resulting in the second iteration of *Block Dodger* being playable by four players at once.

6.5.2 The Dragon's Dungeon

In accordance with the client feedback, four separate audio files resembling a dragon stirring and roaring were chosen to indicate the changing of the dragon's phases. As the dragon starts becoming more active, the audio cues will likewise sound increasingly aggressive. After reaching the final phase, the game will return back to its initial state with the audio cue resembling a disinterested dragon. Additionally, an audio cue resembling falling coins has been added to the game, which is played on loop as long as at least one player is losing points by moving around in an off-limits area. The second iteration was rounded off by allowing the physiotherapist to change the spawn rate of the various collectibles appearing in the area of play, as well as the duration of the various dragon phases.

6.6 Pilot test

Before the second iteration of the three games are tested with the target group, a quick pilot test will be performed with students as participants rather than the children. This section of the report is dedicated to the documentation of the test protocol used for this pilot test, as well as an analysis of the resulting data.

6.6.1 Goal

The goal of this pilot test is to uncover any surface level issues related to the games, so that these can be corrected before the final user test with the target group. These issues can include, but are not limited to, technical issues, usability issues, and game balance issues. Resolving these issues before the final user test should help make sure that no unforeseen problems occur during said test.

6.6.2 Expectations

It is expected that the spawn rate of the various collectibles will have to be altered to better suit the movement speed of the participants, as this movement speed will likely not be identical to the movement speed of the manually controlled player that was used to test and initially balance the game. Furthermore, it is expected that a small number of as of yet undetermined surface level issues are found.

6.6.3 Participants

The recruitment of the participants will take place at the University of Twente, and will consist of two variations. The initial recruitment process will take place by asking fellow creative technology students, as they are expected to be more willing to be participants than the average passerby. Should this recruitment process not result in enough participants, students walking past the playground will be asked to take part as well.

The participants taking part in the experiment will all be competent, adult students of the University of Twente. As the initial stage of recruitment is expected to provide the majority of participants, the majority of participants will likely have previous experiences with the interactive playground and/or user testing due to their background as creative technology students. This is not deemed to be an issue, as the final test will also take place with participants that have previous experiences with the interactive playground. No distinction will be made between recruiting male or female participants, though a somewhat balanced mix would be preferred due to potential unexpected gender based differences. No other distinctions will be used to prioritize certain participants.

6.6.4 Setup

The experiment will take place in the DesignLab at the University of Twente. The interactive playground installed here is similar, though not identical, to the interactive playground located at Roessingh used for the final user test. The playground located at the university contains four Kinects compared to the six Kinects used at Roessingh, and the display resolution is slightly different, with a resolution of 1920:2400 being used at the university compared to 1920:2160 being used by Roessingh. Neither of these differences should have a noticeable

impact on the user interactions with the games, however. Of course, the three games are also required to be downloaded onto the computer. In addition to this, the experiment has been approved beforehand by the ethical committee of the faculty of Electrical Engineering, Mathematics, and Computer Science (EEMCS) under the reference number *RP 2019-56*.

During the experiment, passers-by will be asked to walk around the playground to avoid influencing the game or the participants in any way.

6.6.5 Method

Once the participants have been recruited, they will be brought to the Design-Lab if they are not there already. Once there, a short introduction will be given regarding the project as a whole, as well as what they will be doing, which data will be recorded and how, and what the goal of the experiment is. After this introduction, they will be given the information sheet found in Appendix B, which they will be asked to read through at their own pace. If the participants have any questions, they are free to ask these during this period. Once every participant has read through the information sheet and all questions have been answered, the participants will be asked to carefully read sign the consent form seen in Appendix C, and to sign it if they agree.

After this introduction, the game *Uncover* will be explained to the participants. The participants will be told that the first five rounds will be played in the default game mode to get acquainted with the game. After these five rounds, the game's therapy mode will be enabled, which will remain enabled for the next ten rounds. During the entirety of the play test, the researcher will observe both the system and the participants. Any noteworthy observations will be written down using the document seen in appendix D. A full list of expected noteworthy observations include:

- Players getting confused.
- Players being surprised.
- Players getting frustrated.
- Players becoming sad.
- Players leaving the field of play.
- Players showing unexpected behaviour.
- Players interacting with the system in an unexpected way.
- Players being happy.
- Players verbally commenting on something that happened in the game.
- Players becoming more or less active

After these fifteen rounds in total, the play test for *Uncover* will be over, and the participants will be asked to fill in the questionnaire seen in Appendix E.

After the questionnaires have been filled in, *Block Dodger* will be introduced to the participants. The play test will start off with the participants playing all six levels of the game in the default mode, with all enemies coming from the right side of the screen. After the participants have gotten used to the game this

way, the game will be played again, with the researcher changing the spawn direction and enemy movement speed as they see fit. Similarly to the previous play test, any noteworthy observations will be written down using the second document found in Appendix D. After completing all six levels for the second time, the play test for *Block Dodger* will be over, and the participants will be asked to fill in the questionnaire seen in Appendix E.

Following this, *The Dragon's Dungeon* will be introduced to the participants for the third and final play test. The play test will start with the participants playing the game in its default mode for two minutes. After this, the database will be accessed to unlock the increased rewards mode. To ensure that the mode will actually be unlocked, the step goal will be set to 0 steps beforehand. During both rounds of play, any noteworthy observations will be documented using the second form found in Appendix D. After another two minutes, the play test will end and the participants will be asked to fill in the questionnaire seen in Appendix E for the final time.

6.6.6 Results

The student participants consistently found two technical issues across all three of the games. First of all, the display quality of the games was found to be subpar due to the amount of ambient light in the room and the black surface it was projected on, resulting in players having difficulties identifying objects on the screen. This is a significant problem, as all three games rely heavily on visual cues and objects being shown on the screen. On the other hand, however, the final test location at the Roessingh Centre for Revalidation can be made much darker and has a much lighter floor, so these issues should partially be solved. The second issue is that there was often a short delay in the tracking software, resulting in the games placing the player's icons roughly half a meter to a meter behind them, depending on their current speed. While not a significant issue in *Uncover*, this problem becomes a lot more noticeable in *The Dragon's Dungeon*, and especially *Block Dodger*, as the player's exact movement has more impact on whether or not the player is winning or losing points. *Block Dodger* showed more tracker delay than the other two games, suggesting that it might be at least in part related to the code and not just the playground itself.

Uncover

Uncover's feedback was mostly centred around the fact that due to the subpar projection quality, it was rather difficult to determine exactly which letters were being shown on the screen, and what objects could be seen in the uncovered image. Because of this, it was more difficult than expected to decipher the word after all of the letters had been revealed. This was amplified by the participants feeling like they could use slightly more time for the puzzle segment at the end of each round. Despite this, every participant mentioned the puzzle at the end as the most exciting and rewarding part of each round. Aside from this, the participants also enjoyed working together to uncover all the letters as soon as possible, with one participant noting that they enjoyed trying

to solve part of the word before all the letters had been uncovered, as it made the game more challenging and provided the rest of their team with a good starting point once they started trying to solve the word as well. The observations reinforced these answers, especially the fact that the students would try to work together by having each student clear out their own part of the image, after which they would start trying to solve the puzzle with whatever information they had available. One thing that was not mentioned, however, is that even the shortest round timer available in the therapy mode (ten seconds) allowed the students to almost completely uncover the image, removing a lot of the challenge from the final puzzle.

Block Dodger

Feedback specific to *Block Dodger* also included that players are able to exploit the edges of the playground by quickly leaving and re-entering the area to avoid incoming blocks. Furthermore, the game was found to be rather difficult before the therapy mode was implemented, due to a combination of rather fast enemies and large hitboxes for both the players and the enemies. The participants enjoyed the chaos of the game, being able to run freely around the playground, and watching their fellow participants get hit when the spawn direction of the enemies changed. In regards to the therapy mode, the participants appreciated how the game could be adapted to set a more achievable difficulty. They also enjoyed that the spawn direction could be changed once players got too complacent and stopped actively reacting to the incoming enemies, as this brought some new life into the game. In addition to these points, the observations also revealed that some waves of enemies would literally be impossible to dodge, as a straight line of blocks would fill the entire height of the screen. In addition to this, players would start hiding behind each other when the difficulty standard ramping up, essentially using one player as a human shield in an attempt to avoid having everyone get hit by the blocks.

The Dragon's Dungeon

Finally, *The Dragon's Dungeon*'s feedback is almost exclusively in regard to the low volume of the dragon's audio, both in general and compared to the falling coin sounds, and in regard to the contrast between the red and yellow diagonal lines and the semi-transparent red and yellow surfaces used to indicate the various areas in the game. The contrast between the golden coins and the yellow areas was also mentioned by one participant, as was the fact that another participant found it hard to estimate when an area marked with a yellow diagonal line would become off-limits. Positive feedback included that the participants enjoyed the risky and active behaviour stimulated by the better rewards in the high risk areas. One participant mentioned the rush of adrenaline they got when they grabbed some high value items at the last second, just before the dragon woke up. Overall, the game balance was considered to be very positive, all playstyles being an addition to the team in their own way.

6.7 Third iteration

Based on the results from the pilot test, a number of improvements have been made to the games. In *Uncover*, the round timer used in the default state[12] of the game has been increased from twenty seconds to thirty seconds. Whilst the twenty seconds would have been enough time for the children to uncover the image completely, they likely would not have had enough time to solve the word puzzle as well, seeing as the students already struggled with finishing this task in the allotted twenty seconds. Furthermore, the range of round times available has been changed from ten, fifteen, twenty, and thirty seconds to five, ten, fifteen, and twenty seconds. This was done in order to create an option in which even with four active players, it is unlikely that all letters will be completely uncovered, providing a more challenging puzzle at the end. In addition to this, the size of the player hitbox in *Block Dodger* has been reduced to better encompass the actual radius of the players. Furthermore, the volume levels of the audio files used in *The Dragon's Dungeon* have been raised so that they are more in line with the volume level of the other two games. The other feedback was not directly addressed, as it either fell outside of the scope of the project due to it primarily being related to the playground, such as the tracking delay and the ability for players to dodge blocks by stepping outside of the play area, or due to the feedback being a direct result of factors that were only present at the interactive playground at the DesignLab, and not at the playground at the Roessingh Centre for Revalidation, such as the dark floor resulting in reduced projection quality.

[12] Without making use of the therapy mode

7 Evaluation

7.1 User test protocol

7.1.1 Goal

The goal of this user test is to observe differences in how the children respond to the improved games compared to the old version of the games, both during and after play. Furthermore, the children's responses to *The Dragon's Dungeon* will likewise be investigated.

7.1.2 Expectations

It is expected that the children will respond favourably to the improvements to the older games; the additions to *Block Dodger* should introduce some variety to the levels and provide more challenge to the more skilled children, and the new images introduced to *Uncover* provide the children a goal to works towards whilst the therapy mode should allow the children to play the game at their own pace. For *The Dragon's Dungeon*, it will be interesting to see if the children have any regard for the off-limits areas.

7.1.3 Setup

The user test will take place in one of the therapy rooms at the Roessingh Centre for Rehabilitation. The interactive playground located in this room will be used to play the games, with the playground consisting of six Kinects and two beamers, with a total surface area of roughly 16 square meters. Whilst the computer connected to these components is located in another room, it will be controlled using a wireless keyboard with a touchpad so that the physiotherapist and researcher can both remain in the therapy room while interacting with the games. In addition to this, the experiment has been approved beforehand by the ethical committee of the faculty of Electrical Engineering, Mathematics, and Computer Science (EEMCS) under the reference number *RP 2019-56*.

7.1.4 Participants

The user test will include four participants, all of which will have been selected and pre-screened by the Roessingh Centre for Rehabilitation for their participation within this experiment. The participants will be children aged 8-12 that have been diagnosed with DCD or mild forms of CP, but are still able to walk without the assistance of external tools for at least the duration of the user test. Furthermore, the participants will already have a basic understanding of the interactive playground due to their previous participation in therapy sessions making use of the playground.

7.1.5 Method

The children will all be asked to attend a therapy session together at the user test location. Once there, a short introduction will be given regarding the project as a whole, as well as what they will be doing, which data will be recorded and how, and what the goal of the experiment is. As their parents have already consented to participation in this research project by signing the document seen in Appendix F, neither the children nor their parents will have to sign any new documents.

After this introduction, the game *Uncover* will be explained to the participants. The participants will be told that the first five rounds will be played in the default game mode to get acquainted with the game. After these five rounds, the game's therapy mode will be enabled, which will remain enabled for the next ten rounds. During the entirety of the play test, the researcher will observe both the system and the participants. Any noteworthy observations, such as confusion, surprise, or excitement, will be written down according to the document seen in Appendix D. A full list of expected noteworthy observations include:

- Players getting confused.
- Players being surprised.
- Players getting frustrated.
- Players becoming sad.
- Players leaving the field of play.
- Players showing unexpected behaviour.
- Players interacting with the system in an unexpected way.
- Players being happy.
- Players verbally commenting on something that happened in the game.
- Players becoming more or less active

After playing these fifteen rounds in total, the play test for *Uncover* will be over, and the participants will be asked to fill in the questionnaire seen in appendix G.

After the questionnaires have been filled in, *Block Dodger* will be introduced to the participants. The play test will start off with the participants playing all six levels of the game in the default mode, with all enemies coming from the right side of the screen. After the participants have gotten used to the game this way, the game will be played again, with the researcher changing the spawn direction and enemy movement speed as they see fit. Similarly to the previous play test, any noteworthy observations will be written down using the document found in Appendix D. After completing all six levels for the second time, the play test for *Block Dodger* will be over, and the participants will be asked to fill in the questionnaire seen in appendix G.

Following this, *The Dragon's Dungeon* will be introduced to the participants for the third and final play test. The play test will start with the participants playing the game in its default mode for two minutes. After this, the database

will be accessed to unlock the increased rewards mode. To ensure that the mode will actually be unlocked, the data integration component will be tested half an hour before the experiment to determine whether or not the children have passed their step goals. If this is the case, no extra measures will be taken. If this is not the case, the step goal will be manually set to 0 steps beforehand in order to ensure both variations of the game can be tested. During both rounds of play, any noteworthy observations will be documented using the form found in Appendix D. After another two minutes, the play test will end and the participants will be asked to fill in the questionnaire seen in appendix G for the final time.

7.2 Results

The reduced amount of ambient light and the brighter floor at the Roessingh Centre for Revalidation resulted in a much more crisp and clear image, alleviating some of the concerns raised during the student user test. Some tracking issues were still observed however. For instance, the player object was still often seen to be trailing behind the actual player's position on the playground. Over time, the difference between the actual player's position and the displayed position would slowly start to get larger if the player kept moving around at a high speed. Once this distance reached a certain point, the game would attempt to create a new player object, as it would assume that the trailer player object and the actual players were too far away to be considered one player, and instead assume that they were both players. This copy would usually disappear within three seconds, though this was still plenty of time to confuse any child that happened to see the "ghost", as they would call it. Aside from this, any technical issues were limited to the initial boot of the system, so they did not impact the actual play session with the children.

The children themselves were very positive about the three games, with the two updated games being rated very similar by the children, and *The Dragon's Dungeon* being rated as slightly more difficult and slightly less active. The feedback given by the children was often somewhat contradictory, with some children mentioning actively running around as their favourite part of the games, and some children noting that running around was their least favourite component of the games. One child in particular mentioned that they preferred *Uncover* over *Block Dodger*, whilst giving *Block Dodger* better or equal grades in every category compared to *Uncover*. An overview of the children's responses to the closed questions on the questionnaire can be seen in Figure 26 below. Sadly the playful and easily distracted nature of the children, as well as the limited time available, made receiving elaborations on their answers virtually impossible, resulting in a lack of reasoning behind the children's decisions and ratings.

7.2.1 *Uncover*

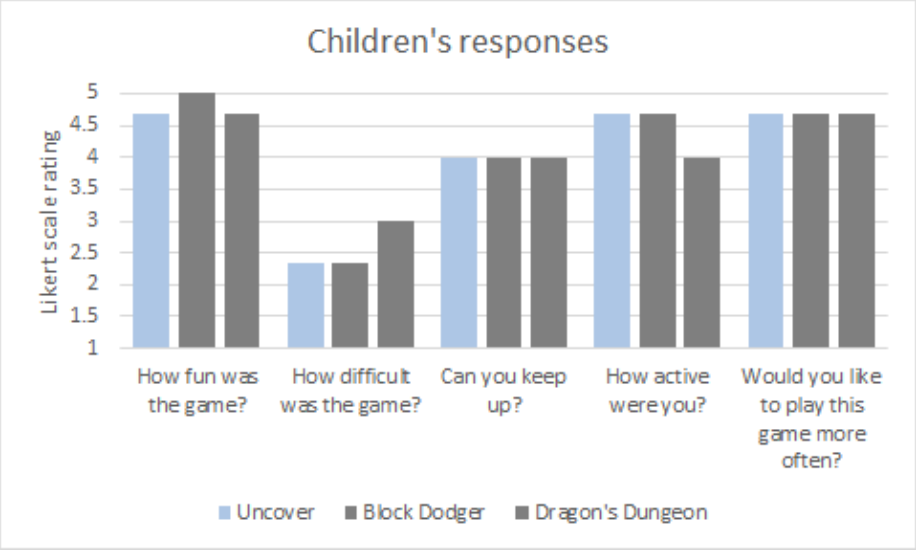

Figure 26: The children's responses to the closed questions in the user test, with *Uncover* responses highlighted in blue.

As can be seen in the bar graph above, *Uncover* was seen as a fun, simple game that promoted a good amount of activity. Based on the observations written down during gameplay, this activity was often in bursts of energy at the start of the round, after which the children would catch their breath while trying to decipher the word shown in the image.

Observations
It was observed that the children behaved surprisingly similar to the students; the children would spread out before each round, with every child being responsible for a specific area. Once this area was sufficiently cleared out, they would help uncover other areas in the game. Unlike the students, the children would only start trying to solve the word when every single letter was available to them. Outside of these strategies, the children also employed some more unorthodox tactics. These often consisted of the children either rolling around on the ground in an attempt to uncover larger areas at once due to the increased surface areas of their bodies, or two children swinging each other around in an attempt to gain enough momentum to swing each other across the entire area. When a low functioning child started getting tired, the physiotherapist was able to motivate them by joining the game and helping the child uncover the area as a pair.

Questionnaire results

The children appreciated that the game not only required physical activity, but also required some mental activity when trying to solve the puzzle at the end of each round. Nevertheless, they also enjoyed running around, with the notable exception of one child, who disliked the running part of the game. Despite the test group being composed of both relatively high functioning and low functioning children diagnosed with DCD, the children all gave similar grades to the five questions seen in the bar graph, with the standard deviation of the answers to the five questions averaging at a value of 0.64. The only notable outlier is that one child rated the game as very easy, whilst the other two children rated the game's difficulty as average. This could be due to the child being more capable mentally than their peers, which could have resulted in the puzzle at the end being perceived as a lot easier than their peers would.

7.2.2 *Block Dodger*

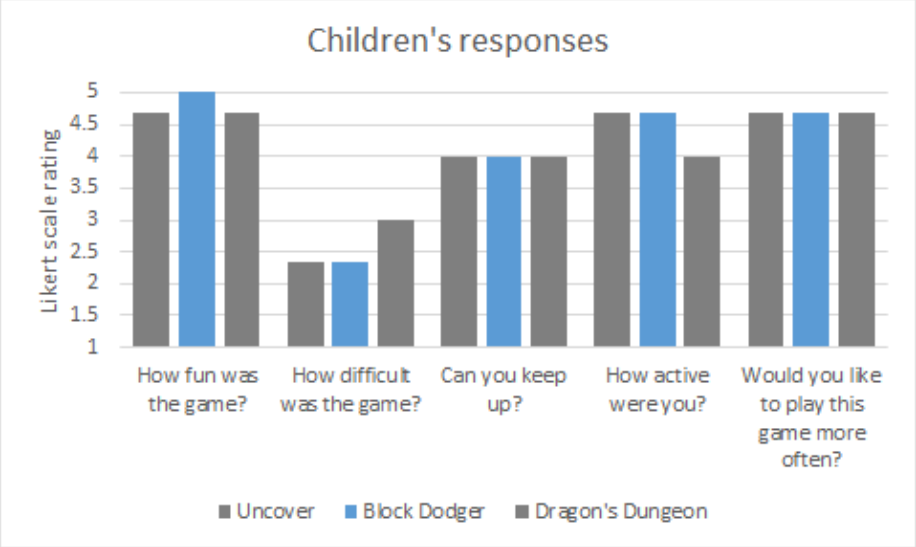

Figure 27: The children's responses to the closed questions in the user test, with *Block Dodger* responses highlighted in blue.

As seen in Figure 27 above, *Block Dodger* was, similarly to *Uncover*, seen as a fun, easy game that encourages physical activity. Compared to *Uncover*, this activity was at a lower intensity, but a lot more consistent due to the less pronounced pauses in-between the rounds.

Observations
One child was observed to attempt to hit as many projectiles as possibles, rather than avoiding them. This could potentially be caused by the fact that in most other games, the children have to touch the items to gain points, though

it could just as easily be something entirely unrelated. This child also started rolling on the ground in an attempt to increase their surface area, which appears to be a recurring theme that might have to be taken into account in the future. When the movement speed of the enemies was increased, the children quickly became very active for a limited amount of time whilst attempting to avoid all the blocks, though this quickly wore out after roughly five seconds, after which they reverted to their initial levels of activity. To expand upon this, the children were observed to quickly respond to a change to either the spawn direction or the movement speed of the blocks, after which they would pay more attention for a short amount of time, before reverting back to their initial level of activity. The low functioning participant was seen not entirely understanding what was going on, though they appeared to enjoy the game nonetheless. Reducing the block speed and changing the spawn direction less often motivated children that had previously stopped playing to join back in on their own and play for the remaining session time.

Questionnaire results

The grading results were more consistent compared to *Uncover*, with an average standard deviation of 0.53 across the various closed questions. The small amount of deviation that is present can be attributed to one child having difficulties staying active throughout the session, and thus also having issues keeping up with the game's pacing. The children themselves consistently listed being able to play the game with the entire group, and the blocks coming from multiple directions as being the two best features of the game.

7.2.3 *The Dragon's Dungeon*

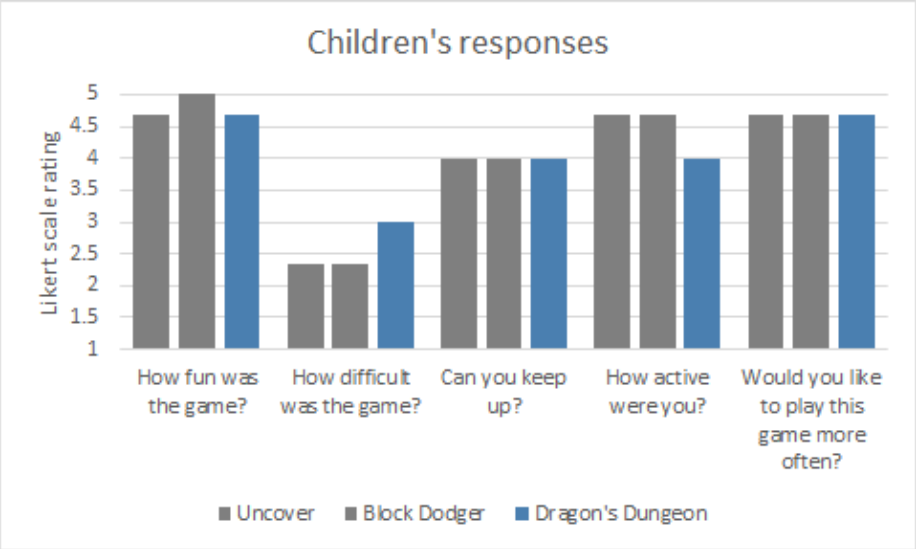

Figure 28: The children's responses to the closed questions in the user test, with *The Dragon's Dungeon* responses highlighted in blue.

Based on the graph seen in Figure 28, *The Dragon's Dungeon* was found to be more difficult at a rating of three out of five, and resulted in the children feeling slightly less active. While it is impossible to definitively state why the children found *The Dragon's Dungeon* to be more difficult than the other two games, the most significant difference between the games that could contribute to a higher perceived difficulty is the fact that *The Dragon's Dungeon* consists of various stages which, while visually similar, require slightly different playstyles to perform optimally in.

Observations
The reduced perceived activity is likely a direct result of the children having to stay immobile within the off-limits areas, with one child commenting during play that he thought the games were supposed to make them more active, not stand still. During the user test, the children were seen to favour different playstyles, not unlike the ones observed during the student pilot test. The higher functioning child would generally try to run back and forth between the various areas depending on the phase of the game, while the lower functioning child would generally pick one of the three areas and play exclusively in that area until they picked a new one. The children were seen getting confused by two elements of the game; the lower functioning child found it difficult to differentiate between the red and yellow stripes, and the red and yellow backgrounds. Furthermore, all the children would get confused if the team was

losing points while they themselves were standing still, but a team member behind them was still moving around in an off-limits area.

Questionnaire results
The grading results were similarly divided as *Uncover* with a standard deviation of 0.64 across the Likert scale based closed questions as well. The largest deviation was determined to be in the question regarded the activity of the children, where one child responded with a two and the other children responded with a five. Aside from this, all answers were within one point of the mean. The children listed waking the dragon and running back and forth across the field of play as the best features of the game. Whilst an important metric in the user test, the children were not able to answer what they thought of the activity sensor integration.

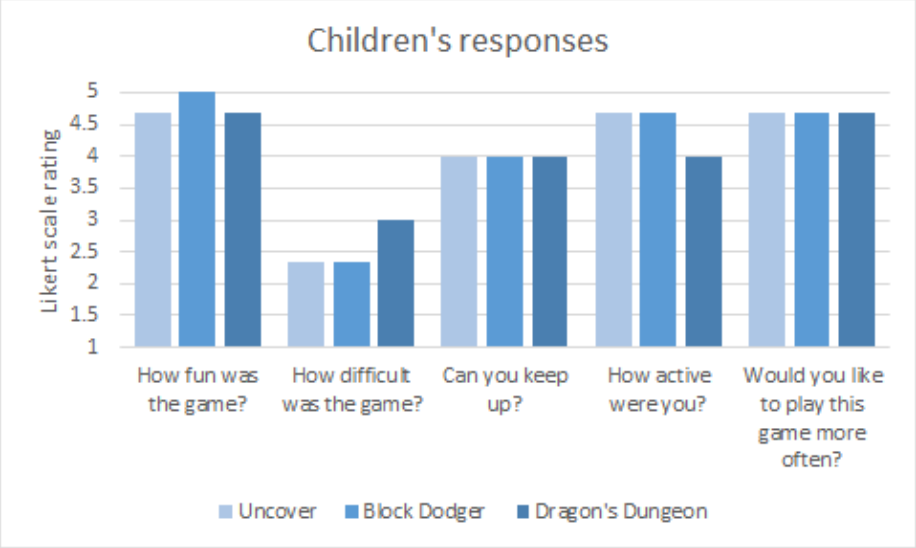

Figure 29: A complete overview of the children's responses to the closed questions in the user test.

In Figure 29 above, a comparison of the various closed question responses can be seen for the various games. In questions regarding their enjoyment of the game, in this case the first and last question seen in the graph, the children rated the games very similarly. The children found *The Dragon's Dungeon* to be more difficult than the other two games, though not too difficult. Despite this, the children thought they were able to keep up with all the games equally well, and even rated themselves as slightly less active when playing *The Dragon's Dungeon* than when playing the other two games. This could indicate that rather than finding the game more physically intensive, the game was more mentally demanding instead. Whether this is due to difficulties understanding

the game, having to rethink their playstyle between the phases, or an as of yet unknown reason, can not be determined without future research.

7.3 Client feedback

Following the user test, the client was asked to evaluate the design process and the resulting products. The client was happy about the amount of input that was asked of both himself and the physiotherapist, as this helped result in a final product that aligns well with the needs of both the user group and the physiotherapists at the Roessingh Centre for Revalidation. The two adapted games are now much more suited for the therapy sessions, in his opinion, and can thus be used to further investigate the use of the interactive playground in clinical use. He also stated that while the data integration of *The Dragon's Dungeon* might not have worked out as initially envisioned due to the children not understanding the connection between their activity data and what is seen on the screen, the game can still be used as a playful and entertaining way for physiotherapists to determine whether or not the children have reached their activity goals during the week before the therapy session. All in all, the client is very positive about both the process and the resulting products.

7.4 Overview

While the questionnaire results are not reliable enough, let alone statistically significant enough, to draw conclusions from, they can still be used to gain insights into how the children feel about the resulting three games. The children seemed to enjoy all of the three games and would like to play all of them again, whilst also stating that even though they were very active, they did not feel like the pacing of the game was too high. This all suggests that at the very least, the games can be used as a fun way to get the children active during the therapy sessions themselves. Regarding *The Dragon's Dungeon* in particular, the children found the game to be slightly more difficult, though it is hard to determine whether this is positive or negative without performing user tests over a larger period of time, so the possible changes in attitudes and performances can be analyzed. All these findings are supported by the children's behaviour during the user test, as observed by the researcher. Furthermore, the three games appear to encourage three different kinds of activity, with *Uncover* encouraging short intervals of high intensity activity, *Block Dodger* encouraging more consistent play, and *The Dragon's Dungeon* challenging the children to alter their strategy during play.

The data integration component did not achieve the desired effect, as the children seemingly do not see the connection between their own activity levels and the game's reaction to this activity. In spite of this however, the client explained that the data integration is still useful in therapy sessions, as it provides a fun and playful way for the therapist to determine whether or not the children were active enough in the week leading up to the therapy session. In addition to this, he stated that the lessons learned from *The Dragon's Dungeon*

would form a good basis for additional research regarding the integration of activity data and the playground.

8 Discussion

During the course of this project, we have managed to alter two existing student games and create one new game, resulting in three games that are fit for use in rehabilitation programs for children diagnosed with DCD and CP. While the activity data integration is only implemented at a very basic level, it still provides insights into what could be achieved with a larger focus on this integration. Furthermore, the integration is already useful for the program as a whole by providing a playful way of evaluation the children's activity during the week before the therapy session.

As is always the case, there were some factors that altered the course or result of the project in an unexpected way, whether it was through difficulties or material limitations. It is important to take note of these factors, so that anyone reading this report can take steps to avoid these issues in their feature endeavors. In addition to this, a list of recommendations will be made at the end of this chapter for those interested in performing further research.

8.1 Difficulties

In regards to the realization of the three new games, a not insignificant amount of time had to be spent replacing a broken computer and fixing other technical issues related to the interactive playground. This resulted in less time than expected being available to the development and evaluation of the various games. This also affected the process of determining which two of the older games would be improved; it was initially planned to involve the children in this process, but due to time constraints only the client and the physiotherapist were asked for their input in this.

One factor that played a more significant role than was previously expected was that the children are an unreliable source of feedback. This is due to multiple factors, with the first of which being their lack of nuance when expressing themselves; it was observed while filling in the questionnaires with the children that when determining how fun they found a game, a five out of five can range anywhere from *I enjoyed it* to *this is the best game ever*. A similar effect was observed by Read and MacFarlane (2006), who found that children aged between seven and nine years old would give a maximum rating almost half of the time, while children aged twelve or thirteen would give a maximum rating less than ten percent of the time. This could suggest that at least in this regard, the children that participated in this user test, all aged at least ten years old, are more similar to neurotypical children aged seven to nine years old than to neurotypical children aged twelve or thirteen. Similarly, children not enjoying themselves would not express this by stating so or even complaining, but by simply refusing to play the game anymore and doing their own thing. Furthermore, the children would very easily change their opinions of games while testing, of which the situation provided in the results subsection being a good example. In this case, a child said that they preferred playing *Uncover* over *Block Dodger*, while filling in the questionnaire that they thought *Block*

Dodger was more fun. When asked to explain feedback such as this, the children would either not respond as they were already getting ready to answer the next question on the questionnaire, or because they were too distracted by other things happening around them. Because of this, it was virtually impossible to determine the children's reasoning behind some more interesting and unexpected answers. In short, the children would give very extreme and short answers, without the possibility for further elaboration. In the future, more elaborate techniques should be used that were not within the scope of this project.

Another major factor that was only discovered towards the end of the user test was that the children might not actually understand the idea behind the integration of the activity data into the serious game; when asked on their opinion that on the combination of the measured data and the game they just played, the children were unable to answer the question and only got confused. While this could potentially be due to poor phrasing of the question, both the client, who has evaluated games with the children before, and the physiotherapist were also unable to obtain any meaningful response when phrasing the question differently. This could thus suggest that the children might not understand that it was their own activity data seen in the game. The lack of understanding this connection between their own actions and what they saw on the screen could in turn make it very unlikely that the children feel more motivated to be more active after playing the games.

Additionally, a mistake was made when designing the questionnaire for the children. A visual representation of a one to five Likert scale had been made using smileys, in order to make the questionnaire seem less boring and more relatable for the children. Only after the user test it was found that rating a game as very difficult would require the children to fill in the circle below the smiling face, something that is very counter-intuitive and could have confused the children. While nobody present during the user test had seen the children having any difficulties with this, it is still possible that this might have influenced the children's responses for this question.

8.2 Limitations of the study

Due to the limited resources of this project, research has been focused primarily on DCD and CP, along with the potentially coexisting conditions of ADHD and dyslexia. This has the consequence of not taking into account all of the common coexisting conditions that one might expect to encounter while dealing with children diagnosed with DCD or CP, such as the briefly touched upon autism spectrum disorder and depression. This could potentially lead to incorrect assumptions made in regards to the target group. Furthermore, some sources used in this paper still expressed doubt whether or not DCD and CP should be seen as distinct conditions, or rather as a spectrum, such as autism spectrum disorder (Pearsall-Jones, Piek, & Levy, 2010) (Williams, Hyde, & Spittle, 2014).

Regarding the database integration, the RRD database did not include a

feature to request activity data belonging to an entire user group rather than a specific user. This has resulted in only one player's activity data being integrated into the game at a time, rather than the entire group's activity data being analyzed. Being able to include every player's activity data might encourage everyone equally to be more active, rather than singling out one user.

Furthermore, only a very limited user test could be performed due to the lack of availability of children belonging to the target group. Because of this, the results of the user test can only be seen as an indication of how similar children might respond, rather than being a statistically significant set of data that can be used to draw definite conclusions from. Similarly, only a single user test could be performed, so possible changes in the children's behaviour and responses regarding the games have not been measured. As a result of this, it is not possible to determine whether or not the increased perceived difficulty of *The Dragon's Dungeon* is desirable or not.

8.3 Future research

In regards to future research, it is recommended to devote more resources investigating the lesser known coexisting conditions that affect children diagnosed with DCD or CP. This way, a more accurate overview can be created of the requirements a system designed for said children should adhere to. Furthermore, a significant number of sources relied on self-reported data or relatively vague terms describing their methodology, results, or even their definitions of DCD or CP. In order to draw more objective conclusions, research into these conditions will have to be performed more objectively, and with more quantifiable methods.

If further research using *The Dragon's Dungeon* is desired, it should be considered to remove the game mechanic that allows the children to stand still to avoid losing points. By removing this, *The Dragon's Dungeon* resembles *red light, green light* less, but it will also force the children to run back and forth between the areas rather than staying within one specific area and standing still when they have to.

Regarding the development of similar games, it is recommended that the complexity of any new game should not exceed that of *The Dragon's Dungeon* until further research into the long term effects of a higher perceived difficulty has been performed. Without this research, it is not possible to determine as of yet what impact this increased difficulty will have on the children's development and their perceived opinion on said new games. When integrating these new games with a database similar to the one used in this project, it is recommended to include a feature that allows the database to receive activity requests for both individual players and groups as a whole, as this would all members of a specific therapy group to be analyzed at once.

Furthermore, further research could be performed in regards to the physiotherapists role in games played on the digital playground. As seen during the user test while evaluating *Uncover*, the physiotherapist can play an active role in motivating and guiding the children while they are interacting with the

playground. For this reason, it should be considered to increase the maximum amount of player from four to five or six, to allow physiotherapists or other supervisors to join in.

In addition to this, it should be considered that as every participant will have to wear and maintain one of these MOX sensors during the periods between therapy sessions, at least one MOX sensor should be available for every participant. As therapy groups will typically consist of roughly four participants, this number will quickly ramp up if this is not taken into account. Additionally, even if this is taken into account, the added costs of purchasing new sensors could result in less participants being able to take part in therapy sessions, or at least those involving the interactive playground. Furthermore, should a participant forget to charge or bring their activity sensor, a lot of data will be missing.

When designing a user test for a similar target group, it is recommended to first perform a pilot test with capable adults beforehand. This not only helps detect technical issues that can then be fixed before the actual user test, but it also gives an indication of the user behaviour that one might be able to expect in the user test. This in turn allows researchers to prepare accordingly and be watchful of this behaviour. This is especially important as the results from this user test suggest that observations and expert interviews might be a lot more reliable than feedback directly received from the children. When looking for ways to receive feedback from the children, such as through a questionnaire, it is recommended to design forms or methods that normally be used for children a few years younger than the target group. Finally, it is recommended to test with a larger group of children across a longer span of time, in order to create a statistically significant data set that also shows any possible changes in user behaviour over the course of an entire ten week therapy program.

Finally, further research could also be directed at developing non-digital versions of the interactive playground games, as this could in turn result in variations of the initial traditional games that are better suited for children with motor deficiencies than the original games were.

9 Conclusion

Now that all three games have been developed and evaluated, the final step is to answer the research questions using the information gained during the project.

9.1 Research questions

The main research question, as stated before in section 1.5, is the following.

"How can a wearable sensor provide added value when integrated with an interactive playground regarding the rehabilitation of children with motor deficiencies?"

To answer this question, the four sub-questions also mentioned in section 1.5 will be answered first using the knowledge gained during the background research of this project, as well as insights gained during the design process and the evaluation of the final prototypes.

"What requirements should be taken into account when designing a system for children diagnosed with DCD or CP?"

When designing a system for children diagnosed with DCD or CP, it is important to not only account for severely impaired motor skills, but to also design for the most common co-existing disorders. In the case of DCD and CP, these co-existing disorders include, but are not limited to, dyslexia, Autism Spectrum Disorder (ASD), Attention Deficit Hyperactive Disorder (ADHD), epilepsy, mental retardation, and severely impaired speech. Due to these conditions, any product or system designed for this user group should not require the children to make precise movements, read small text or complicated words from a screen, pay close attention for long periods of time, feature flashing images, or require extensive communication between the players. Furthermore, it is desirable that the resulting system makes use of a goal-oriented and group-based approach, which can be used by a group encompassing a wide variation of competencies, without the poor performance of one child affecting the rest of the group in a negative way, as this could result in social tensions.

In addition to this, the system should not only align with the requirements of the target users, but also to those of the professionals that will be operating or supervising the system. These requirements are very context-dependent, but should not be disregarded, as failure to abide by these requirements could negatively impact the likelihood that the new system will be adopted into existing rehabilitation frameworks.

"How can the data from a wearable activity sensor be integrated into an existing interactive playground?"

The data from the wearable sensor should be uploaded to a central database,

where all the relevant data of the various wearables in use as part of the system can be stored and organized. Using a web service attached to this database, a game being played on an interactive playground can then send a request to said web service to request the required data. To ensure proper data security, it is recommended to include an authentication process in this step. Following this, the server will respond with the relevant data, which can then be used by the game in various ways.

Regarding the use of the activity data in the game, three variations of an activity-based reward structure were proposed during the ideation process of this project. These variations consisted of, in order of impact the data would have on the overall gameplay experience, giving the players points, visual rewards, or small power-ups. During this project, the first of these options was explored. Of course, various game design and gamification techniques could be applied to the system to create other methods of incorporating the activity data into a serious game.

"In what way does playing a game that is able to react to this data facilitate the therapy sessions?"

By integrating the activity data into a game based on the interactive playground, the physiotherapist is able to analyze the children's activity outside of the therapy sessions in a way that does not interrupt the children's physical activity, as the children are still able to play the game throughout this process. This can work as a good transition to or from the other playground games, and results in the children being active for a larger share of the therapy session as they no longer have to take a break to discuss their activity during the week prior to the session.

"How can a wearable sensor provide added value when integrated with an interactive playground regarding the rehabilitation of children with motor deficiencies?"

In theory, a game making use of the children's activity data could help them become more aware of their activity levels and goals, and potentially even motivate them to achieve these goals by rewarding the players based on their activity levels in relation to previously determined goals. Should this motivate the children enough to change their behaviour outside of therapy sessions and become more active, this behaviour might become part of their daily or weekly routine, potentially improving their activity levels even beyond the duration of the rehabilitation program.

In practice, the evaluation of *The Dragon's Dungeon* suggested that simply including the activity data in an otherwise unrelated game does not make the children relate their own activity to the values seen on the screen. Furthermore, only giving the players additional points for achieving their activity goals might not be not a large enough incentive to encourage additional activity outside of the therapy sessions. All-in-all, the activity data would likely have to play a more central and easily relatable role in the game in order to

encourage the children to be more active outside of therapy sessions.

Furthermore, a game making use of the children's activity data can be used by a physiotherapist during the therapy sessions to help visualize and analyze the children's activity in a fun and playful manner, making the process more enjoyable for the children and removing the need for the children to take a break from being active to discuss their physical activity during the previous days.

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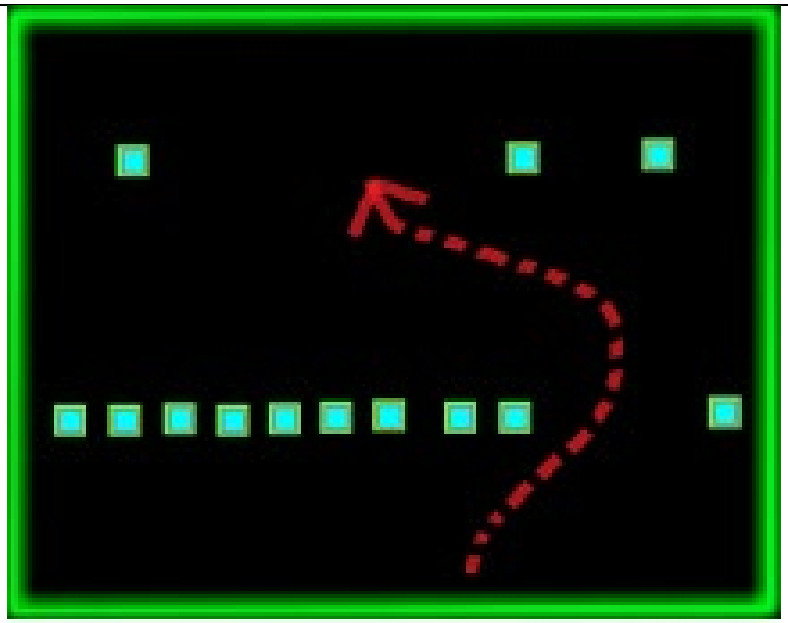
Appendices

A Overview of existing playground games

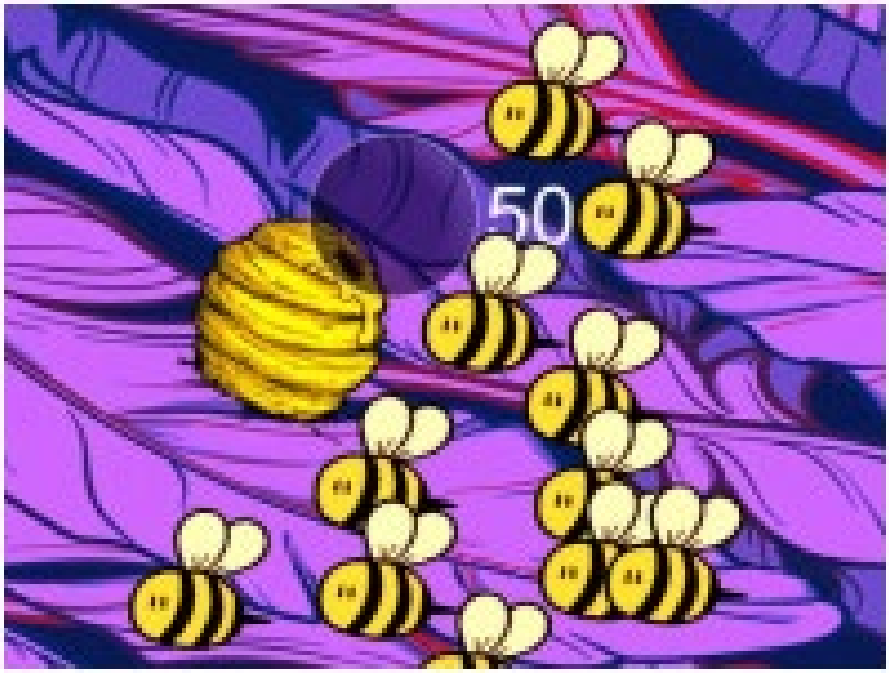
Overview

Block Dodger



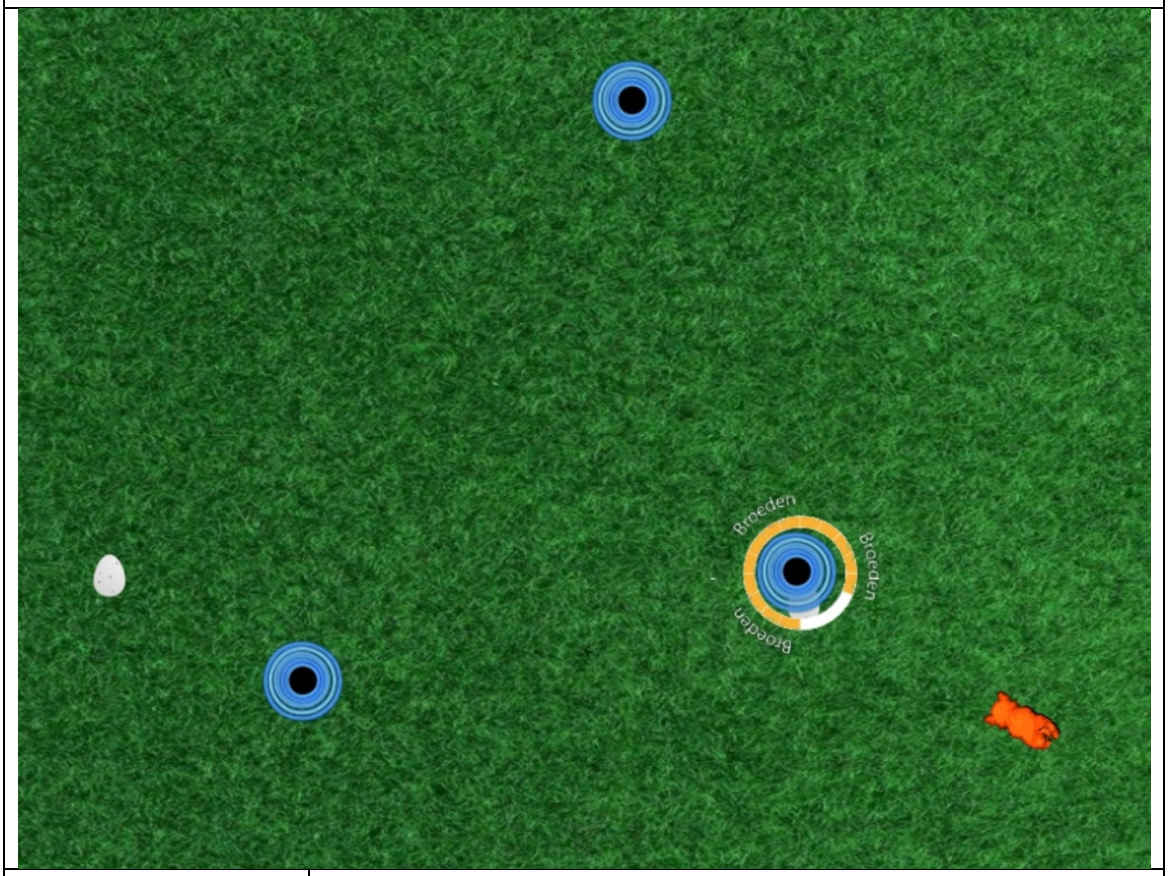
Number of players	1
Summary	Blocks will come rushing towards the player at various speeds, with every level getting more intense. Quickly dart through the gaps until you have completed all six levels.
Goal	Complete all six levels by avoiding the blocks.
Purpose of the game	The game was designed to investigate the impact of music intensity on perceived difficulty. Whilst the last three levels are equally difficult, the music will still become more intense per level, possibly affecting the perceived difficulty.
Interactions/Instructions	Walk along the interactive playground in order to avoid the blocks.
Available buttons	P – Start the game M – Mute the audio / - Increase music intensity A – Rotate spawn direction counter-clockwise D – Rotate spawn direction clockwise Z – Reduce enemy speed X – Increase enemy speed
Wizard of Oz (WOOZ) mode	W – Toggle WOOZ mode Arrow keys – Move around in the WOOZ mode

Buzz



Summary	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.
Goal	To collect as many bees as possible.
Number of players	1-4
Purpose of the game	The game has been designed to not require instructions, as well as lacking a distinct beginning and end. This allows new users to take part in the game whenever they want.
Interactions/Instructions	By touching the bees, the user will capture the bee and gain a point.
Available buttons	N/A
Wizard of Oz (WOOZ) mode	W – Toggle WOOZ mode 0-3 – Select a player in the WOOZ mode Arrow keys – Move around in the WOOZ mode

Cat Game

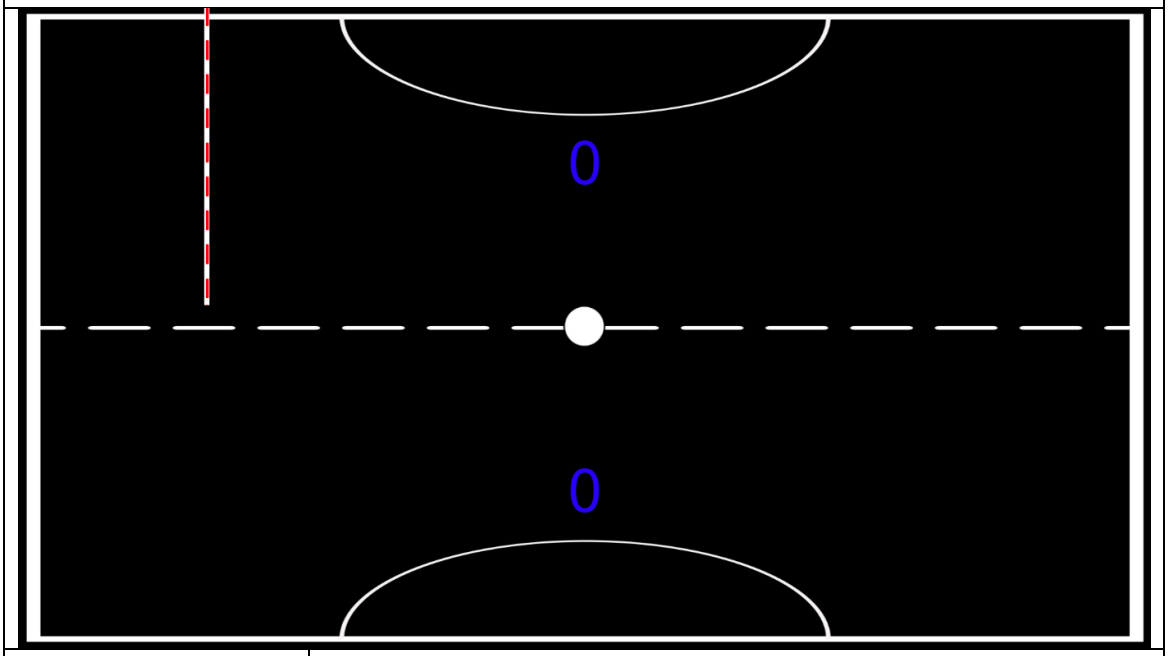


Summary	Players are tasked with hatching as many bird eggs as possible, whilst scaring away the cats that are trying to get to the eggs first.
Goal	To hatch as many eggs as possible
Number of players	2-3
Purpose of the game	The game has been designed in such a way that teamwork is required to do well in the game; the team needs at least one person hatching the eggs and one person scaring the cats in order to gain points.
Interactions/Instructions	Players can either try to hatch eggs by sitting on them, or try to scare away cats by walking towards them.
Available buttons	E – Enables cats R – Disables cats
Wizard of Oz (WOOZ) mode	W – Toggle WOOZ mode 0-2 – Select a player in the WOOZ mode Arrow keys – Move around in the WOOZ mode

Coin Collection

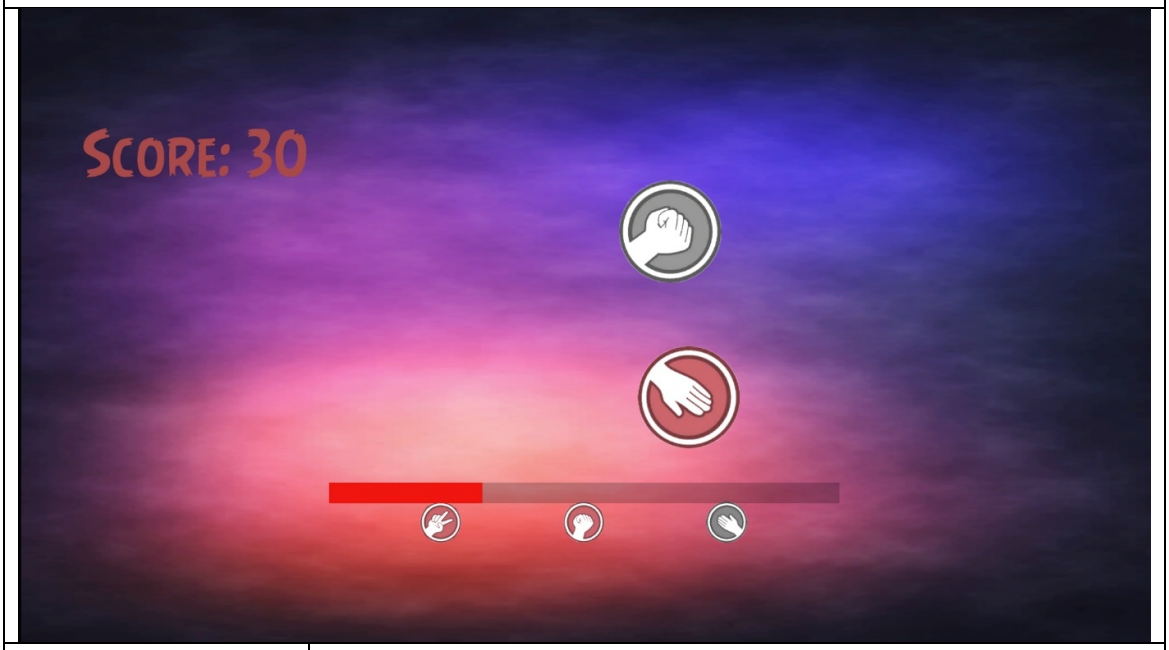
Summary	While the game features various game modes, the general gameplay revolves around collecting as many coins as possible.
Goal	To collect as many coins as possible.
Numbers of players	2-4
Purpose of the game	Can be combined with biomedical sensors and smart coaching to teach children to self-manage their asthma.
Interactions/Instructions	The players can collect coins by touching them.
Available buttons	N/A
Wizard of Oz (WOOZ) mode	W – Toggle WOOZ mode 0-3 – Select a player in the WOOZ mode Arrow keys – Move around in the WOOZ mode

Pong (DIPP)



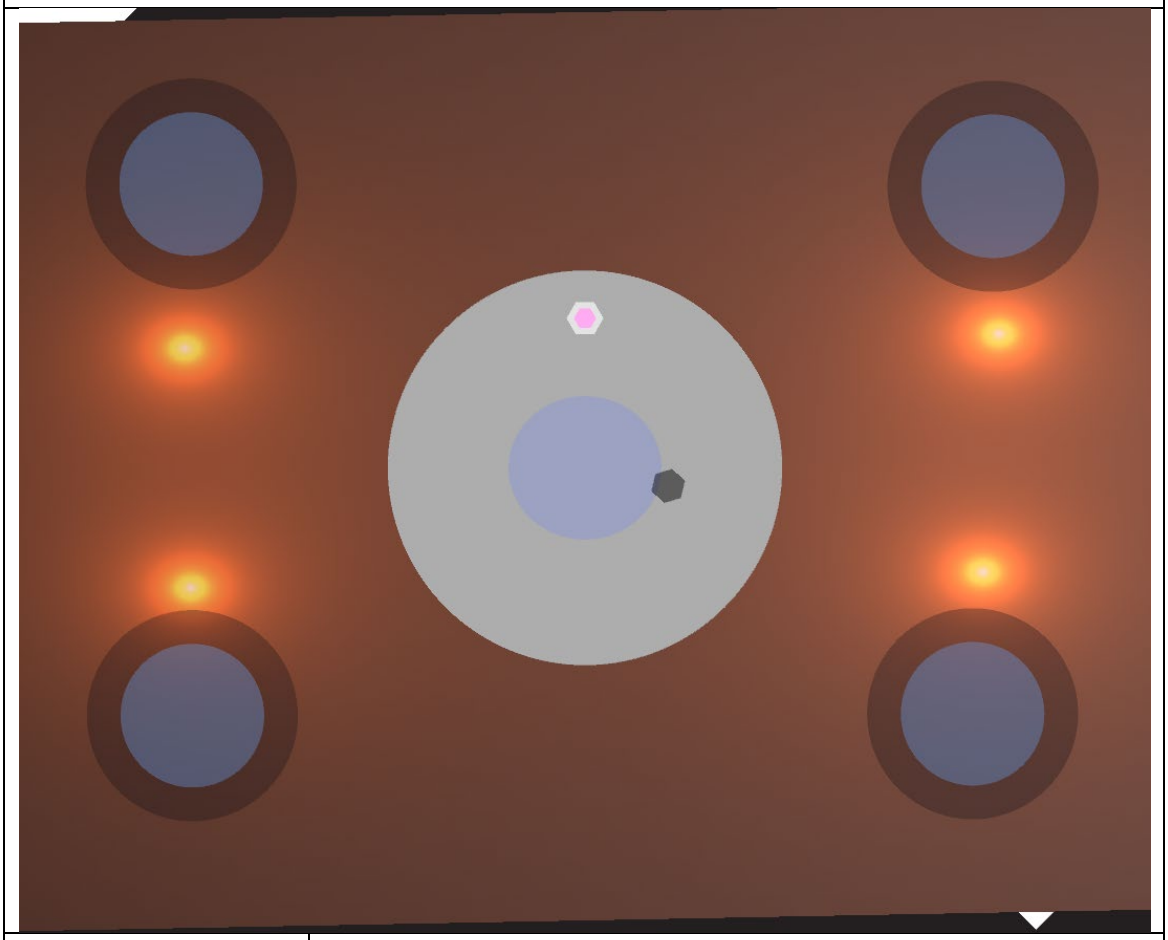
Summary	An implementation of the old arcade classic; every player controls their own bar, which can be used to bounce the ball back to the other side. A variation exists in which two players must work together to control a single bar.
Goal	To score more points than the opposite team.
Number of players	2-4
Purpose of the game	To determine whether teamwork between team members increases when they have a shared bar, rather than both having their own.
Interactions/Instructions	Players can use the bar at their position to deflect the ball.
Available buttons	N/A
Wizard of Oz (WOOZ) mode	W – Toggle WOOZ mode 0-3 – Select a player in the WOOZ mode Arrow keys – Move around in the WOOZ mode

Rock Paper Scissors



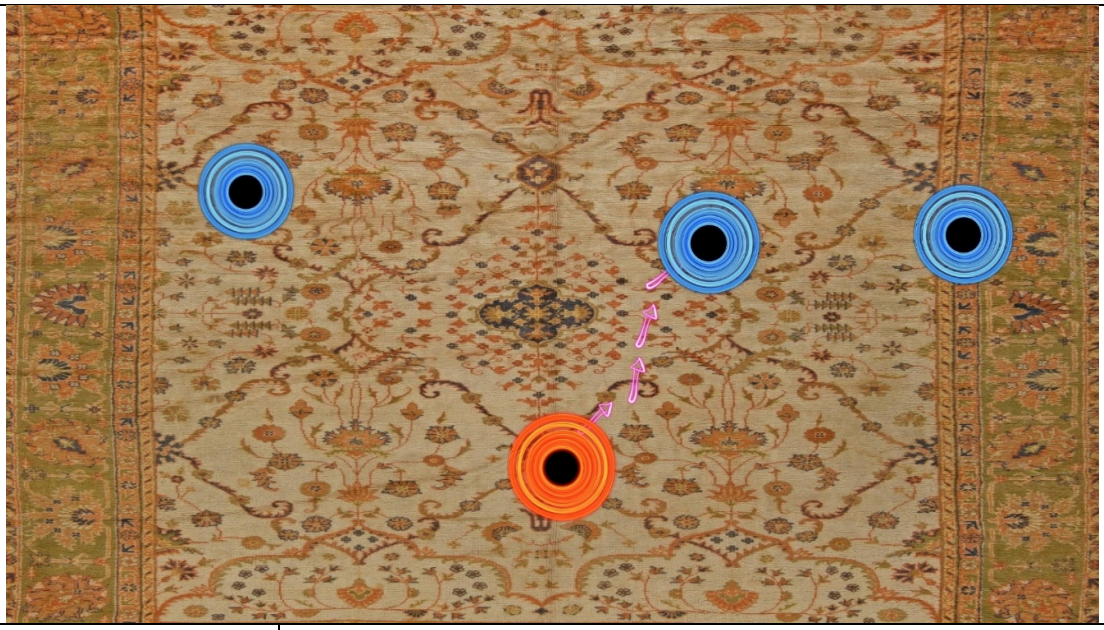
Summary	A digital version of the classic game of Rock, Paper, Scissors. As one of the three symbols moves towards the player, they must choose which response to pick before the symbol reaches the bottom of the screen.
Goal	To achieve a score of 100 by choosing the correct responses.
Number of players	1-3
Purpose of the game	To create a game that can be played without the interactive playground as well.
Interactions/Instructions	The players can walk over to any of the three responses at the bottom to pick a response to the incoming symbol. By then walking into the grey symbol, they can attempt to beat it.
Available buttons	N/A
Wizard of Oz (WOOZ) mode	W – Toggle WOOZ mode 0-3 – Select a player in the WOOZ mode Arrow keys – Move around in the WOOZ mode

SyncJump



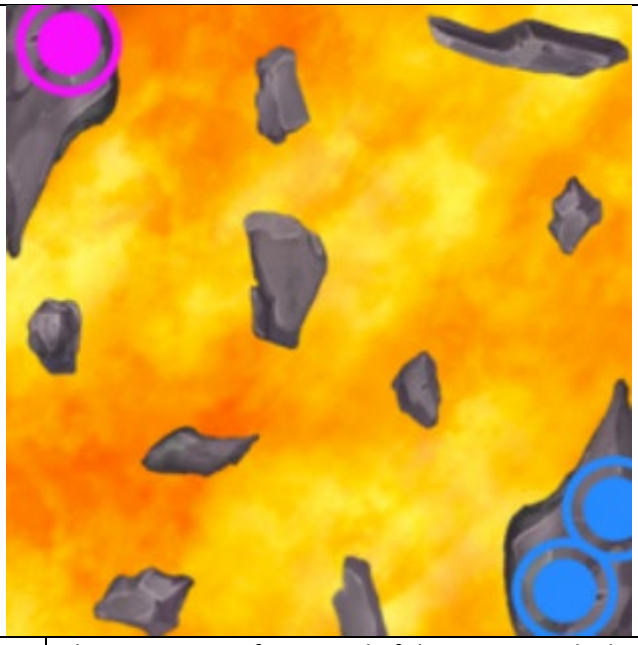
Summary	Players must jump exactly when the game tells them to. Be careful to time your jumps carefully, however, as jumping at the same time as everyone else will reward the players with nice visual effects.
Goal	To coordinate your jumps with the rest of the group, so everyone jumps at the same time.
Number of players	1-4
Purpose of the game	The purpose of the game was to investigate how players can be enticed to behave in a certain way, if they are rewarded with purely visual changes. Furthermore, the game was made to test how the playground would react to jumping behaviour.
Interactions/Instructions	Players have to stand at the designed areas and jump exactly when the darker hexagon passes the lighter one.
Available buttons	R – Reset the game Left arrow – Reduce object speed Right arrow – Improve object speed
Wizard of Oz (WOOZ) mode	N/A

Tag



Summary	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*.
Goal	Do not be *it*.
Number of players	2-6
Purpose of the game	To determine how player behaviour can be altered using cosmetic changes.
Interactions/Instructions	The player that is *it* can turn a different player into *it* by touching their circle with their own.
Available buttons	V – Toggle adaptive circle sizes P – Toggle power ups A – Toggle arrows
Wizard of Oz (WOOZ) mode	W – Toggle WOOZ mode 0-5 – Select a player in the WOOZ mode Arrow keys – Move around in the WOOZ mode

The Floor is Lava

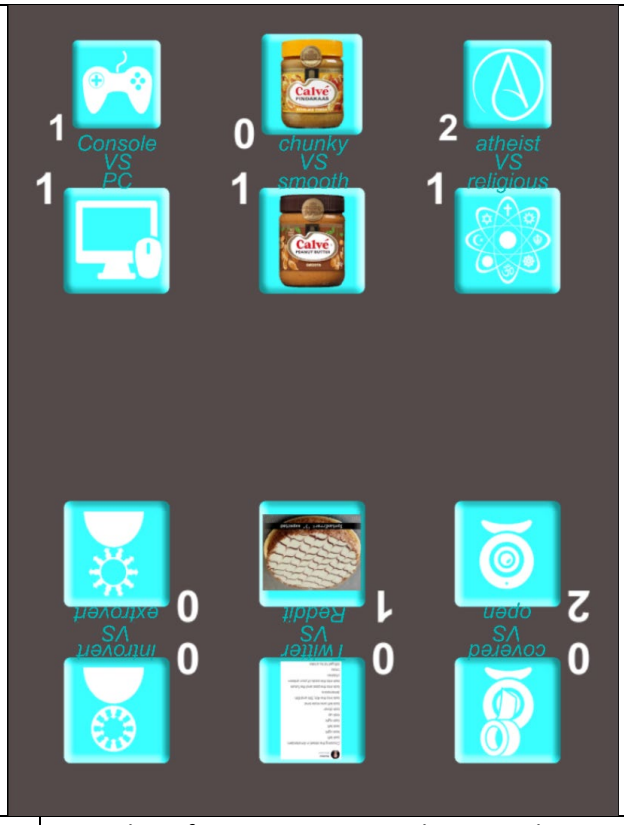


Summary	Players compete for control of the various rock platforms scattered around the map, all while avoiding the lava as much as possible. Stand in the lava for too long, and you'll temporarily get knocked out of the game.
Goal	Control more platforms than the opposite team.
Number of players	2-4
Purpose of the game	The game was designed to provide an engaging game that encourages social interaction.
Interactions/Instructions	Players can stand on the rock platforms to capture them for their team, and lose energy for standing in lava.
Available buttons	N/A
Wizard of Oz (WOOZ) mode	N/A

Uncover

Summary	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.
Goal	To reveal the image hidden underneath.
Number of players	1-4
Purpose of the game	The game has been designed to not require instructions, as well as lacking a distinct beginning and end. This allows new users to take part in the game whenever they want.
Interactions/Instructions	Walk across the black areas to uncover the image.
Available buttons	R – Reset the background
Therapy mode	T – Turn on therapy mode H/J/K/L – Set the round timer to 10/15/20/30 seconds, respectively P – Reveal the entire image G/F – Mark the answer as correct/incorrect, respectively
Wizard of Oz (WOOZ) mode	W – Toggle WOOZ mode 0-3 – Select a player in the WOOZ mode Arrow keys – Move around in the WOOZ mode

Vote



Summary	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.
Goal	To cast your vote on all of the various choices.
Number of players	1-4
Purpose of the game	The game has been designed to not require instructions, as well as lacking a distinct beginning and end. This allows new users to take part in the game whenever they want. The also game enables dialogue between the users on several different topics.
Interactions/Instructions	Stand still on one of the two voting options to count your vote
Available buttons	P + Right shift – Reset the game
Wizard of Oz (WOOZ) mode	W – Toggle WOOZ mode 0-3 – Select a player in the WOOZ mode Arrow keys – Move around in the WOOZ mode

B Student information sheet

Dear reader,
With this information sheet we would like to inform you about the research you are about to participate in. The testing will take place in the Design Lab at the University of Twente in Enschede. In the proposed research, the participants are going to play three games in a group based setting on an Interactive Playground Platform. Two of these games will be variants of existing games created for use in therapy sessions, while the third game will be a new game created for the same use scenario. These three games have been created for a Graduation Project called "RE-Play: An exploration of game induced exercise promotion in clinical use". This project is focused on developing serious games for children aged 8-12 years old that have been diagnosed with either Developmental Coordination Disorder (DCD) or mild forms of Cerebral Palsy (CP). These games will be played using the interactive playground platform, consisting of an interactive floor projection that responds to player positions as measured by top-down Kinects.

The purpose of this project is to create a set of games that can be used in combination with the interactive playground platform and activity sensors. These games are then able to reward or otherwise provide feedback based on the amount of physical exercise measured throughout the days before the therapy sessions. Ideally, this should motivate the children to be more active even when there are no medical personnel nearby to monitor them.

The goal of this test is to identify any flaws in the three game prototypes. These can be technical in nature but can also stem from mistakes made during the design phase of the project. These flaws can then be addressed before the games are presented to the children.

Regarding participation in the experiment, it is important that you are at least 18 years of age. While there are no inherent risks accompanied with the experiment, it is possible that participants may trip due to the physical activity required to play the games. Furthermore, you can decide to stop at any point during the course of the experiment without having any specific reason, this will not have any consequences for yourself. Your data will be handled in a confidential manner; your anonymity is guaranteed and will never be disclosed to third parties without your permission. After participating in the experiment, you are able to object to use of your data during a 5 day period. If this is the case, your data will be destroyed and will not be used for the project.

If you have any complaints about this research, please direct them to the secretary of the Ethics Committee of the Faculty of Electrical Engineering, Mathematics and Computer Science at the University of Twente, mw J.A. Rebel de Boer, P.O. Box 217, 7500 AE Enschede (NL), telephone: +31 (0)53 489 6719; email: ethics-commewi@utwente.nl.

Yours sincerely,
Research leader/Research assistant: Kevin Folkertsma; Tel: +31 6 2545 7910; email: k.folkertsma@student.utwente.nl

Coordinator: dr.ir. R.W. van Delden; Department HMI, Zilverling building, Faculty of EWI
University of Twente; Tel: +31 53 489 3925; email: r.w.vandelden@utwente.nl

C Student consent form

Declaration of consent
By signing this document, you declare to be at least 18 years of age; that you are well informed about the research, the methods used to gather, analyse, and store research data, and any potential risks you would expose yourself to by taking part in this experiment.

Should you have had any questions, by signing this document you are declaring that you had the chance to ask these questions and that they have been sufficiently answered. You state that your participation in the experiment is voluntary. You will receive a copy of this signed declaration, should you want one.

I agree to participating in this experiment conducted by Kevin Folkertsma. The goal of this declaration is to document the terms of my participation.

1. I received adequate information regarding the research project. The goal of my participation as a participant in this experiment has been explained clearly to me, and I understand what this means for me.

2. My participation in this experiment is on a voluntary basis. There is no explicit or implicit pressure for me to take part in this experiment.

3. I have the right not to answer questions. If I feel uneasy during the experiment, I have the right to end my participating in the experiment

4. I have received an express guarantee from the researcher conducting this experiment that they are responsible for making sure that I am not identifiable through published data, reports, or articles My privacy is safeguarded as a participant of this experiment.

5. I have been guaranteed that this experiment has been assessed and approved by the ethical committee of the EWI Ethics Committee. For any reservations regarding the setup or execution of the experiment, I can turn myself to the secretary of the Ethical Committee of the faculty Electrical Engineering, Mathematics and Computer Science of the University of Twente via ethics-comm-ewi@utwente.nl.

6. I have read and understand this form. All my questions have been sufficiently answered and I am voluntarily agreeing to participate in this experiment.

7. I have received a copy of this declaration of consent, which has also been signed by the researcher conducting this experiment.

_____ _____ _____

Name participant Signature Date

_____ _____ _____

Name researcher Signature Date

D User test observation form

User test observation form

Observer:	Game: Uncover/Block Dodger/Dragon's Dungeon
GroupID:	Participants: __ students/children
Round/Timestamp: _____	Observations: - - - - -
Round/Timestamp: _____	Observations: - - - - -
Round/Timestamp: _____	Observations: - - - - -
Round/Timestamp: _____	Observations: - - - - -
Round/Timestamp: _____	Observations: - - - - -

Round/Timestamp: _____	Observations: - - - - -
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	- -
Round/Timestamp: _____	Observations: - - - - -
Round/Timestamp: _____	Observations: - - - - -
Round/Timestamp: _____	Observations: - - - - -
Round/Timestamp: _____	Observations: - - - - -
Total duration: ___ rounds ___ minutes	Additional comments:

E Student questionnaire

User test vragenlijst

Spel: Uncover/Block Dodger/Dragon's Dungeon

1a. Did you experience any technical issues?

☐ Yes

☐ No

1b. If yes, what technical issues did you experience?

_____

_____

_____

2a. Did you understand how the game works?

☐ Yes

☐ No

2b. If not, what aspect of the game was confusing?

_____

_____

_____

3a. Were there any game aspects you enjoyed in particular?

☐ Yes

☐ No

3b. If yes, please describe these game aspects.

_____

_____

_____

4a. Were there any game aspects you disliked in particular?

☐ Yes

☐ No

4b. If yes, please described these game aspects.

_____

_____

_____

F Roessingh informed consent form

Titel: RE-PLAY, begeleiden van activiteit bij kinderen

➔ Informatie voor ouders/verzorgers Enschede, 25 Februari 2019

Geachte heer/mevrouw,

Wij vragen u vriendelijk om mee te doen aan een (medisch) wetenschappelijk onderzoek in het Roessingh, getiteld: RE-PLAY, het begeleiden van activiteit bij kinderen. U beslist zelf of u wilt meedoen. Voordat u de beslissing neemt, is het belangrijk om meer te weten over het onderzoek. Lees deze informatiebrief rustig door en bespreek het met uw partner, vrienden of familie. Hebt u na het lezen van de informatie nog vragen? Dan kunt u terecht bij de onderzoekers, die onderaan deze brief vermeld zijn.

Dit vooronderzoek wordt uitgevoerd door Roessingh Research and Development (RRD) en Roessingh Centrum voor Revalidatie. Deelnemers aan dit onderzoek zijn kinderen (tussen de 6 en 16 jaar) die geselecteerd zijn om mee te doen aan het "Actief leven programma".

1. **Wat is het doel van het onderzoek?**

Kinderen bewegen steeds minder. Een gezond activiteitspatroon is echter heel belangrijk voor kinderen. Voor kinderen met een ontwikkelingsachterstand, bewegingsbeperkingen of andere fysieke of mentale uitdagingen heeft beweging een positieve invloed op het voorkomen van zowel fysieke (hart- en vaatziekten) als psychologische klachten (depressie en angst). Om kinderen te motiveren om meer te bewegen en daarnaast meer contact te laten hebben met leeftijdsgenoten binnen Roessingh Centrum voor Revalidatie, is het onderzoeksproject genaamd RE-PLAY gestart.

De fysiotherapeut maakt nu al vaak gebruik van activiteitensensoren en hartslagmeters om dagelijkse activiteit in de thuissituatie goed te meten als onderdeel van de therapie (Actief leven programma). Binnen het RE-PLAY project wordt een applicatie ontwikkeld waarin deze thuis-monitoring gekoppeld wordt aan een elektronische interactieve speelvloer in het Roessingh Centrum voor Revalidatie (zie afbeelding 1).

Het doel van dit vooronderzoek is om te onderzoeken wat u en uw kind van de app en van de speelvloer vindt, welke verbeterpunten er zijn, en of de app technisch goed werkt. Deze informatie zal bijdragen aan de verdere doorontwikkeling van een applicatie die kinderen motiveert en gemotiveerd houdt om meer te bewegen.

Afbeelding 1: Elektronische speelplaats

2. Hoe wordt het onderzoek uitgevoerd?

De huidige therapie (het actief leven programma) duurt ongeveer 10 tot 12 weken. Binnen deze periode maakt de fysiotherapeut gebruik van een activiteitenmeter, hartslagmeter, vragenlijst en een logboek om de activiteit te meten voor 1 week aan het begin, 1 week in het midden en de laatste week van de therapie. Verder zijn er binnen het traject verschillende groepstherapiesessies waarbij uw kind aanwezig is. Hierin wordt er met een groepje van ongeveer 5 kinderen gewerkt aan het herkennen en oplossen van belemmeringen in verschillende activiteiten.

Bij deelname aan het RE-PLAY project zal er tijdens de groepstherapiesessies ook gebruik gemaakt worden van de elektronische speelvloer bij het Roessingh Centrum voor Revalidatie (zie afbeelding 1). Tijdens het spelen is de fysiotherapeut aanwezig. Na de sessie zal in een kort interview gevraagd worden wat uw kind van de spellen vond.

Daarnaast worden voor het onderzoek gedurende 4 weken alle activiteiten van uw kind gemeten. Dit wordt gemeten in het aantal stappen en de intensiteit van de stappen met een activiteitenmeter genaamd de MOX (zie afbeelding 2) en wordt doorgestuurd naar de RE-PLAY app. In de RE-PLAY app kunt u zelf de activiteiten terugzien. Daarnaast is er in de app een scherm waarin de voortgang tot het dagelijkse stappendoel van alle kinderen in de therapiesessie van uw kind te zien is (zie afbeelding 3).

Afbeelding 2: MOX activiteitsensor

Afbeelding 3: RE-PLAY ranking

3. Wat wordt er van u verwacht?

Gedurende het behandeltraject vragen we uw zoon/dochter aanwezig te zijn bij de therapiesessies. Tijdens deze sessies worden naast de gebruikelijk therapie verschillende spellen op de speelvloer aangeboden. We vragen uw zoon/dochter tussendoor om de spellen te evalueren middels een korte vragenlijst met smileys. Na afloop van de sessie vragen we uw zoon/dochter middels een kort interview naar zijn/haar mening over de speelvloer.

Verder vragen we u gedurende 4 weken alle activiteiten van uw kind te meten met behulp van de MOX activiteitenmeter en een logboek/activiteitenvragenlijst in de RE-PLAY app bij te houden. De activiteitenmeter kan in de broekzak gedragen worden. Naast de activiteiten overdag zijn we ook geïnteresseerd in de slaapactiviteit. Daarom vragen we de MOX ook ’s nachts te dragen. Met de MOX mag uw kind niet zwemmen, douchen en dergelijke.

De MOX wordt, wanneer toestemming is gegeven, via Roessingh Centrum voor Revalidatie uitgeleend en kunnen direct na het project weer worden ingeleverd. U bent zelf niet aansprakelijk ben voor eventuele schade of verlies van sensoren. Maar we vragen u wel voorzichtig met de sensoren om te gaan.

4. Wat gebeurt er als u niet wenst deel te nemen aan dit onderzoek?

U beslist samen met u uw kind mee wilt laten doen aan het onderzoek, deelname is vrijwillig. Als u besluit niet mee te doen, hoeft u verder niets te doen. U hoeft niets te tekenen. Ook wanneer u nu toestemming geeft, kunt u te allen tijde zonder opgave van redenen deze weer intrekken. Uw besluit zal, wat het ook is, geen enkele consequenties hebben voor de behandeling van uw kind.

5. Wat gebeurt er met uw gegevens?

Voor dit onderzoek worden de persoonsgegevens van uw kind zoals naam, adres, geboortedatum en geslacht gebruikt en bewaard. Om de privacy van uw kind te beschermen krijgen deze persoonsgegevens een code. Alleen met de sleutel van de code zijn gegevens tot uw kind te herleiden. De sleutel van de code blijft veilig opgeborgen bij uw behandelaar in het Roessingh Centrum voor Revalidatie.

Naast uw persoonsgegevens worden tijdens het onderzoek verschillende meetgegevens (vragenlijsten, activiteitsmetingen, notities van korte interviews) en gezondheidsgegevens (diagnose, lichaamslengte, gewicht, eventuele conditietest uitslag) van uw kind verzameld. Het verzamelen, gebruiken en bewaren van uw gegevens is nodig om de vragen die in dit onderzoek worden gesteld te kunnen beantwoorden en de resultaten te kunnen publiceren. Wij vragen voor het gebruik van uw gegevens uw toestemming. Deze gegevens worden anoniem naar Roessingh Research and Development gestuurd en bevatten alleen de code, maar niet uw naam of andere gegevens waarmee u kunt worden geïdentificeerd. Ook in rapporten en publicaties over het onderzoek zijn de gegevens niet tot u te herleiden.

Bewaartermijn gegevens

Uw persoonsgegevens worden tot maximaal 3 maanden na afloop van het onderzoek bewaard bij de opdrachtgever: Roessingh Centrum voor Revalidatie. Hierna worden deze gegevens vernietigd. De anonieme meetgegevens blijven onbeperkt beschikbaar.

Intrekken toestemming

U kunt uw toestemming voor gebruik van uw persoonsgegevens altijd weer intrekken. De anonieme onderzoeksgegevens die zijn verzameld tot het moment dat u uw toestemming intrekt worden nog wel gebruikt in het onderzoek.

Meer informatie over uw rechten bij verwerking van gegevens

Voor algemene informatie over uw rechten bij verwerking van uw persoonsgegevens kunt u de website van de Autoriteit Persoonsgegevens raadplegen.

Bij vragen over de verwerking van uw persoonsgegevens kunt u contact opnemen met uw behandelaar. Voor dit onderzoek is dat:

Allard Dijkstra, fysiotherapeut Roessingh Centrum voor Revalidatie
Zie bijlage A voor contactgegevens

Bij vragen over uw rechten of klachten over de verwerking van uw persoonsgegevens kunt u contact opnemen met de Functionaris voor de Gegevensbescherming van de instelling:

Jos Spoelstra (Roessingh Research & Development)
Zie bijlage A voor contactgegevens

6. Zijn er extra kosten of krijgt u een vergoeding wanneer u besluit aan dit onderzoek mee te doen?

Er worden alleen de kosten voor de behandeling bij u of uw zorgverzekeraar in rekening gebracht. U maakt geen extra kosten voor het onderzoek. U krijgt geen vergoeding voor deelname aan het onderzoek.

7. Wilt u verder nog iets weten?

Mocht u na het lezen van deze brief nog nadere informatie willen ontvangen, of komen er voor of tijdens het onderzoek nog vragen bij u op, dan kunt u contact opnemen met de onderzoekers of de fysiotherapeut via onderstaande gegevens.

Ondertekenen toestemmingsverklaring

Als u besluit deel te nemen aan dit onderzoek, dan vragen wij u dit op de bijbehorende toestemmingsverklaring schriftelijk te bevestigen. Door uw schriftelijke toestemming geeft u aan dat u de informatie heeft begrepen en instemt met deelname aan dit vooronderzoek. Het handtekeningenblad wordt door de onderzoeker bewaard. U krijgt een kopie of een tweede exemplaar van deze toestemmingsverklaring. U blijft de vrijheid behouden om zonder opgave van redenen uw medewerking te stoppen. Is uw kind 12 jaar of ouder, dan vragen wij u ook om zijn/haar handtekening.

Vriendelijke groet,

Allard Dijkstra, fysiotherapeut Roessingh Centrum voor Revalidatie
A.Dijkstra2@Roessingh.nl / 053-4875304
Monique Tabak, senior onderzoeker Roessingh Research and Development
M.Tabak@rrd.nl / 088 087 5744
Mattienne van der Kamp, Junior onderzoeker Roessingh Research and Development
M.vanderkamp@rrd.nl / 088 087 5768

Bijlage A:

Contactgegevens voor Roessingh Centrum voor Revalidatie en Roessingh Research and Development

Betrokken zorgverlener: Allard Dijkstra, fysiotherapeut Roessingh Centrum voor Revalidatie
A.Dijkstra2@Roessingh.nl
053-4875304

Betrokken onderzoeker: Mattienne van der Kamp, MSc.
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Betrokken onderzoeker: Monique Tabak, PhD
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088 087 5744

Functionaris voor de Gegevensbescherming van de instelling:
Jos Spoelstra
j.spoelstra@rrd.nl
088 087 5757

Toestemmingsverklaring

Titel van het onderzoek: RE-PLAY vooronderzoek

Ik verklaar dat ik de patiënten informatiebrief heb ontvangen en gelezen en naar tevredenheid over het RE-PLAY project geïnformeerd ben. Ik heb voldoende tijd gehad om over mijn deelname na te denken en ben in de gelegenheid geweest om vragen te stellen. Deze vragen zijn naar tevredenheid beantwoord.

Deelname aan het onderzoek is vrijwillig en ik ben gedurende het gehele onderzoek in de mogelijkheid om op elk moment te stoppen, zonder opgaaf van reden.

Ik ben geïnformeerd over het feit dat ik zelf niet aansprakelijk ben voor eventuele schade of verlies van sensoren. Maar ik ben mezelf er van bewust dat de sensoren kostbaar zijn en ik zal er daarom ook voorzichtig mee omgaan.

Ik geef toestemming voor het gebruik van de data van mijn kind voor de doelen van RE-PLAY vooronderzoek. Ik ga ermee akkoord dat de volgende data verzameld wordt:

* Demografische gegevens, zoals diagnose, leeftijd, geslacht, lengte en gewicht.

* Activiteit en hartslagdata gemeten met de sensoren.

* Monitoringsgegevens uit de RE-PLAY app (logboek/vragenlijst).

* Vragenlijst/interview gegevens over de gebruikerservaring met de speelvloer/app.

Door dit formulier te tekenen geef ik toestemming voor deelname aan het RE-PLAY project.

Naam Deelnemer:	Plaats en datum:	Handtekening:
_____	_____	_____

Indien uw kind 12 jaar of ouder is:

Naam Kind:	Plaats en datum:	Handtekening:
_____	_____	_____

Naam onderzoeker:	Plaats en datum:	Handtekening:
_____	_____	_____

Verklaring behandelend therapeut:
Zowel schriftelijk als mondeling is de bovengenoemde deelnemer geïnformeerd ten aanzien van het onderzoek RE-PLAY. De deelnemer heeft toegestemd te willen participeren binnen dit onderzoek. De behandelend therapeut verklaart dat een vroegtijdige beëindiging van de deelname geen invloed heeft op de zorg die hem of haar toekomt.

Naam behandelend fysiotherapeut:	Plaats en datum:	Handtekening:
_____	_____	_____

Een kopie van het ondertekend toestemmingsformulier en de informatiebrief wordt meegegeven.

G Children questionnaire

User test vragenlijst

Spel: Uncover/Block Dodger/Drakenkelder

Therapie modus: Ja/Nee

					
Hoe leuk vond je het spel?	O	O	O	O	O
Hoe moeilijk was het spel?	O	O	O	O	O
Kon je het spel goed bijhouden?	O	O	O	O	O
Hoe actief was je tijdens het spel?	O	O	O	O	O
Zou je het spel vaker willen spelen?	O	O	O	O	O

Wat vond je het leukste deel van het spel?

_____

_____

Wat vond je het minst leuke deel van het spel?

_____

_____

Welk cijfer geef je het spel?

_____

Voor Drakenkelder:

Wat vind je ervan dat je stappenteller deel is van het spel?

_____

_____