# Keep Your Eyes on the Road, Kid!

Motivating Children with DCD to Ride a Bike in VR

*Graduation Report*




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# Abstract

Twinsense360 and Het Roessingh Research and Development have developed a project that aims to help children aged 6 - 12 with DCD (Developmental Coordination Disorder) learn how to perform an essential daily task, riding a bike from home to school. This will help them regain their confidence and independence. DCD is a chronic neurological disorder that impacts a child's ability to perform simple and complex motor tasks, like tying their shoes, writing, and riding a bike. The project is about a serious VR game, where the child sits on a real bike while cycling through a VR world. At the moment, the children are not motivated to play the game. This study investigates how to motivate the children to play the game more than once, so that it can be efficiently used as physical therapy.

Based on a literature review of current knowledge, a prototype of a new game level has been created. By performing an expert review with 5 experts, the study shows that by making the serious game attentive to the specific needs of the children regarding their disorder, and by making the game fun and implementing motivation methods, the children are motivated to play the game multiple times, increasing the capability of the physical therapy and helping them overcome their problem.

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# Introduction

Children with a disability or disorder often have very low self-confidence. This impacts their life greatly, making them less independent and able to live out their life to the fullest. Twinsense360 and het Roessingh Research and Development have developed a project that aims to help children with DCD (Developmental Coordination Disorder) learn how to perform an essential daily task, riding a bike from home to school. This will help them regain their confidence and independence. DCD is a chronic neurological disorder that impacts a child's ability to perform simple and complex motor tasks, like tying their shoes, writing, and riding a bike.

The project consists of a serious game in VR, where the player (child) can ride a real bike while wearing a VR headset. They bike through a VR world, which is made to mimic real life. Throughout the serious game, their ability to focus and ride the bike is tested in various degrees. A group of students from Saxion doing their Smart Solutions Semester (SSS) worked on this project, and they made the base mechanics and Unity project.

The aim of this graduation project is to make the game fun for the children to play. The children need to be motivated to want to play the game, because then they will play the game more often and thus, learn better. The target group is children aged 6 - 12 with DCD and ADHD (Attention Deficit Hyperactivity Disorder).

Firstly, the problem will be defined. From this, the main and sub questions can be created. With help from literature research, some of those questions can already be answered and a clearer view of the target group can be created. Multiple concepts will be made with knowledge gained from the research, from which a prototype will come forth. That product will then be tested. With the results from the testing, the main research question can be answered. After presenting the results, there will be a discussion, in which the results will be reflected upon and interpreted, followed by a conclusion. Lastly, recommendations about how to continue this project will be given.

# Practical Analysis

Currently, the game is not fun enough for the children. They have no desire to replay the game or to even finish it. To fix the problem, Het Roessingh research and Development wants a story to be added to the game. They had an idea that the child had to deliver a pizza to a Non-Playable Character (NPC) in the game. Whether this story is fun enough for the children has not been researched, but the real question is, is adding a story the solution to the problem?

This project started about 2 years ago. A group of students doing the Smart Solutions Semester (SSS) from Saxion worked on it. They created a Unity project where the player can bike along a realistic road where they'll encounter obstacles, like ducks crossing the road or oncoming traffic. A real bike was connected via an Arduino to the PC, and an HTC Vive was used as the VR headset.

During the testing phase of the SSS group, when any of the children tried out the VR game for the first few times, they loved it. They found it really cool how they were able to cycle on a real bicycle and ride through a VR world. However, after playing it more, the novelty of playing a game in VR wore off. They had seen it all and got bored while playing and didn't want to keep playing until the end goal. This is the main problem. The children are not motivated to play the game enough for it to help them.

So why are the children not motivated? There seem to be multiple causes. When the SSS group did their tests, they tested with healthy children aged 6 to 10. Some of the children had difficulty playing the game, and some of the children got nauseous while playing the game. Others found that the steering and peddling were too unrealistic. Only some of the children wanted to keep playing until the end of the game, and none of them wanted to play a second time.

The main problem is that the children are not motivated enough to play and finish the game more than once. Whether adding a story will solve the problem will have to be researched. The first and foremost focus should be on how to design a game that motivates the target group. The target group is children aged 6 to 12 with DCD and ADHD. Children who come to het Roessingh for treatment are of the same age range and have DCD. Since more than half of the children with DCD also have ADHD, it was decided to include ADHD for the target group, as it impacts a child's capability to be motivated.

## Scope

The game that has to be created has some limiting conditions. It needs to be suitable for children aged 6 to 12 who have an attention disorder and motor problems. This means, that if a narrative gets added to the game, it cannot be overly complicated or contain any mature elements, like depiction of illegal activities, violence, or adult content. Since the game design has to be created and implemented less than 6 months, only one level will be made. The first level of the game will be made, because it will be a nice introduction to the game, and the core mechanics can be focused on. A level in the game should take about 5 – 15 minutes according to Het Roessingh, so the level also cannot be too big.

The game also needs to be adjustable in real time. When a child is playing the game, a therapist will be present to monitor them. Het Roessingh requested that the therapist can add and remove things from the levels and pause or replay the game when they see fit. This way, the therapist can adjust the game for each child. So, some game elements will have to be editable.

## Context of Use

In a normal day scenario, the child will come in to start their therapy. The therapist will set up the game and help the child with putting on the VR headset. Then, the therapist will take place in front of the desktop pc. They can adjust, change, start/stop/pause, and replay the game, and they can see exactly what the child is doing in-game. Whether the parents will be present or not depends on the circumstances. They don't have to be present, but if the child is very young or the parents want to be there, then they can join and keep the child company.

# Main and Sub Questions

In this part, the main question and the sub questions will be formulated. The sub questions are the questions that need to be answered in order to answer the main question.

## Formulation of the Main Question

As mentioned in the previous part, the main problem is that the target group is not motivated enough to play the game.

So, the main question is

'How do you create a serious game that motivates children aged 6 – 12 with DCD and ADHD to play and finish the game more than once, so the game can be used as physical therapy?'

When this question is answered, the problem of Het Roessingh will be solved. They want a serious game that motivates the target group to play it however many times needed, so that the therapy is effective. In order to do that, the target group needs to be motivated throughout the game.

## Formulation of the Sub Questions

The sub questions that will help answer the main question are:

- What is DCD and ADHD, and what kind of therapy gets used to treat them?

By knowing the symptoms of DCD and ADHD, how it affects the children's life, and how they get treated for it, a clearer view of the target group can be created. Plus, the principles used in therapy might be able to be used in the end product.

- How do children aged 6 - 12 with DCD and ADHD differ from typically developing kids aged 6 - 12?

The differences between the target group and typically developing children need to be known, so that the end product can be adjusted based on that.

- What are the characteristics of a serious game, and how does it differentiate from a video game?

The game created for this project is different from a conventional video game. By answering this question, a clearer view of the end product will be created.

- What game design elements do children aged 6 - 12 find entertaining, and why?

If it is known what makes certain games attractive for children, then those elements could be incorporated into the end product.

- What is the best method to motivate children aged 6 - 12?

Once the best method to motivate the children has been researched, that method can be used in the game.

# Theory

This chapter provides an answer based on scientific literature to the sub-questions of this study. After each section, a conclusion will be given with a statement about how the findings will be used in the design process.

## DCD

### Symptoms DCD

DCD is a chronic neurodevelopmental disorder affecting 5-6% of children (Tabak, 2019). Because of the disorder, they are unable to perform daily tasks like getting dressed, handwriting, and doing PE in school. In order to get a diagnosis, the child's problems cannot stem from any known physical, neurological, or behavioural disorder (Missiuna, Rivard, & Pollock, 2011).

Children diagnosed with the disorder are not all the same, though. DCD only impacts the motor development, so other areas, like IQ and mental capabilities, can be high, low, or normal. More than half of the children with DCD also have ADHD (Watemberg, Waiserberg, Zuk, & Lerman-Sagie, 2007). Not only are motor exercises very hard to do for the children, learning them is even harder. It takes a lot of time and energy for them to learn tasks that are simple for people without DCD. Remembering how to do the tasks is also a challenge. One week they may be able to do something, but the next week they will have forgotten how. According to the therapists of Het Roessingh, the kids are also not able to transfer skills learned in one environment into another. For example, if they learn how to ride a bike in a controlled environment, like at a clinic, they won't be able to ride a bike somewhere else, like outside on the road. For a full list of the characteristics and problems of children with DCD, please check out appendix 1. Because of these problems, children with DCD often have a very low self-esteem. They see that people younger than them have no trouble performing tasks that they struggle with. This in turn creates social and anxiety problems. Children do not necessarily grow out of having DCD despite what some people are saying (Missiuna, Rivard, & Pollock, 2011). After lots of training and hard work, the children can learn the tasks they struggle with, but they will still have trouble with new age-appropriate tasks.

### Cause DCD

At the moment this research was done, the cause of DCD is not known (Debrabant, Van Waelvelde, & Vingerhoets, 2010). Because of the heterogeneity of the group and the high comorbidity, it is difficult to find which parts of the brain are influenced by DCD. According to Debrabant, Van Waelvelde & Vingerhoets, (2010) there are a few clues that point to the cerebellum, the parietal cortex, the corpus callosum, and the basal ganglia (see Figure 1).

Cerebellar disfunctions indicate deviant motor coordination. Children with DCD also often have trouble processing visual-spatial information, which is processed in the parietal cortex. Children with DCD also often have increased amounts of associated movements, which is related to disfunctions in the corpus callosum, and the basal ganglia oversee motor control and motor learning, both which are hard to do for people with DCD. However, according to the study previously mentioned, there is not enough evidence to be sure of any of the previous statements. More research will have to be done in order to find out what really causes DCD.

### Treatment for Children with DCD / Learning Motor Skills

There are multiple ways to treat the symptoms, but that does not mean that there is a cure for DCD. No amount of medication or treatment will stop a person from having DCD.

An interesting article from the Netherlands talks about a new method for children with DCD to practise their motor skills (Calame, de Kloet, & Smits-Engelsman, 2005). Calame et al (2005) talk about a new treatment method, called Cognitive Orientation to daily Occupational Performance (CO-OP). In short, with CO-OP, instead of the parents or the therapist choosing what motor problems the child will work on, the child can choose those themselves. Then by keeping the exercises very simple and making sure the child knows each step to take in order to complete the exercise, the child will learn how to solve their problem. CO-OP is also the method that Het Roessingh uses in their therapy. CO-OP has a few enabling principles that add to its success:

- Make it fun (Play games or use rhymes)
- Do one thing at a time (do one activity or strategy)
- Work towards independence (Therapist will help less and less)
- Guided discovery (Ask questions and don't tell the child what to do)

However, according to Calame et al (2005), CO-OP might not work for every child. More than half of the children with DCD have disorders like attention deficit hyperactivity disorder (ADHD) as well, and CO-OP might not be suitable for them. A more recent study (Dullaart & Rodermans, 2012) about CO-OP for DCD talks about the same problem. They only tested with 13 subjects, which is not enough to draw strong conclusions from. CO-OP needs more testing before it is sure that generally it works better than Neuromotor Task Training (NTT) for children with DCD.
The treatment method that is also used is Neuromotor Task Training (NTT). Just like CO-OP, NTT has 4 components (Dullaart & Rodermans, 2012):

- The motor control
- The Learning psychology or motor learning
- The competence, which includes the child's attribution style
- Pedagogical-didactic component

The aim is to make all those components be as coherent as possible during the treatment. During the treatment, daily tasks get practised, making sure the child gets the best instructions and feedback.

### Conclusion

With the findings from the previous chapters, certain characteristics of the target group come to light that should be considered when designing the serious game:

- Each child with DCD has a different skill level, so the game should have adjustable components that the therapist can change.
- The children need to practise their therapy a lot to learn the motor skills, so the game needs to be repeatable.
- The children have trouble transferring skills from one environment to the other, so the skills needed to play the game should be realistic.
- A child with DCD has low self-esteem. Only positive reinforcement works to help correct their mistake without causing the child more stress.

## ADHD

### Symptoms ADHD

ADHD is a developmental disorder, occurring in about 5% of the population (Polanczyk, De Lima, Horta, Biederman, & Rohde, 2007). There are nine inattentive and/or hyperactive/impulsive criteria that are used to diagnose ADHD. A patient should meet at least 6 of the 9 criteria (Voeller, 2004). ADHD symptoms include inattentiveness, distractibility, impulsivity, hyperactivity, low frustration tolerance, shifting activities frequently, difficulty organizing, and daydreaming (Wilens, Biederman, & Spencer, 2002). Not all people with ADHD exhibit all of those symptoms. There are three subtypes of ADHD: predominantly inattentive, predominantly hyperactive-impulsive, and a combined subtype. The combined subtype is the most common.

While ADHD usually gets diagnosed in childhood, the symptoms persist into adulthood, causing an increased risk of substance abuse, obesity, and mental health issues.

## Cause ADHD

Just like with DCD, the cause of ADHD is at the time of this research not known. It is a hereditary disorder, meaning that if the parents have ADHD, their child(ren) have a chance of 50% or higher to also have ADHD (Farone & Doyle, 2001). Which gene or genes are responsible for ADHD is also not known during the time of this study. A few studies searched for different causes of ADHD. Castellanos et al (2002) looked at the brain volume of 152 children and adolescents and found that they have reduced brain volume, while another study (Langley, Rice, Van Den Bree, & Thapar, 2005) saw a correlation between ADHD and pre-natal smoking. A study from 1995 looked at the diet from 53 boys with ADHD and saw that they had some nutritional deficiencies (Stevens, et al., 1995). Lastly, Johnson et al (2010) found an 11.5% increase in ADHD in 219 children with premature birth and low birth weight. However, all of those studies admit that there is not enough hard evidence to back those claims up. More research needs to be done in order to find the true cause of ADHD.

## Treatment ADHD

At the time this study was done, there was no cure for ADHD, but medication and non-medical treatment options, are available. Since only non-medical options are relevant to this study, medical options will not be discussed.

There are numerous non-pharmaceutical therapeutic options that can help with ADHD. According to the medical website Healthline (2017), psychotherapy can help someone change their behaviour and help overcome problems, by having the patient open up about their feelings and explore behaviour patterns. Behaviour therapy can teach someone how to develop strategies for how to behave in certain situations. Then there's training, like special skills training, training the parents on how to cope with their child who has ADHD, and support groups to help share experiences (Healthline Editorial Team, 2017).

Tips that parents get who have a child with ADHD are most useful for this research, since those can be integrated into the game design. The tips help with the child's behaviour. Some of those tips are (CDC. Centers for Disease Control and Prevention, 2019):

- Managing distractions
- Limiting choices, so that the child does not become overwhelmed
- Being clear and specific
- Using positive reinforcement like praise and rewards
- Setting up clear goals
- Disciplining effectively

These tips can be integrated into daily life, making it easier for both child and parents to cope.

## Conclusion

The tips from the previous chapter can be used to help make the game design. Below is a list of the tips and how they can be used:

- Children with ADHD get distracted easily, so there should be no unnecessary distractions in the game.
- Children with ADHD can get overwhelmed by too many choices, so limit the amount of possible choices.
- Just like with DCD, the children profit best from positive reinforcement.
- The kids need clear goals to be able to focus better, and instruction should be clear and specific.

## Serious Games

Serious games have an educational purpose and are not intended to be primarily played for entertainment (Abt, 1970). This is unlike non-commercial video games, which main purpose is to entertain. It wants to provide amusement and enjoyment to the player (Lexico, 2020).

There are no set characteristics a serious game should have. Some people say that the games should have entertainment and practical elements combined (Alvarez & Michaud, 2008), while other say that all games that contain a serious purpose (gambling, fortune telling, etc) should be called serious games (Sawyer & Rejeski, 2002). A study (Laamarti, Eid, & El Saddik, 2014) done in 2014 reviewed multiple papers about serious games, and they came to the conclusion, that to best define a serious game, it needs to have 3 components; experience, entertainment, and multimedia. See figure 2 for the differences between serious games and a few terminologies.

Below are a few examples of serious games. These have either had great success or are being used in therapy at the time of this study. The three main components from figure 2 (multimedia, experience, entertainment) will be used to help see how the examples are considered serious games.

- IBM CityOne

CityOne is a serious game developed by IBM, a US computer hardware company. Since it's a game, it adheres to the multimedia and entertainment component. It is designed to teach people about smart city design (experience component), and the impact that industry solutions can deliver to complex problems (CityOne (2010), n.d.).

- Gryphon Rider

Gryphon Rider, a serious game made by Grendel Games in collaboration with Het Roessingh Research and Development, is a game (multimedia component) where the player has to control the flying gryphon by balancing (Grendel Games, n.d.). The game focuses on the story and the entertaining aspects of the game instead of on the learning aspects (entertainment component). But its main purpose is still to help the player learn a skill, it just does with more stealthily. It is used to rehabilitate young clients after Acquired Brain Injury (ABI) (experience component).

- Airplay

Airplay is designed to help children with asthma to help with physical exercise (experience component). It teaches them how to self-manage and control their asthma (Airplay, n.d.). Through an interactive playground (entertainment component), the kids can play games (multimedia component) and get rewarded. It is developed by a collaboration of UT Twente, Het Roessingh Research and Development, Medische Spectrum Twente, and Ziekenhuisgroup twente.

## Games for Children 6 – 12

By looking at games that have been made for children aged 6-12, and by looking which one of those sold the most and have the highest ratings, the type of games the target group likes. Only games that have been made for the last 10 years have been reviewed, except for franchises. If a franchise was very popular in the last 10 years (like Mario), then it is also included, even if the first game of the franchise was made longer than 10 years ago. Also, only games that are marketed towards our target group have been included. For example, Fortnite (Epic Games, 2017) is a very popular games among many children, but it is actually only for children above 13 years old. The sources show most popular/best-selling games. The games made for children aged 6-12 in the last 10 years have been extracted and put into a list. See figure 3 for the list with the most popular games (in alphabetical order).

When looking at the genre of the games, they might seem very different from each other. But when looking at all the characteristics from each game, quite a few have a lot of similarities. Almost all of them have bright colours, with cutesy, non-realistic characters. The games themselves are also not realistic and have a strong core in fantasy. Most of these games aren't super competitive, but that doesn't mean that they are single-player games or never have players play against each other. Some are multiplayer games that rely on teamwork. A story, if there is one, consists of a simple task, like

"Save the princess from the bad guy" or "Save the world". Some games consist of small, simple challenges that require problem solving skills to complete, while others are all about sport-type playing, or caretaking of a digital pet. Most games can be completed quite easily (Going from point A to B) but contain more challenges if the player wants them (Going from A to B within a certain time while collecting all the items).

This supports research done on how to design video games for children. Game designers often categorize their audience into a few different age groups (Extra Credit, 2014). Ages 4 – 6, 7 – 9, 10 – 11, 12 – 14, 14+. Each age is very different, and a difference of 1 year is already big. This is why games that have multiple ways of being played (simple, or more difficult), do better in general. A game studio that makes games for children wrote a paper about how to design games for kids. For primary schoolers (age 6 – 8), teamwork, learning new skills, and being in control is important (Funday Factory). For tweens (age 8 – 10), time investment and expertise are important. Since the target group for this research includes both those groups, it seems that the list made, and the research done by Funday Factory both support each other.

### Conclusion

Each child likes something different. Some will gravitate towards action adventure games, while others will like casual games much more. But, from the list, it seems that generally, kids like:

- Bold, bright colours
- Cute characters
- Fantasy elements
- Adventure elements
- Teamwork
- Simple story
- Special main character
- Levels that can be completed simply or more challenging

Those aspects will be used to help create the game design.

## Motivation

Motivation is "the reason or reasons one has for acting or behaving in a particular way" and "The general desire or willingness of someone to do something." (Lexico, 2020). People are often looking for ways to motivate themselves or others. In this part, different methods of motivating will be looked at.

### Maslow

Maslow's Hierarchy of Needs is a very commonly used theory. It is a motivational theory that is often depicted as 5 hierarchical levels within a pyramid (McLeod, 2018), as seen in figure 4. The lowest level needs to be achieved before the other levels can be satisfied. By making sure each level is satisfied, the person will be happy and more motivated.

### SDT

A motivation theory that has been proven to work is the Self-Determination Theory (SDT). SDT focuses on motivating through intrinsic goals and motivation, instead of extrinsic (Deci & Ryan, 2012). For example, doing a task because you yourself want to do it, maybe because you'd like to get better at doing that task, means you have an intrinsic goal that is motivated by intrinsic motivation. If you did the task because someone else wanted or needed you to do it, you would have been motivated by extrinsic motivation. SDT has five minitheories, see figure 5.

SDT also focuses on meeting 3 psychological basic needs: autonomy, competence, and relatedness. Autonomy concerns wanting to do a task. When an activity is done for interest or personal value, autonomy is high. Providing choice and non-controlling instructions enhance autonomy. Competence

is a need for challenge. Enhancing competence involves providing opportunities to enhance skills and receiving positive feedback. Relatedness refers to someone feeling like they belong. A way to enhance it is making the person feel connected to others by having them be involved with teamwork related tasks (Ryan, Rigby, & Przybylski, 2006).

This theory has been applied to an educational setting (Reeve, 2012), a work environment (Gagné & Deci, 2005), and a video game environment (Ryan, Rigby, & Przybylski, 2006). In all three of the scenarios, the SDT improved motivation by fulfilling the person's needs for autonomy, competence, and relatedness. The previous studies have been performed on (young) adults, but there are also studies who tried the SDT with children. By having Physical Education (PE) teachers support students' autonomy (minimizing pressure in class, encouraging the students' voice and choice, using non-controlling language), competence (providing the tools required for success, giving feedback, introducing challenging tasks), and relatedness (making the students feel that teachers genuinely like them, respect them, and value them, when they feel accepted by their peers, when they experience a sense of belonging in their peer group), it has worked with motivating children with DCD to do school PE (Katartzi & Vlachopoulos, 2011), as well as motivating healthy children to do PE (Chatzisarantis, Biddle, & Meek, 1997).

### Gamification

A well-known motivation method is one that is already being used for this project. It's gamification. Gamification is the use of game mechanics and experience design to digitally engage and motivate people to achieve their goals (Burke, 2014). Gamification has been proven to work, though the full effect depends on the context (Hamari, Koivisto, & Sarsa, 2014). Serious games are often the result of applied gamification, but not all gamified applications are serious games. An example of an app with gamification is Duolingo (Huynh, Zuo, & Lida, 2016). Duolingo is a language learning platform. A user can earn points by following lessons. The more lessons they do, the more points they earn. With those points, they can buy items from the Duolingo shop that helps them with their lessons. They can also earn achievements, which will display on their profile.

### Player Motivation Models

Gamification is used by applying game design techniques. Those techniques make the game fun by applying goals, rules, challenges, interaction, immersion, and more. Game design is a broad and complex subject. For this project, only player motivation models will be looked, since the goal is to motivate the target group (players) to play the game.

### SDT-based player motivation model

The SDT is actually a player motivation model as well. By having a healthy balance of intrinsic and extrinsic motivation, a game can motivate players (Neves, 2018).

### PENS

The Player Experience of Need Satisfaction (PENS) model, is a model created with SDT at its foundation (Rigby & Ryan, 2007). Rigby and Ryan, the creators of PENS, found that PENS "is a more detailed and precise model of "fun" and player satisfaction that provides both heuristic value to developers as they seek to design games to achieve specific goals, as well as analytic value in evaluating games both within and across genres". The PENS model uses the basic needs as described by SDT, and translates them into gaming:

Competence: Easy to learn, difficult to master.

Autonomy: Giving players choices, agency, and customization.

Relatedness: Feedback and social systems.

Once a game satisfies the basic psychological needs, it is long lasting for players. (Neves, 2018).

## The PNRC System

Another way to motivate players is to give them rewards. But what reward is appropriate to give for which challenge? The PNRC system, or motivation loop, as shown in figure 6, handles this.

PNRC stands for Player State, Needs, Reward, Challenge. The player's motivation can be based on those functions (Ghozland, 2007). If the player state is low (weak armour, no items, low health, etc), then the player's needs are high, which means the reward and thus challenge should be high as well. But not too high, because the player might not be able to overcome that challenge. Once the player gets a reward, then the player's state goes up, and so forth.

## Conclusion

A lot can be concluded from this chapter. There are many ways to motivate people, but it all boils down to satisfying someone's psychological needs. Maslow's theory focuses on the most basic needs and which ones need to be fulfilled in which order, but Maslow is a bit too broad to be fully integrated into the game design process for this study. This is where the SDT comes in. It is more finetuned and can more easily be used in game design, as proven by the PENS theory. With the help from those theories, gamification, and PNRC, a list with motivational tips is created to help the game design.

- The SDT shows that intrinsic motivation is just as important as extrinsic motivation, so a combo of intrinsic + extrinsic motivation has to be used.
- The PENS theory shows that when applying STD to a game environment to help fulfil the 3 psychological basic needs (autonomy, competence, and relatedness), the player becomes more motivated. So, the game design has to keep these 2 needs in mind, making sure they are being fulfilled.
- Rewarding a player is another way of motivating. Using the PNRC system, the right reward for the right challenge can be given.

# Research

This chapter will go in-depth about the design process and the testing done.

## Design model

The chosen design model for this project is design thinking. Design thinking is a design model that focusses first and foremost on the user. It seeks to understands a person's needs and comes up with a solution to meet those needs. This is called a solution-based approach to problem-solving (Stevens E. , 2019). The method consists of 5 phases, as shown in figure 7.

Phase 1: Empathise

To empathise is to understand and share the feelings of another (Lexico, 2020). In this phase, the users' needs are researched. It allows the researcher to gain an empathetic understanding of the problem (Interaction Design Foundation, 2020).

Phase 2: Define

During this stage, the researcher collects the information gathered from the previous stage and starts analysing it to define the core problem(s) (Interaction Design Foundation, 2020).

Phase 3: Ideate

This phase is about creating ideas to solve the problem. This can be done through techniques like brainstorming, storyboarding, mindmapping, or any other ideation methods. It is best to generate as many ideas as possible.

Phase 4: Prototype

This step is about taking the some of the best ideas from the previous phase and creating a prototype/prototypes from them.

Phase 5: Test

The testing phase is about testing the prototype(s) from the prototype phase. During the testing phase feedback will be gathered.

Design thinking is not a linear progress. Often, feedback that's gathered during the test phase gets used to create new prototypes (Prototype phase) or new ideas (Ideate phase). Figure 8 shows how this works.

This design model was chosen because it focusses on the users' needs, and the most important part of this project is meeting the needs of the children with DCD and ADHD. Plus, design thinking allows for a creative and non-linear approach, which is the approach often preferred for game design.

## Empathise and Define Phase

The theory chapter and the practical analysis chapter in this document include phase 1 and 2 of design thinking. By researching the target group and gathering all possible information, the main problem was defined, and a clearer picture of the target group and their needs was created.

To add to the empathise phase, two personas were created. These personas will also be of help during the ideate phase. Better concepts can be created by theorising whether the personas will like them or not. 2 personas have already been created by the previous group who worked on this project. See figure 9 and 10.

Most of the data seems to correspond with the found research. Their frustrations and goals are similar to those of a lot of children with DCD (Simple actions are difficult, clumsy, feeling different, wanting a higher self-esteem) and ADHD (Forgetting a lot of things, not feeling understood, impatient). However, their personality type, technology skills, and brand preferences do not have a lot to do with

their condition, so they are not relevant. It is also not clear what they mean with the “motivations”. If Julia’s social motivation is low, then why is one of her goals to make new friends?

Because of these reasons, instead of creating a brief image overview of a persona with a few characteristics, a narrative format was created. This helps the researchers to empathise better with the personas, as it portrays them as more human.

A regular day for Julia and Pim has been described.

Julia gets woken up early in the morning by her mother. She needs to get ready for school. Her mum has prepared breakfast for her and she quickly eats it. After breakfast, she goes to brush her teeth. She hates brushing her teeth, as it requires a lot of concentration for her to do it. When it’s time to put on her clothes, her mother has to help her. Julia wishes she could do it herself but doing stuff like buttoning up a shirt or tying shoelaces is too difficult for her. Her hands just don’t seem to listen to the instructions her brain gives them. Her mum brings her to school with the car. At school, Julia doesn’t have a lot of friends. She feels like she is too different from other people. She’s too shy to approach anyone to try and make friends. She’s afraid they won’t understand her and think she’s weird. At school, she has no trouble understanding the subjects that are being taught to her, but she has trouble with writing. Her handwriting is very messy, and the teacher often reprimands her for it. After school, her mum picks her up and brings her home. She spends the rest of the day playing with her My Little Pony’s. In the future, she hopes that she will have more friends, and that she will become less clumsy.

Pim wakes up on his own, usually a bit later than intended. He prepares his own breakfast and puts on his own clothes. This takes him longer than the average child. He often gets distracted by other things. He usually walks to school. This also takes quite some time. His parents used to bring him to school, but he doesn’t want that anymore. Riding a bike would be quicker, but that is something he still hasn’t mastered yet, even though other boys his age have less trouble with it. At school, he finds it difficult to sit still and pay attention. He would rather run around outside or play with his friends. He also has trouble controlling the volume of his voice. This can make him a distraction for other kids in the class, which in turn means the teacher is often angry at Pim. Pim wants to explain to the teacher that it’s not his fault, but he stumbles over his words, causing him to be afraid to speak up. After school, he usually meets up with friends. They either watch some tv or play games. He’d rather watch tv, for he often loses when playing video games. His life-long dream is to become a professional soccer player and learn how to ride a bike better, so that he becomes more independent.

## Ideate phase

With the target audience and the problem defined, it is now time for the ideate phase. A list of requirements has been made with data from the conclusion sections from the theory chapter. See figure 11 for the list.

Ideally, a level of the game should meet all of these requirements. However, that is not possible. Some of these requirements contradict each other. A level cannot be realistic while also containing fantasy elements with bold bright colours.

After creating this list, it was reviewed by therapists from Het Roessingh. Overall, they agreed with the list and liked it, but they had some comments. The visuals of the levels do not have to be realistic, so having bold bright colours is not a problem. Only the actions in the game, like having to ride a bike on the correct side of the road, stopping before a red traffic light, etc, have to be realistic. They did want the story to be somewhat realistic, so nothing too fantasy like, like dragons or magic can be in the game. They also had the requirement of having one level take 5 to 15 minutes to complete.

Brainstorming was the main technique used to create plot and game mechanic concepts. As many possible ideas were put down paper by the researcher. Inspiration was drawn from looking at current games for children, by looking at the requirements and coming up with ideas that cover the requirements, and by theorising what the personas would enjoy playing.

Two types of ideas were created, plots and elements. A plot is the main narrative design for one level. Elements are mechanics that are not tied to any plot, and thus can be added or removed to any plot/level, making the level adjustable. The concepts were written down using one or two sentences, to put the main idea down. Then, the best ideas were picked, based on which appealed the most and seemed to not be too difficult for the children to play.

Every chosen plot and element got a list with which requirement they adhered to. Then, the concepts were presented to colleagues of Twinsense360. They provided constructive feedback. They liked all of the ideas, but the 'Lost Animal' concept they liked the most, since they personally thought it was what the children would like best and seemed most feasible to implement within the current timeframe.

See figure 12 and 13 for the chosen ideas. See appendix 2 for all of the concepts.

Two days after collecting the feedback from Twinsense360, an appointment with Lieke Acherman and Hielke Penterman, two therapists from Het Roessingh, was scheduled. We met in the Usability Lab at Roessingh Research and Development. The VR game had been set up in the lab, so that the therapists could see the new setup of the bike and how easy it was to connect it to the PC. A PowerPoint presentation had been prepared to help explain how the ideas formed and which ones were created. During the presentation, the two therapists gave their feedback on each concept, while also coming up with a few smaller ones themselves. To see the full notes from the meeting, see appendix 3.

The therapists were a lot more focussed on the therapy aspect of the project, which contrasts with Twinsense360's feedback, who were focussing more on the game aspect. The therapists want the end product to still be therapy, and not just a game. They approved of the list with requirements that was made and agreed with them.

The overall feedback was positive. They liked the Lost Animal plot and Friend plot the most, because most children like helping, and getting to help an animal or a friend will make them feel good. Since the Lost Animal plot is easier for beginners, they wanted to have that one implemented first. Their general opinion about the concepts is that they have to be realistic, not too distracting, and make the children feel good about themselves. One very important thing the game also needs is good wayfinders. The therapists weren't sure what the best wayfinder would be, since children as young as 6 need to understand them. They came up with a few possible ideas, and in the end decided that different wayfinders would need to be tested, but for now, adding simple signs like posters might work. The therapists had two more main points if feedback: The SSS group had implemented smileys in the game. They would appear when the children were looking at certain things. Both the therapists and children liked them a lot, and the therapists requested that the smileys stay in the game. They also want to give appropriate feedback to the children while they are in therapy. This means adding a microphone option in the game for verbal feedback, as well as a way to review the child's actions, like recording the child's in-game actions.

In the end, the therapist wanted to at least see the Lost Animal plot with the smiley element, a microphone and webcam, adjustable game objects, posters as wayfinders, and duck obstacles in the game.

## Implementation

A list of all possible game mechanics and design elements was created. From that list. a MoSCoW (Must have Should have Could have Won't have) was created to divide up the multiple mechanics and tasks (See Figure 14).

In the 'must have' section are the most important and necessary mechanics, like the ones the therapists requested. Without those, there would be no product. The 'should have' section contains mechanics that should be implemented if time allows it but are not as important as the must have mechanics.

Most of the mechanics in that list are extensions from the must have mechanics, like adding more obstacles, wayfinders, and adjustable game objects (called adjustables). Checkpoints and a timer were added to that list because they would add replay ability and another feedback option to the game, which is what the therapists wanted.

The ‘could have’ section is for the mechanics that would be nice to have in the product, but only if there’s extra time left. The therapists briefly mentioned it would be nice to have a fake scoreboard where the player would always end up on top, to boost the player’s morale, and they mentioned that adding a profile of how the player did with a replay of their actions so that they can give better feedback would be helpful. An example video of how to exactly play the game was also requested. All these functions would take a lot of time to implement, which is why they’re in the could have section.

Lastly, the ‘won’t have’ section is for mechanics that definitely will not be implemented, because there is not enough time or budget. To make the biking feel more realistic, the therapists wanted the child to be able to balance on the bike, as you do in real life. Currently, that’s not possible. Since the bike is stationary and it gets placed between two holders, there is no possibility to add balance. A new device for the bike would have to be purchased, which is not within the current budget. Same with the statistics page. It is a more detailed version of the player profile, but there is not enough to time to implement it, unfortunately.

### Project Set Up

The previous group made the full project in the Unity Game Engine. Every asset and needed scripts were in there. However, there was a problem with the project. It was very unorganised and cluttered. There was no folder structure. Half of the assets were never even used in the project. There were too many un-used objects in the scene, causing the fps to become much too low. Because of this, it was decided that a new Unity project will be made. A project with the correct folder and scene structure.

A newer version of Unity was chosen to create the new project in, version 2019.3.5f1. It has improved features, like new terrain tools, new programmer tools, profiling improvements, and general bug fixes.

All the assets needed to implement the must have mechanics were exported from the old project and imported into the new project, and as version control software, Unity Collab was chosen.

Figure 15 shows a screenshot of the old Unity project, both the start screen and the game view.

### Prototype Phase

Firstly, the level design was created. The idea was to recreate an existing road and route from Enschede, to make it as realistic as possible. Google Maps was used to browse through Enschede and look for an appropriate road. Unfortunately, all the existing roads were much too complicated. So, it was decided to create a new road from scratch, one that would be easy to follow for the children and would fit the plot.

The level starts with a simple, straight, one-way road, with ducks crossing the road. After the first obstacle, the first turn to the left and right get introduced. After the turns, an intersection appears. The players have to stop in front of the traffic lights and cross the intersection. A t-section follows. They will have to turn right, follow the road, and make a left turn. They’ll encounter a roundabout. Using the roundabout, they’ll have to turn left. Lastly, they need to follow the road, which turns from a clear asphalt road into a sand road, until they arrive upon their destination, the owner of the lost animal.

The posters are placed where the player has to make a choice of where they need to go, and the obstacles are placed evenly across the map.

Figure 16 shows a table with all the different iterations the game went through. After each iteration, the game was tested in both VR and non-VR, and any small bugs were fixed for the current iteration, while bigger bugs were moved on to the next one. All the new models and UI were supplied by the design intern from Twinsense360.

Right after implementing VR in the first iteration, a big error was found. Normally, the player can choose to use VR or not in the main menu. Depending on what the player chose, the game would automatically start VR or not. This was broken. It would either not start VR at all, or it would not switch back to non-VR. The project settings which take care of this were the same as the ones in the project from the SSS group, and it worked in their project. That meant that upgrading to the newer Unity version was the problem. Since downgrading was not an option, a different solution was used. At first it was tried to use a VR plug-in, called VRTK, that switched between the two different modes, but that one broke more stuff than it fixed them. In the end, it was discovered that the current VR plug-in (SteamVR) needed a manual update. This fixed the bug.

After implementing the therapist UI, a bug was found when it was being used in VR. The VR headset also has a camera and microphone, and the game would automatically enable those two devices. The therapist will use a webcam to communicate via the player, so the camera and microphone from the webcam should be enabled, not the ones from the VR headset. To fix this, a dropdown menu for both the camera and microphone were created. This way, the therapist can manually choose which devices they want to use.

The UI in the game changed a lot. The first UI was the standard UI from Unity. This was used because the functionality can easily be tested. Once the functionality was working, the UI went a few big changes. The first change was getting custom made buttons and a nice layout for the therapist UI. The last change was changing the buttons to fit the stylesheet made by het Roessingh. See figure 17 for the changes the therapist UI went through and see figure 18 for the changes the main menu went through.

Figure 19 shows the final look of the game.

In the end, all the ‘must have’ mechanics were implemented, as well as the obstacles from the ‘should have’ list. There was not enough time left to implement more mechanics.

The final product was now finished and ready to be tested. To see the final product, please refer to appendix 9.

### Test Phase

From early on, het Roessingh indicated that no tests could be done with the target group, children aged 6 – 12 with DCD and ADHD. The reason for this is, that the testing would count as therapy, which would mean the product and test procedure would need to be medically and ethically approved. This would add 2 to 3 weeks extra time to the testing phase, which unfortunately was not available. For this reason, the choice was made to test with “healthy” children (children with no diagnosed illness or disorder) instead.

When it was time to start the test phase, Roessingh unfortunately did not want to test with the children in VR. They were too afraid that a child would get sick or would fall off the bike, and they did not want to be responsible for if that happened. They proposed to let the children test the game with mouse and keyboard. While that was not ideal, it was still better than no testing, so it was agreed upon to have the kids test the game without VR.

For the tests, an information letter, permission form, and protocol were needed. The information letter is to inform the parents about the test, and the form is for them to sign an agreement that they allow their child(ren) to participate in the test. The protocol describes the whole test set up. To read the information letter and permission form (in Dutch), please see appendix 4. They were made with help from and approved by Het Roessingh.

While het Roessingh did not want to test in VR, they did mention that tests in VR could be done, but only if het Roessingh wasn’t involved. The plan was to contact Saxion and ask if the tests could be done in the XR-lab. Unfortunately, before anything could be decided upon, the Coronavirus disease (COVID-19) was declared as a pandemic by the World Health Organization (Ghebreyesus, 2020). This meant all gatherings had to be cancelled, including this study’s tests.

There was not much that could be done about the situation. It was decided to do an expert review instead. An expert review is when an expert regarding the target group reviews the product and provides their opinion on what the target group would think of it.

Even though there will be no actual tests with the target group done, a protocol for the perfect test setup (testing in VR with children aged 6-12 with DCD and ADHD) has been made. Hopefully, it will be used in the future.

One of the most important things about the protocol was that it has to be suitable for young children. They have to feel comfortable and confident while they're being tested. To make sure the testing environment was friendly, some guidelines from a journal article about which guidelines to use for usability testing with young children was used (Hannah, Risden, & Alexander, 1997). See the list below for the guidelines used.

- **Use a friendly test environment.**
  By using the usability lab at Het Roessingh, which is decorated to resemble a living room, the testing environment is friendly and comfortable
- **Use a script for introducing children to the testing scenario.**
  A script was written. This way, the tester can be sure they mention everything they need to mention and won't forget important information.
- **Tester has to be in the same room as the kids.**
  This way, the tester can offer immediate help and feedback, if needed.
- **Positive reinforcement.**
  Like mentioned in the Theory chapter, positive reinforcement is the best way to keep the children feeling encouraged.
- **Observe their behaviour.**
  A child might not recall all of their emotions from when they were testing the game. By observing them, a more accurate respond to the game can be measured. There is an observation section in the protocol, where the tester can check the child's emotions.
- **After testing, give the child a thank-you gift.**
  This is a nice way to show your gratitude towards the child.

The questions for the children also have to be child friendly. For that, the journal article "Designing and testing questionnaires" was used. Just like the previous article, it mentions guidelines that help with creating the questions. Below are the guidelines used for creating the interview questions in the protocol (Bell, 2007).

- Keep the questions short and straightforward.
- Avoid suggestively phrased or worded questions that might play to the child's desire to please.
- Use scales with verbal labels, like smileys.
- Don't offer the 'don't know' or 'no opinion' answer
- Don't ask too many questions.

To see the protocol, please refer to appendix 5.

The experts for the expert review are two therapists from het Roessingh, Hielke Penterman and Lieke Acherman, and researchers/people heavily involved in this project, including Roos Bulthuis, a researcher, Ina Flierman, the coordinator, and Monique Tabak, the project lead and researcher. A paediatrician from het Roessingh had also been asked to participate, but unfortunately, he fell ill and couldn't do the expert review.

A playable version without VR of the game had been sent to the experts, as well as an instructions document and the questions that needed to be answered. See appendix 6 and 7 for those documents (in Dutch). Some of the questions are not relevant to this study, since they have nothing to do with the target group (for example, "How easy was it to use the therapist UI?)". Those questions still needed to be answered to get an overall review of the game, but for the results of this study, those questions will

be ignored. Sadly, the experts could not be interviewed via a voice call, since all of them have busy schedules and couldn’t say when they would exactly have the time to do the review.

For some of the experts, a few problems arose. They tried to run the game on their work laptops, which were too old to run the demo. Those experts had to review the game via a video instead of playing it for themselves.

A Skype interview was scheduled to discuss the project, including the demo of the game and the expert review questions, but not all of the experts had played the game yet or answered the questions, so the discussion was skipped.

# Results

5 people managed to complete the expert review. Unfortunately, only one of the therapists participated. The other therapist did not fill in the questionnaire, due to unknown reasons. For the full answers to each question, check out appendix 8. As mentioned in the previous chapter, some questions have been ignored. Only the questions relating directly to the research problem will be discussed. For the charts of the results, please see figures 20 – 24.

*Question 1: What is your first impression of the game?*

All the first impressions of the game were positive. The respondents really liked the environment and the details, like the flower and different houses.

*Question 2: How educative is the level?*

3 out of 5 respondents found the level educative. Their reasoning was that the level was realistic and a good starting point to learn how to ride a bike.

*Question 3: Is this level suitable as level 1?*

2 people found the level as suitable as level 1, because the environment was calm. Once again, the two people who answered neutral did so because they are not therapists, and thus didn't want to fully answer the question. The person who answered 'unsuitable' did so because they thought that the level maybe contained too many obstacles.

*Question 4: How realistic are the traffic situations in the game?*

4 out of 5 people found the game realistic. The only one who answered neutral did not give reasoning. The others found the traffic lights realistic.

*Question 5: How likely is it that this game will be used to treat the target group?*

2 out of 5 people answered with 'Likely'. One of them was the therapist, but they gave no reasoning why they answered that. The other person who answered 'Likely' gave as reasoning that this game in VR can really contribute as a bridge between practical lessons done inside and biking lessons done in the real outside world. The respondents who answered with 'neutral' did so because while they believe it has potential, some parts still need to be improved, like nausea and the control of the bike.

Below are the most important questions the therapist answered about what the target group would think of the game.

*How fun will the target group find the game?*
Fun.

*How do you think the target audience will react to the game?*
Interested.

*Is it clear which way the children have to bike?*
Clear.

*Do you think the children will find this level difficult or easy?*
Easy.

*How motivated would the children be to play the game multiple times?*
Motivated.

See figure 25 and 26 for all of the questions answered by the therapist regarding the target group.

# Discussion

## Interpretations

The data suggests that the demo will motivate the children once they get to play it. People's first impression when they play the game is positive, and most find it educative and suitable as the first level of the game. The actions in the game, like the traffic, are realistic, and with a few more improvements, the game will most likely be used as physical therapy. According to an expert, the target group will have a positive reaction to the game. They will find it fun, easy to play and follow, and will be interested and motivated to play it more than once.

The results of the expert review support the findings of the literature research. Looking back at the list of requirements that was made (figure 11), the current game adheres to most of the requirements, and according to the experts, the target group will be motivated by the game, which was the goal of this study. The experts mentioned that with some improvements, the children will be motivated even more. Those improvements include checkpoints, a better link between smileys and the player score, nausea reduction, and better control of the bike. The first two mechanics were features that were supposed to be implemented but had to be dropped because of the time limit. Checkpoints make the game repeatable, and a clearer link between the rewarding system works as positive reinforcement, both which are on the list of requirements. This means that if there had been enough time to implement all the mechanics, the game would have been more motivating, supporting the research done before even more.

The suggested game improvements of no more nausea and better control of the bike are actually already in the game, but could not be tested, since the game could not be played in VR. If it was tested in VR, then maybe the experts would have found the game even more motivating and fitting as therapy.

The actions in the game were found to be realistic, which is good, since children with DCD have trouble transferring skills. If the actions were unrealistic, the skills taught to the children would have been useless, as they could not use them outside of the game.

The 2 people who gave the neutral answer for the second question did so because they were not therapists and thus did not think they could give a correct insight to the question. In hindsight, options should have been included that could be ticked by people that felt they could not answer certain questions because it was outside of their scope.

An expert mentioned that the level was not suitable for level 1, as it contains too many obstacles. However, the obstacles can be turned off. Whether this was not clear enough, or they simply forgot is not known, but it can be reasonably assumed that this does make the level suitable as level 1.

Adding the game design requirements to the requirement list was meant to make the game more appealing towards children. This proved to work, since the expert hypothesised that the children will find the game fun and interesting.

## Limitations

Unfortunately, since the results are not actually tested by the target group, practice will have to show whether the experts and this study are correct in their findings. It is a shame that no tests with the target group could be performed, but the reasons for that were outside of this study's control. The experts also did not have the opportunity to test the game in VR and had to use an adapted version they could try at home on their pc. So, the bike's movement and control could not be tested. Another limitation was the time frame for this project. If there had been more time to implement the other mechanics, the results could have provided an even clearer view of whether the requirements were correct or not.

One expert answered almost all of the questions with 'neutral'. The reason they did this is because they could not play the game themselves, because of the hardware errors of their laptop, and thus did

not feel qualified to fully answer the questions. Because of this, it can be safely said that their answers are not reliable and can mostly be ignored. When this is done, the answer sway toward an even more positive result.

There was also contradicting feedback from time to time. The therapists were a lot more focussed on the therapy aspect of the project, which contrasts with Twinsense360's feedback, who were focussing more on the game aspect. The therapists want the end product to still be therapy, and not just a game. And at times, the therapists contradicted themselves. When the concepts were presented to them, they were adamant that they did not want a 'helper' that gave the children feedback, since the therapist can give that themselves. However, during a later meeting when the demo was supposed to be discussed, one of the therapists had the idea that an NPC in the game who gave constant positive feedback to the child would be nice, since it would make the child feel better. This is basically the 'helper' concept that was presented to them earlier. So, figuring out what the therapists actually wanted and needed proved to be challenging at times, but since their response to the game was positive, it seems like it was done correctly in the end.

## Implications

So, how do you create a serious game that motivates children aged 6 – 12 with DCD and ADHD to play and finish the game more than once, so the game can be used as physical therapy? The sub questions got answered in the theory chapter. Then the results from the literature review were tested, and they turned out to be correct. So, in order to create a serious game that motivates children aged 6 – 12 with DCD and ADHD to play and finish the game more than once so that the game can be used as physical therapy, you have to closely see what makes a child with DCD and ADHD different from a healthy child, and understand what DCD and ADHD exactly do. Then, you can accommodate the game to fit the needs of the children. The next step is to make the game fun. By adding game design elements from popular video games, the game becomes more attractive to the children, motivating them to play it. Lastly, by adding proven motivation methods, like the Self-Determination Theory, it motivates the children to keep playing the game, and thus making it more effective as physical therapy.

# Conclusion

By questioning the experts regarding the target group, this thesis has shown that making a serious game fun and attentive to the needs of the target group, it will motivate them to play a serious game more than once. Thorough literature research on DCD, ADHD, serious games, motivational methods, and popular children's games has been done, to help understand the target group and gather needed information. With that information, a game concept was created and made into a prototype, ready for testing. Because of unfortunate circumstances, the target group could not test the product, and thus the results might not be fully correct. Nonetheless, the expert therapist gave a useful insight into how the target group might react to the product. While the game is not fully useable as physical therapy yet, it has enough potential to be considered the first step into creating a serious game that can be used as effective physical therapy.

# Recommendations

The likelihood that someone will continue to work on this project is high, since het Roessingh wants to continue working on the serious game, perfecting it until it can be used as therapy. For the next researcher or game developer who will be working on this project, the first steps to take would be to implement the mechanics that have not been implemented yet, like the checkpoints and the extra obstacles and adjustable objects. Adding more control to the bike, like being able to use both brakes and getting the budget to try out hardware where the child can use balance to control the bike, would improve the game as well. This would add more realism to riding the bike, and thus would help the child learn the skill better. Having more levels that require a different skill level would also be good. Now, if a child's skill level exceeds the one needed for the first level, they do not have anything else to play. After the implementation of those mechanics, user testing with the target group in VR should be done. Only then can the real efficiency of the product be tested. If it's not possible to test with the target group, a group that closely relates should be tested with, for example, children aged 6 – 12 with only ADHD, or just healthy children aged 6 – 12. After the testing, it should be discussed how the target group differs from the tested group, and what impact it had on the results. With knowledge from the literature research, it can be theorised how the actual target group would have responded to the test. With the feedback from the testing, the product can then be refined to an even better game.

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# List of Figures

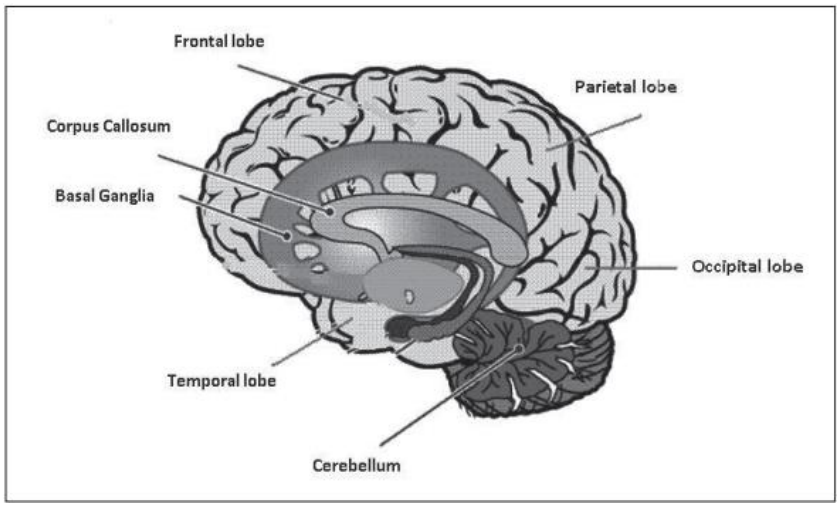



*Figure 1: Brain map with positions of the corpus callosum, cerebellum, basal ganglia, and parietal lobe (cortex) (* (Debrabant, Van Waelvelde, & Vingerhoets, 2010)*)*

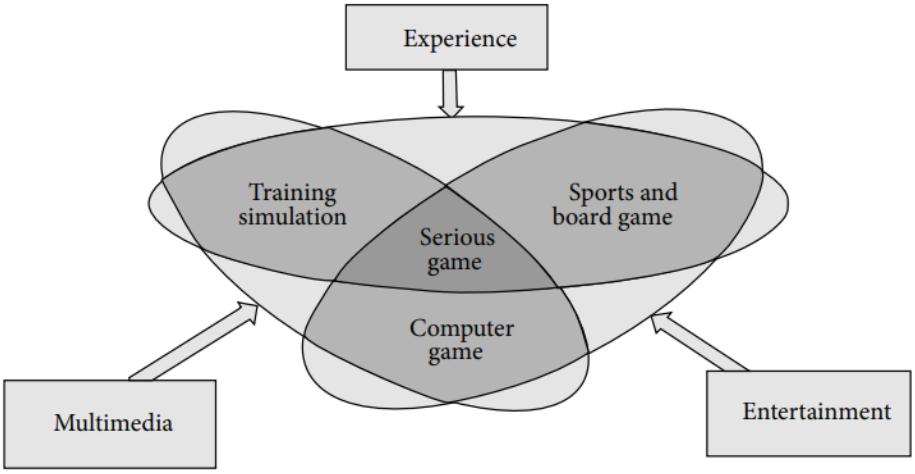



*Figure 2: Definition of Serious games. (Laamarti, Eid, & El Saddik, 2014)*

| Video Game | Genre | Characteristics |
|---|---|---|
| Angry Birds | Casual, Puzzle | Bold bright colours, cute characters, adventure elements, easy to challenging levels |
| Animal Crossing | Social Simulation | Bold bright colours, cute characters, teamwork, simple story |
| Candy Crush Saga | Casual, Tile-matching | Bold bright colours, easy to challenging levels |
| Crash Bandicoot | Platformer, Party, Racing | Bold bright colours, cute characters, adventure & fantasy elements, easy to challenging levels, special main character, simple story |
| Cut the rope | Puzzle | Bold bright colours, cute characters, simple story, easy to challenging levels |

| | | |
|---|---|---|
| Fruit Ninja | Casual | Bold bright colours, easy to challenging levels, |
| Hill Climb Racing 2 | Racing | Bold bright colours, adventure elements, simple story, teamwork, |
| Kinect Adventures | Adventure, Sport | Bold bright colours, adventure elements, teamwork |
| Legend of Zelda | Action-Adventure | Bold bright colours, cute characters, adventure & fantasy elements, special main character |
| Lego games | Action, Adventure | Bold bright colours, cute characters, adventure & fantasy elements, teamwork, special main character |
| Little Big Planet 2 | Platformer | Bold bright colours, cute characters, adventure & fantasy elements, teamwork, easy to challenging levels |
| Mario games | Platformer, Puzzle, Party, Racing, Sports, RP | Bold bright colours, cute characters, adventure & fantasy elements, teamwork, easy to challenging levels, simple story, special main character |
| Minecraft | Sandbox, Survival | Bold bright colours, cute characters, adventure & fantasy elements, teamwork, simple story |
| My Talking Tom | Digital Pet | Bold bright colours, cute characters |
| Neko Atsume | Casual | Bold bright colours, cute characters |
| Nintendogs + Cats | Digital Pet | Bold bright colours, cute characters |
| Pokemon | Adventure, RP | Bold bright colours, cute characters, adventure & fantasy elements, special main character, simple story |
| Pou | Digital Pet | Bold bright colours, cute characters |
| Roblox | MMO | Bold bright colours, simple story, teamwork, adventure & fantasy elements |
| Rocket League | Sport | Bold bright colours, simple story, teamwork |
| Skylanders | Action | Bold bright colours, cute characters, adventure & fantasy elements, special main character, simple story |
| Snipperclips | Puzzle | Bold bright colours, cute characters, teamwork, easy to challenging levels |
| Sonic | Platformer | Bold bright colours, cute characters, adventure & fantasy elements, easy to challenging levels, simple story, special main character |
| Splatoon | Third-person shooter | Bold bright colours, cute characters, adventure elements, teamwork |
| Stardew Valley | Simulation, RP | Bold bright colours, cute characters, simple story, teamwork |

| | | |
|---|---|---|
| Subway Surfers | Endless Runner | Bold bright colours, easy to challenging levels |
| Temple Run 2 | Endless Runner | Bold bright colours, easy to challenging levels |
| Unravel | Platformer | Bold bright colours, cute characters, fantasy & adventure elements, teamwork, special main character |
| Where's my water? | Puzzle | Bold bright colours, easy to challenging levels, cute characters |

*Figure 3: Table of Popular video games with children 6 – 12 y/o. Created with data* from (Stringfellow, 2019) (Sirani, 2019) (Serrels, 2019) (Petite, 2019) (List of best-selling video games, 2019)

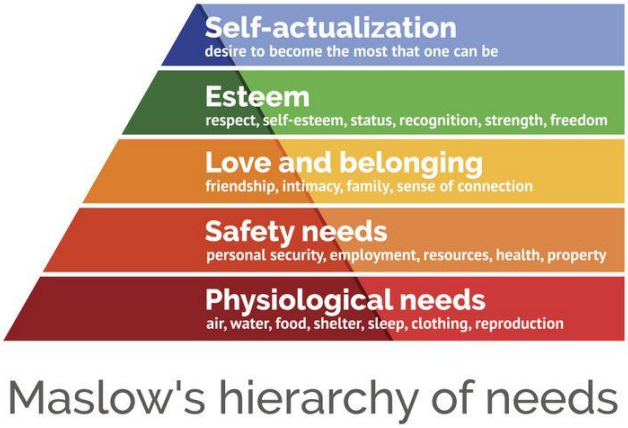



*Figure 4: Maslow's Pyramid. (Hopper, 2019)*

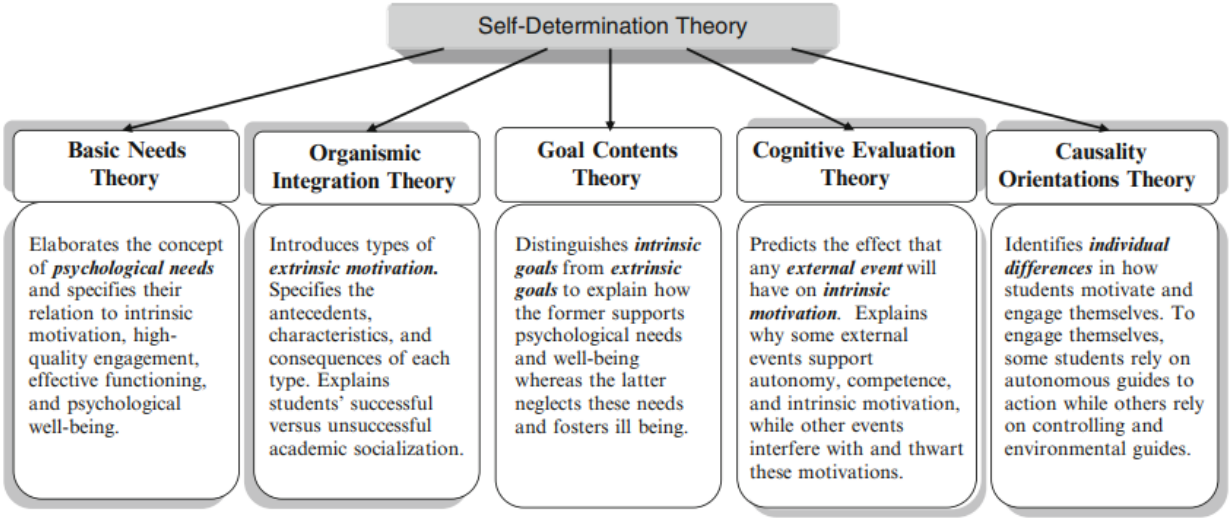



*Figure 5: Five minitheories of self-determination theory.* (Deci & Ryan, 2012)

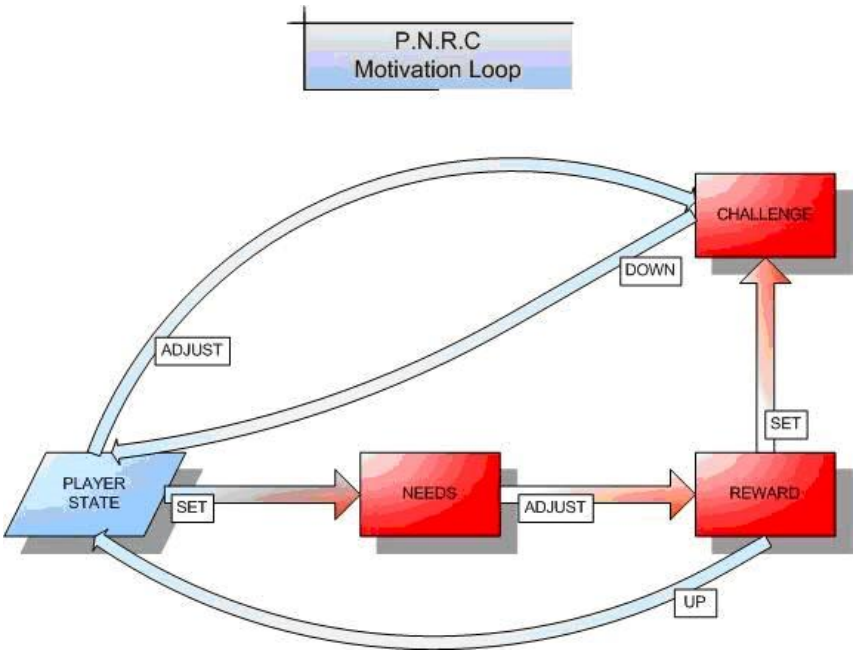



*Figure 6: The PNRC system* (Ghozland, 2007)

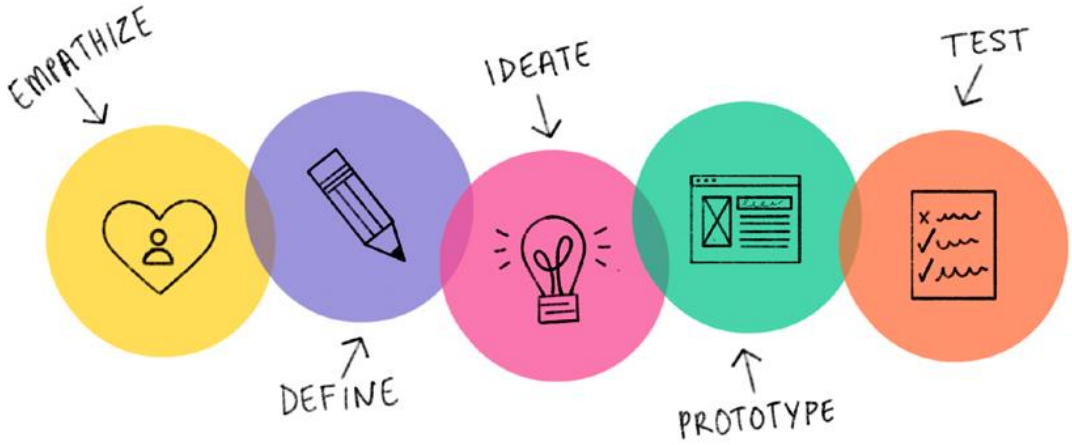



*Figure 7: Design Thinking Phases.* (Eurib, 2020)

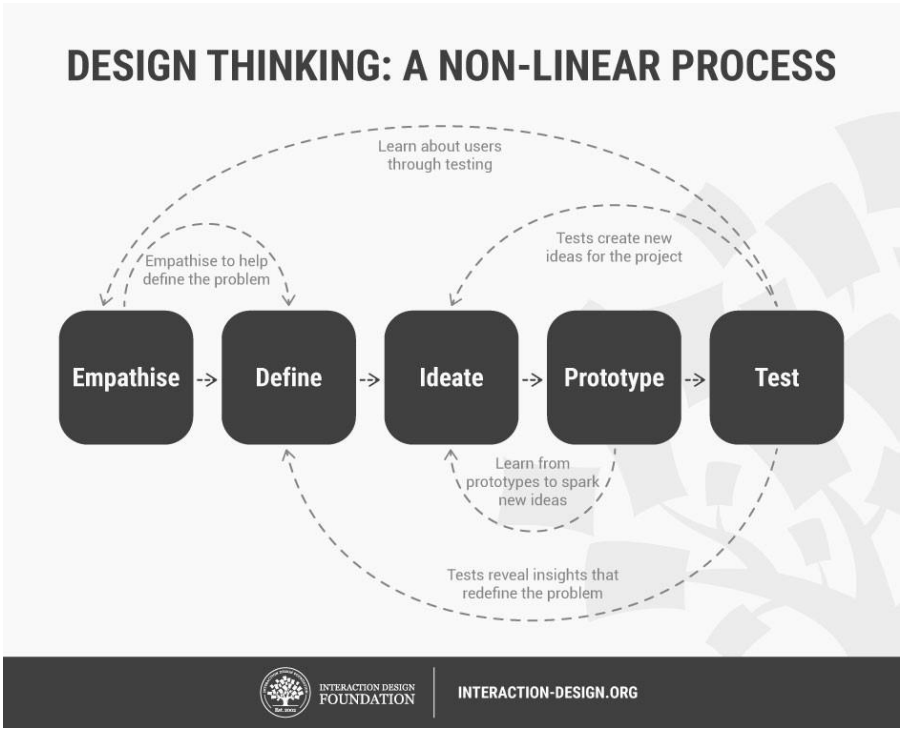



*Figure 8: The non-linear process of design thinking* (Interaction Design Foundation, 2020)

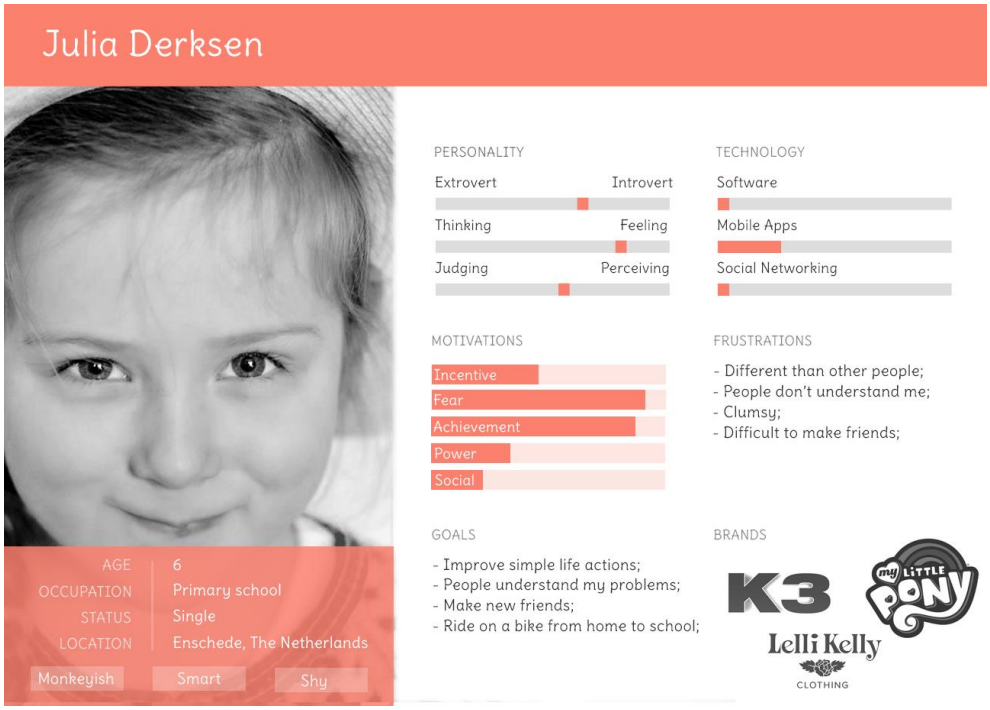



*Figure 2: Persona 1, Julia Derksen*


*Figure 10: Persona 2, Pim van Vliet*

| **Requirements** | | | | | |
|---|---|---|---|---|---|
| | DCD | ADHD | Game Design | Motivation Method | Therapist Request |
| Adjustable (In real time) | x | | | | |
| Repeatable | x | | | | |
| Realistic | x | | | | |
| Positive reinforcement | x | x | | | |
| No unnecessary distractions | | x | | | |
| Limit possible choices | | x | | | |
| Clear goals | | x | | | |
| Clear and specific instructions | | x | | | |
| Bold bright colours | | | x | | |
| Cute characters | | | x | | |
| Fantasy elements | | | x | | |
| Adventure elements | | | x | | |
| Teamwork | | | x | | |
| Simple story | | | x | | |
| Special main character | | | x | | |
| Levels that can be completed simply or more challenging | x | | x | | |
| Combination of intrinsic + extrinsic motivation | | | | x | |
| Autonomy | | | | x | |
| Competence | | | | x | |
| Relatedness | | | | x | |
| Right reward for right challenge | | | | x | |
| 5 - 15 minutes to complete one level | | | | | x |

*Figure 11: List of Requirements*

| Plot | Adjustable (In real time) | Repeatable | Realistic | Positive Reinforcement | No unnecessary distractions | Limit possible choices | Clear goals | Clear and specific instructions | Bold bright colours | Cute characters | Fantasy elements | Adventure elements | Teamwork | Simple story | Special main character | Levels that can be completed simply or more challenging | Combination of intrinsic + extrinsic motivation | Autonomy | Competence | Relatedness | Right reward for right challenge | 5 - 15 minutes to complete one level |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Lost Animal | | | | | | | | | | | | | | | | | | | | | | |
| Child finds lost animal. Type of animal depends on the child. Therapist can choose what animal for which child. Goal is to bring animal back to owner at the end of the level. The animal will be placed in the basket of the bike. Have to bike safely, or animal will be distressed. The child obviously must not crash with the bike, or the animal will get hurt. | X | X | X | | | X | X | | | X | | | | X | X | | | | | X | | X |
| Farm breakout | | | | | | | | | | | | | | | | | | | | | | |
| The gates keeping all the farm animals in their fields have been left open. All the animals have escaped. Player needs to lure the animals back to their respective field and close the gate. Needs to collect specific food for specific animal, place it in field, wait until animals are in the field, close the gates. Can't hit any of the animals. Therapist can choose which animals and how many there are. | X | X | X | | | X | X | | | | | | | | X | | | | | | | X |
| Cure | | | | | | | | | | | | | | | | | | | | | | |
| A scientist is creating a cure for a disease. On her way to work, her backpack broke and parts of her equipment fell out. She needs the player to go and collect the parts and bring them back to her. Then she can finish the cure and help the sick people. Therapist can place items and choose how many items there are. | X | X | | | | X | X | | | | | X | | X | X | | | | | | | X |
| Friend | | | | | | | | | | | | | | | | | | | | | | |
| Player's friend is too scared to bike to school alone. Player needs to accompany him/her. First, Player has to go pick up a friend (NPC) from their house. Then they bike to school together. Player has to closely follow or lead friend. | | X | X | | | X | X | | | | | | X | | X | | | | | | | X |

*Figure 12: The chosen plots and the requirements they fulfil*

| Elements | Adjustable (In real time) | Repeatable | Realistic | Positive Reinforcement | No unnecessary distractions | Limit possible choices | Clear goals | Clear and specific instructions | Bold bright colours | Cute characters | Fantasy elements | Adventure elements | Teamwork | Simple story | Special main character | Levels that can be completed simply or more challenging | Combination of intrinsic + extrinsic motivation | Autonomy | Competence | Relatedness | Right reward for right challenge | 5 - 15 minutes to complete one level |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Time | | | | | | | | | | | | | | | | | | | | | | |
| Have to complete level within certain time AND/OR time the player. A way to track progress and compete with themselves. Therapist can set time. | X | | | | | | | | | | | | | | | | | | X | | | |
| Private Scoreboard | | | | | | | | | | | | | | | | | | | | | | |
| Scored should only be used to compare results from one child. This will help track progress. The results shouldn't be used to compare the children to each other, since the kids have a very low self-esteem, and seeing other kids do better than them won't motivate them. | | | | X | | | | | | | | | | | | | | | | X | X | |
| Electronic Helper | | | | | | | | | | | | | | | | | | | | | | |
| A small, cute/cool device on one of the handlebars will give them tips or say how well they are doing. | | | | X | | | | | X | X | | | | | | | | | | X | | |
| Health | | | | | | | | | | | | | | | | | | | | | | |
| After X amount of crashes/doing something wrong, player has to restart level/checkpoint. | | | | | | | | | | | | | | | | | | | X | | X | |
| Items | | | | | | | | | | | | | | | | | | | | | | |
| Player can collect items like health refills, level-specific items, etc. Therapist can choose where to place items and how many. | X | | | | | | | | | | | | | | | | | | X | | | |
| Customisation | | | | | | | | | | | | | | | | | | | | | | |
| Player can choose colour of bike and in-game items | | | | | | | | | | | | | | | | | | X | | | | |
| Wayfinders | | | | | | | | | | | | | | | | | | | | | | |
| Coins, light, etc, to show where kids need to go | X | | | | | | | | | | | | | | | | | | | | | |
| Obstacles | | | | | | | | | | | | | | | | | | | | | | |
| Distractions, ducks crossing roads, etc. | X | | | | | | | | | | | | | | | | | | | | X | |

*Figure 13: The chosen elements and the requirements they fulfil*


*Figure 14: MoSCoW*

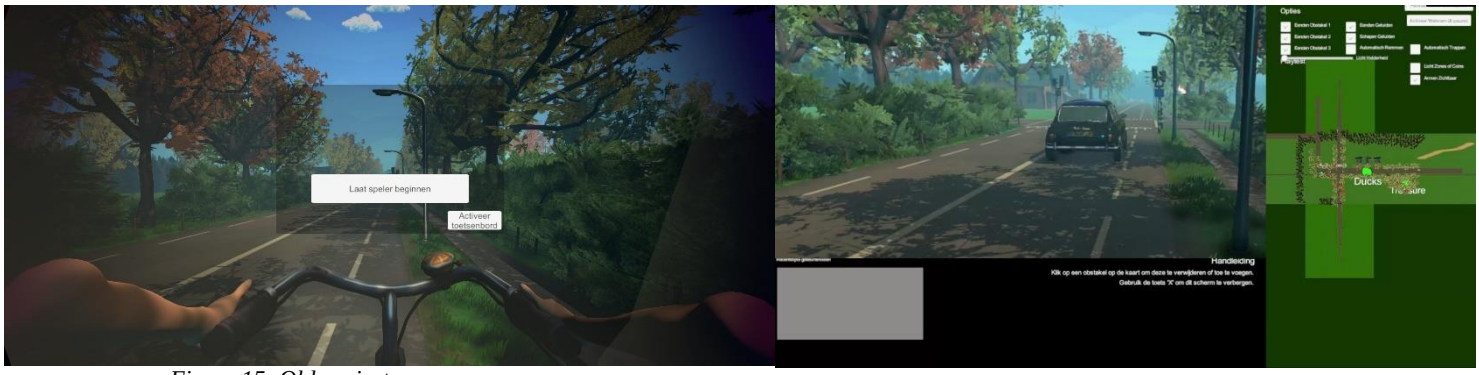



*Figure 15: Old project*

| Iteration | Features |
|---|---|
| 1 | Road layout, Ducks, Houses, Posters (placeholders), Bike mechanics, Cars, Traffic lights, Smileys, General mechanics, VR (Bug with switching between VR and non-VR) |
| 2 | VR switch bug fixed, therapist UI (bug with webcam and microphone), Anti-VR sickness mechanics (Vignette, Virtual Nose) |
| 3 | Dropdown menu for webcam and microphone |
| 4 | New models for roads, environmental design, updated UI |
| 5 | Occlusion culling, Animal models, Poster models, New house models |
| 6 | Game translated to Dutch |
| 7 | New UI, New cars, Human model, All animations |
| 8 | Final bug fixes, Light bake |

*Figure 16: The different game iterations*

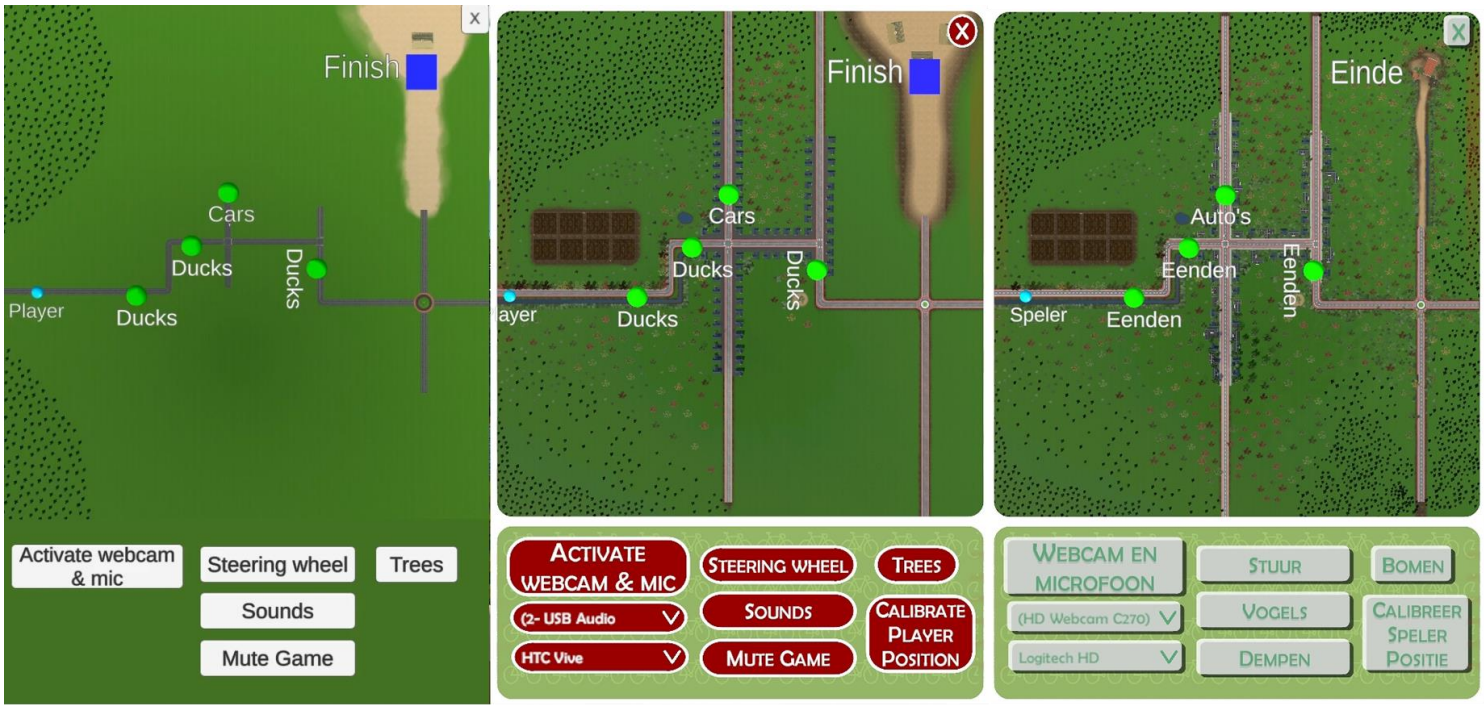



*Figure 17: Therapist UI changes*


*Figure 18: Main menu changes*


*Figure 19: Game window*

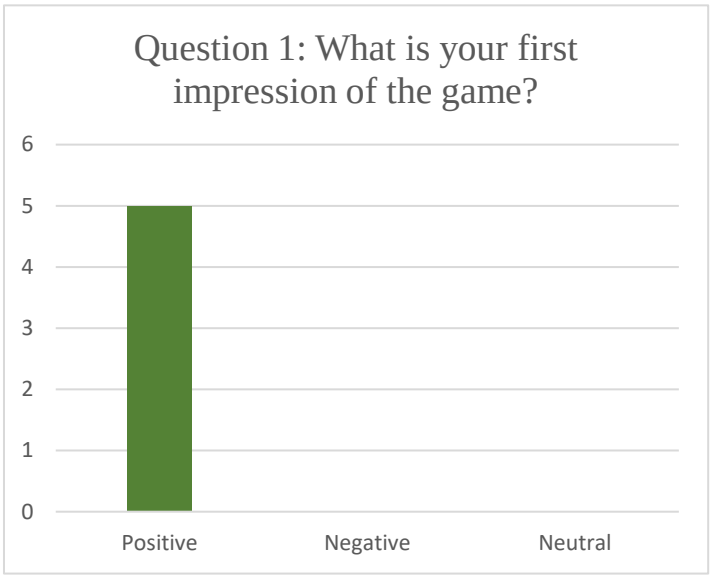



*Figure 20: Q1 results*

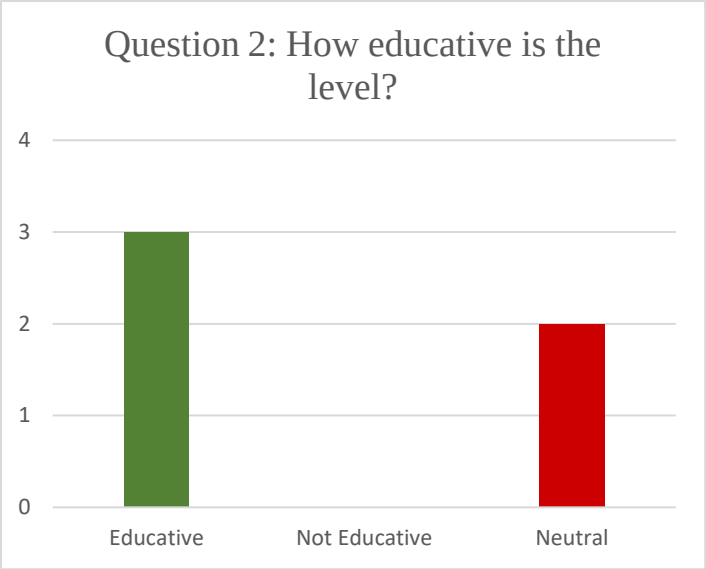



*Figure 21: Q2 results*

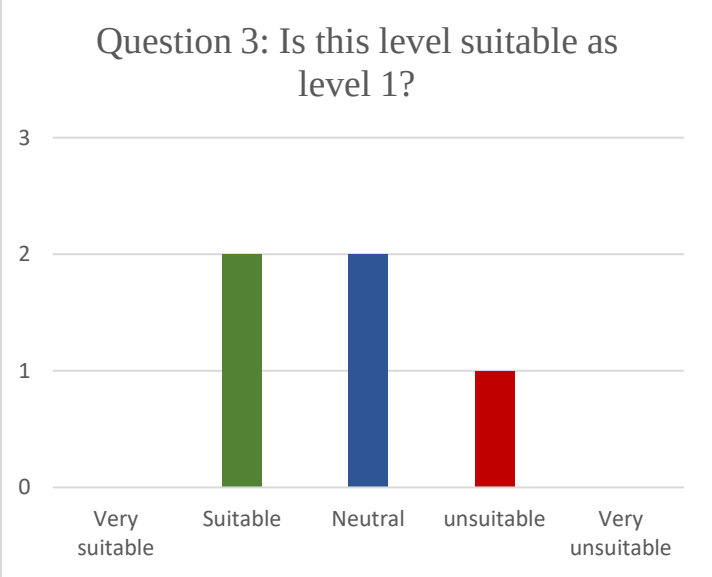



*Figure 22: Q3 results*

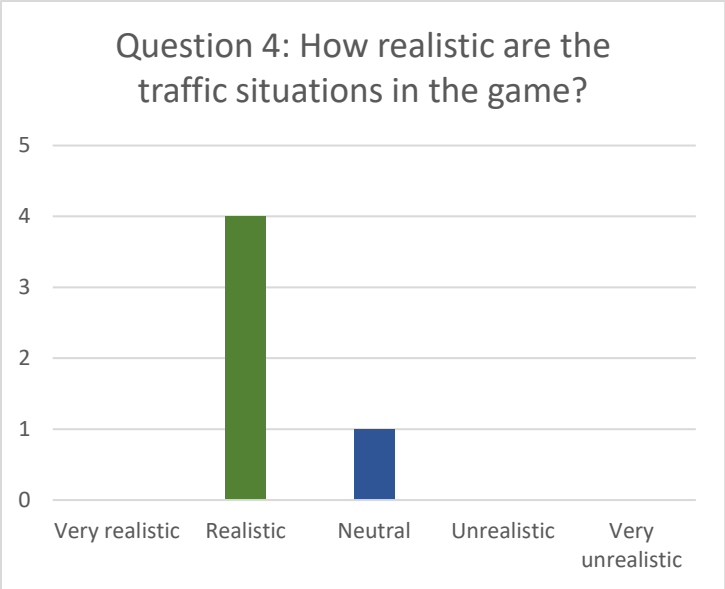



*Figure 23: Q4 results*

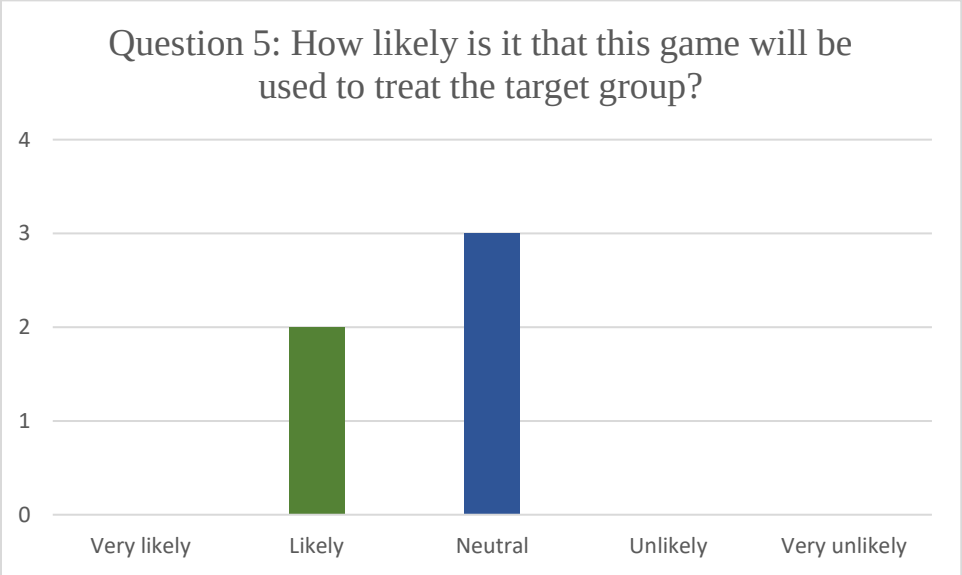



*Figure 24: Q5 results*

| How fun will the target group find the game? | What would the children like / dislike | How do you think the target audience will react to the game? | Is it clear which way the children have to bike? | Please explain your answer (optional) | Do you think the children will find this level difficult or easy? | Please explain your answer (optional) |
|---|---|---|---|---|---|---|
| Fun | Difficult to estimate whether this is too easy, but that has to be proven in practice | Interested | Clear | Practice will have to show whether the children understand the traffic signs with the directions | Easy | I think that children do not find this very difficult, but that it is a good level to get used to the VR glasses and the environment |

*Figure 25: Therapist answers part 1*

| How motivated would the children be to play the game multiple times? | Please explain your answer (optional) | Do you think the animal posters are clear enough for the target group? | Would you like to change something about the animal posters? If so what? | How would the children react to the crossing ducks? | How would the children react to the intersection with the cars? |
|---|---|---|---|---|---|
| Motivated | If you can redo parts and don't have to go back to the starting point every time. If they are less motivated, it can also mean that they have to go to the next level. The link between behaviour, smileys and score is not clear and could be motivating. | Clear | I don't know for a moment. We should test on children | Seems good to me, the first ducks are a bit in a dark roadside, the other ducks are better seen in advance. | Seems fine to me, they don't need many |

*Figure 26: Therapist answers part 2*

# Appendices

## **Appendix 1.** Characteristic Features of Children with DCD (Missiuna, Rivard, & Pollock, 2011).

When describing children with DCD, it is important to recognize that they are a very mixed group. Some children may experience difficulties in a variety of areas, while others may have problems only with specific activities. The following is a list of some of the more common characteristics that may be observed in a child with DCD.

Physical Characteristics

1. The child may be clumsy or awkward in his/her movements. He/she may bump into, spill, or knock things over.

2. The child may experience difficulty with gross motor skills (whole body), fine motor skills (using hands), or both.

3. The child may be delayed in developing certain motor skills such as riding a tricycle/bicycle, catching a ball, jumping rope, doing up buttons, and tying shoelaces.

4. The child may show a discrepancy between his/her motor abilities and his/her abilities in other areas. For example, intellectual and language skills may be quite strong while motor skills are delayed.

5. The child may have difficulty learning new motor skills. Once learned, certain motor skills may be performed quite well while others may continue to be performed poorly.

6. The child may have more difficulty with activities that require constant changes in his/her body position or when he/she must adapt to changes in the environment (e.g., baseball, tennis).

7. The child may have difficulty with activities that require the coordinated use of both sides of the body (e.g., cutting with scissors, stride jumps, swinging a bat, or handling a hockey stick).

8. The child may exhibit poor postural control and poor balance particularly in activities that require balance (e.g. stair climbing, standing while dressing).

9. The child may have difficulty with printing or handwriting. This skill involves continually interpreting feedback about the movements of the hand while planning new movements, and is a very difficult task for most children with DCD.

Emotional/Behavioural Characteristics

1. The child may show a lack of interest in, or avoid, particular activities, especially those that require a physical response. For a child with DCD, performing motor skills requires significant

effort. Fatigue and repeated failure may cause the child to avoid participating in motor tasks.

2. The child may demonstrate a low frustration tolerance, decreased self-esteem, and a lack of motivation due to difficulties coping with activities that are required in all aspects of his/her life.

3. The child may avoid socializing with peers, particularly on the playground. Some children will seek out younger children to play with while others will play on their own or follow the educator or playground supervisor. This may be due to decreased self-confidence or avoidance of physical activities.

4. The child may seem dissatisfied with his/her performance (e.g., erases written work, complains of performance in motor activities, shows frustration with work product).

5. The child may be resistant to changes in his/her routine or in his/her environment. If the child has to expend a lot of effort to plan a task, then even a small change in how it is to be performed may present a significant problem for the child.

Other Common Characteristics

1. The child may have difficulty balancing the need for speed with the need for accuracy. For example, handwriting may be very neat but extremely slow.

2. The child may have difficulty with academic subjects such as mathematics, spelling, or written language which require handwriting to be accurate and organized on the page.

3. The child may have difficulty with activities of daily living (e.g., dressing, using a knife and fork, brushing teeth, doing up zippers, organizing a backpack).

4. The child may have difficulty completing work within an expected time frame. Since tasks require much more effort, children may be more willing to be distracted and may become frustrated with a task that should be straightforward.

5. The child may have general difficulties organizing his/her desk, locker, homework, or even the space on a page.

## **Appendix 2.** Concepts

**Final Concepts**

Plots

1. Lost Animal

Child finds lost animal. Type of animal depends on the child. Therapist can choose what animal for which child. Goal is to bring animal back to owner at the end of the level. The animal will be placed in the basket. Child has to bike safely, or animal will be distressed. The child obviously must not crash with the bike, or the animal will get hurt.

- Adjustable, because the type of animal can be changed
- Repeatable, because the level can be replayed.
- Realistic, because the story takes place in the real world.
- Specific goal: Bring back the animal.
- Simple story: Bring back the animal.
- No choices.
- Cute characters: Animals
- Main character is special, because they save an animal.
- Relatedness, because the child will feel accepted and loved by the animal owner.

2. Farm breakout

The gates keeping all the farm animals in their fields have been left open. All the animals have escaped. Player needs to lure the animals back to their respective field and close the gate. Need to collect specific food for specific animal, place it in field, wait until animals are in the field, close the gates. Can't hit any of the animals. Therapist can choose which animals and how many there are.

- Adjustable, because therapist can choose which animals and how many there are.
- Repeatable, because the level can be replayed.
- Realistic, because the story takes place in the real world.
- Clear goals: Bring back the animals to the cages.
- Simple story: Bring back the animals to the cages.
- Main character is special, because they save animals.
- Limited choices. Player can only choose which animals to save first.

3. Cure

A scientist is creating a cure for a disease. On her way to work, her backpack broke and parts of her equipment fell out. She needs the player to go and collect the parts and bring them back to her. Then she can finish the cure and help the sick people. Therapist can place items and choose how many items there are.

- Adjustable, because therapist can place items and choose how many items there are.
- Repeatable, because the level can be replayed.
- "realistic". Takes place in the real world, but it's unlikely something like this were to actually happen, which is why the word is in quotation marks.
- Clear goals: Get back items.
- Limited choices. Player can only choose the order they collect the items.
- Adventure elements.

- Simple story: Help scientist by collecting items.
- Special main character, because they are the only one who can help the scientist.

4. Friend

Player's friend is too scared to bike to school alone. Player needs to accompany him/her. First, Player has to go pick up a friend (NPC) from their house. Then they bike to school together. Player has to closely follow/lead friend.

- Repeatable, because the level can be replayed.
- Realistic. This can happen in the real world.
- Clear goal: Help friend
- No choices, player has to help friend.
- Special main character. Only they can help their friend.
- Teamwork. Player has to work together with friend.

Elements

1. Time

Have to complete level within certain time and/or time the player. Another way to track progress and compete with themselves. Therapist can set time.

- Competence. Setting a timer is a way to provide a new challenge.
- Adjustable, because therapist can set time.

2. Private Scoreboard

Scored should only be used to compare results from one child. This will help track progress. The results shouldn't be used to compare the children to each other, since the kids have a very low self-esteem, and seeing other kids do better than them won't motivate them.

- Positive reinforcement if they end up on top of the scoreboard.
- PNRC -> Challenge. Scoreboard adds another challenge.

3. Electronic Helper

A small, cute/cool device on one of the handlebars will give them tips or say how well they are doing

- Positive reinforcement. Device will only give positive comments.
- Cute
- Bright colours
- Relatedness. Can make the player feel connected.

4. Health

After X amount of crashes/doing something wrong, player has to restart level or checkpoint.

- PNRC -> Challenge. Adds another challenge.
- Competence. Adds another challenge.

5. Items

Player can collect items like health refills or level-specific items. Therapist can choose where to place items and how many.

- PNRC -> need, reward. Items create a reward for the player, which influences their need.

- Adjustable, because therapist can choose where to place items and how many.

6. Customisation

Player can choose colour of bike and in-game items

- Autonomy, since it provides a choice for the player.

7. Wayfinders

Coins, light, etc, to show where kids need to go

- Adjustable.

8. Obstacles

Distractions, ducks crossing roads, etc.

- Adjustable.
- PNCR -> Challenge. Obstacles create challenges.

**Disregarded ones**

1. Scouting expedition

Hidden area in forest. Player needs to find it.

2. Safari/photography

Player has to take photos of specific items/scenery/animals/flowers.

3. Obstacle course

Player has to safely follow intricate path. Therapist can adjust path

4. Find the right route

Player has to go from point A to B with the quickest route. Player doesn't know the route. Have to find it through trial and error.

5. Choices

Player has to make choices during game, will affect ending.

6. Hide & seek

NPC hides, player has to find them.

## **Appendix 3.** Meeting Notes

Lost Animal

Animal on front of bike is too distracting. Also, not realistic. Can use a 'real' animal (plushie), to introduce the children to the plot. Kids comes in, can choose which animal to save, can pick up plushie, put it on the bike, put headset on, and start the game. Therapists don't want any sounds to come from the animal, will be too distracting. In general, they liked the idea.

Farm breakout

They had difficulty understanding this idea. At first, they didn't like that this idea can only take place in a rural area. The more they talked about this, though, the more they liked it. It might be a good concept for early (easy) levels.

Friend

They really liked this concept! It'll make the kids feel good, because they're helping a friend and doing something important. Having the NPC cycle next to the player might be too distracting though. Good if therapist can choose where the NPC cycles (next to or behind player).

Cure

Bit too unrealistic, but definitely fun! Instead of helping a scientist, player could go to different shops to get different groceries, and then bring them to grandma, who will then bake pancakes. Could be an idea for a more difficult level.

Time

Timing a player is fine but setting a time limit won't work. The kids will just race through the level and not pay attention to anything, because of ADHD. Setting a time limit for certain scenarios might work, like at a crossroad with traffic lights, because in real life, you have a limited amount of time to respond to the traffic light.

Scoreboard

Therapists think a fake scoreboard might work. No matter what time the player finishes the level, they always end up on top, or at least in the top 3. This will make the kids feel good about themselves. Something similar to Mario Kart might also work, where you can race against 20 different NPCs, but they always lose.

Helper

They didn't like that idea. They don't need a device to give verbal feedback to the player, they can do that themselves.

Health/items

Maybe. Has to be realistic. So, nothing like collecting coins while cycling.

Wayfinders

Definitely needed in the game. But how is difficult. Coins are not realistic, and a paediatrician from Roessingh said that coins are too commercial. But kids don't know which way to bike, so something is needed. Arrows or colours on the road can work, but it's not realistic and might distract too much. Signs are realistic, but the kids might be too young to understand them, or they simply won't notice them. A simple bike lane would work, but in real life that often splits into different lanes, so could still be confusing. Therapists can also just tell the kid where to go. That is also realistic, since the parents will often tell the kid(s) where to go during cycling.

General Ideas/feedback:

- Therapists want microphone added so that they can give verbal feedback to player.

- About the smileys the previous group added: they really like them! They like that they give immediate feedback. Cannot be on the screen for too long though. Plus, a child might not always know why the smileys appeared. Another idea would be to provide constant positive feedback, throughout the whole game. So, a happy smiley appears after every 10-ish seconds.

- About creating motivation: The kids already have some intrinsic motivation because they want to learn how to ride a bike.

- Therapists would like to be able to pause the game at any second and give feedback. They would like to see the last 10-ish seconds of the game, so that they can show the kids exactly what they did wrong/right. They pitched the idea of recording the last 10 seconds, but that would be too heavy for the software and would impact game performance.

Solution: Instead of literally recording the game (making a video), just recording the positions of the objects would be better because that doesn't take too much memory/power. Then when the therapist wants to see a replay of the game, the game would resimulate the game with the data. This technique is used in video games that have a kill cam. Whether this would work and how hard it'd be to implement will have to be tested.

## **Appendix 4.** Information letter and permission form

INFORMATIE OVER DEELNAME AAN ONDERZOEK VOOR PROJECT "VREYE!"

**Keep Your Eyes on the Road, Kid!**

Geachte ouder(s)/verzorger(s),

Mijn naam is Ayla Arisci. Ik studeer aan het Saxion in Enschede en volg de studie Creative Media and Game Technologies (CMGT). Momenteel ben ik bezig met mijn afstuderen. Voor mijn afstuderen werk samen met Het Roessingh Research and Development (RRD) en Twinsense360 aan het project 'VREye!'.

'VREye!' gaat over het ontwikkelen van een Virtual Reality (VR) spel voor kinderen met Developmental Coordination Disorder (DCD). Kinderen met DCD hebben moeite met veel verschillende, uiteenlopende handelingen die van invloed zijn op hun dagelijks leven. Voor veel kinderen met DCD is het moeilijk om te leren fietsen. Het is de bedoeling dat het VR spel tijdens een therapiesessie gebruikt kan worden om een kind met DCD veilig te leren fietsen in verschillende omgevingen en verkeerssituaties.

Tijdens dit project heb ik mij beziggehouden met het ontwikkelen van de verhaallijn en het level design. We willen nu onderzoeken hoe leuk een kind het spel vindt. Via deze brief wil ik u vragen of uw kind mee wilt doen aan het onderzoek, omdat we op zoek zijn naar gezonde kinderen in de leeftijd van zes tot twaalf jaar.

Deelname aan dit onderzoek is geheel vrijwillig. Voordat u en uw kind de beslissing nemen, is het belangrijk om meer te weten over het onderzoek. Lees deze informatiebrief rustig door.

Hebben u of uw kind na het lezen van de informatie nog vragen? Dan kan u altijd contact met mij opnemen, emailadres ayla@twinsense360.nl

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

Om ervoor te zorgen dat de therapie goed werkt, is het belangrijk dat het kind gemotiveerd is om het spel te spelen. Daarvoor moet het spel leuk zijn om te spelen. Het eerste level van het spel is gemaakt, en nu is de vraag wat kinderen van het spel vinden.

2. **Hoe wordt het onderzoek uitgevoerd?**

Voor de start van het onderzoek wordt het spel uitgelegd. Vervolgens zal uw kind het spel op een computer met muis en toetsenbord spelen. Het spelen zal ongeveer 5-10 minuten duren. Daarna worden er wat vragen aan het kind gesteld. Het hele onderzoek zal maximaal 30 minuten duren.

3. **Wat wordt er van u en uw kind verwacht?**

Er wordt van uw kind verwacht dat hij/zij het spel speelt en daarna de vragen eerlijk beantwoordt.

4. **Wat zijn mogelijke voor- en nadelen van deelname aan dit onderzoek?**

Er zijn geen specifieke voordelen of nadelen voor uw kind binnen dit onderzoek.

5. **Wat gebeurt er als u of uw kind niet wenst deel te nemen aan dit onderzoek?**

U en uw kind beslissen zelf of uw kind aan het onderzoek deelneemt. Deelname is vrijwillig. Als u of uw kind besluit niet mee te doen, hoeft u verder niets te doen. U hoeft niets te tekenen. U hoeft ook niet te zeggen waarom u niet wilt meedoen. Als uw kind wel meedoet, kunt u of uw kind zich altijd bedenken en toch stoppen. Ook tijdens het onderzoek, mag uw kind op elk moment stoppen.

## 6. Wat gebeurt er met de gegevens van uw kind?

De gegevens van uw kind blijven vertrouwelijk. De gegevens worden gecodeerd en zijn binnen het onderzoek niet herleidbaar naar individuele personen. Mocht u interesse hebben naar de resultaten of eventuele vragen over het testen, kan dit altijd besproken worden tijdens een individueel gesprek.

Met vriendelijke groeten,

Ayla Arisci

ayla@twinsense360.nl

06-29861614

Toestemmingsformulier

*Titel van het onderzoek:*
**Keep Your Eyes on the Road, Kid!**

Ik ben gevraagd om toestemming te geven voor deelname van mijn kind aan dit onderzoek:

Naam proefpersoon (kind): …….. Geboortedatum: …… / ……. / ……..

Ik heb de informatiebrief voor de proefpersoon gelezen. Ik kon aanvullende vragen stellen. Mijn vragen zijn naar tevredenheid beantwoord. Ik had genoeg tijd om te beslissen of mijn kind mag meedoen.

Ik weet dat meedoen helemaal vrijwillig is. Ik weet dat mijn kind op ieder moment kan beslissen om toch niet mee te doen. Daarvoor hoeft mijn kind geen reden op te geven.

Ik geef toestemming om de gegevens van mijn kind te gebruiken, voor de doelen die in de informatiebrief staan.

Ik wil mijn kind laten meedoen aan dit onderzoek.

Naam ouder/verzorger:
Datum : __ / __ / __

Handtekening: ……

Naam ouder/verzorger:
Datum : __ / __ / __

Handtekening: ……..

Ik verklaar hierbij dat ik de ouders van deze proefpersoon volledig heb geïnformeerd over het genoemde onderzoek.

Als er tijdens het onderzoek informatie bekend wordt die de toestemming van de proefpersoon zou kunnen beïnvloeden, dan breng ik hem/haar daarvan tijdig op de hoogte.

Naam onderzoeker (of diens vertegenwoordiger):

Handtekening: Datum: __ / __ / __

**Appendix 5.** Perfect Test Protocol

Enschede, xx/03/2020

# Protocol VREye!

*Testing a serious VR game for children with DCD*

Ayla Arisci

# Project Overview

## Summary

The purpose of this study is to test whether children with Developmental Coordination Disorder and Attention Deficit Hyperactivity Disorder are motivated to play a serious VR game that will be used as physical therapy for teaching them how to ride a bike. If they are motivated to play it, then teaching them how to ride a bike will be quicker and easier. The population is children aged 6 – 12 with Developmental Coordination Disorder and Attention Deficit Hyperactivity Disorder. The participants will have to play the game while in VR and on a bike. Through observation and an interview, the data will be collected.

## Investigators

Ayla Arisci | Twinsense360

She will lead the tests and interview the participants.

Roos Bulthuis | Roessingh Research and Development

She will observe the participants and note down their reactions to the game.

# Introduction

## Subject

'VREye! 'is about the development of a Virtual Reality (VR) serious game for children with Developmental Coordination Disorder (DCD). Children with DCD have difficulty learning motor skills, which impacts their daily life. For a lot of the children with DCD, cycling is big problem. The goal is to help the children learn how to ride a bike, by having them play the game during therapy sessions and safely bike through different environments and traffic situations in VR.

50% of children with DCD also have Attention Deficit Hyperactivity Disorder (ADHD). Because of this disorder, the children are often distracted and find it hard to focus. One of the problems this game faces is keeping the children interested in playing, because if they do not find the game fun to play, learning from the game will be very difficult.

To test how fun they find the game, their reactions while playing will be observed and they will be interviewed. If the children want to play the game more than once, than it means they like the game and are motivated to play it.

## Goal

The goal of the VR-game is to support/coach the children during the cycling in different environments. In order to accomplish that, the children must be motivated to play the game. Through literary research, a level designed to motivate the children has been created.

When the child enters a therapy session, the therapist will inform the child that the goal today is to return a lost pet to the owner. The child has to get on the bike and bring the animal back. The therapist can choose what kind of animal (cat, bunny, dog) the child will bring back. When cycling to the owner, the child will encounter different obstacles, like ducks crossing the road or cars at an intersection. The therapist can enable/disable these obstacles, adjusting the level based on the child's skills. Depending on how well the child pays attention to traffic signs and obstacles, the child can receive a score. The higher the score, the better.

## Study Locations

The study will be executed at Roessingh Research and Development at the Usability Lab. This location was chosen because the Usability Lab is created for the purpose of testing new technology and user experience. It will also provide a comfortable and effective setting for the participants.

## Hypotheses

### Primary objective:

1. Do the children like playing the game and are they motivated enough to play it multiple times?

   Hypothesis: Children really like playing the game and would like to play it multiple times.

### Secondary objective(s):

1. Is the level easy enough for level 1?

   Hypothesis: The level is for most children good as level 1. They do not have trouble following the road or understanding the obstacles they face while playing the game.

2. Do the children become nauseous while playing the game?

   Hypothesis: Only a few children will become a little bit nauseous.

## General Approach

1. Setting up equipment at study location
2. Welcome child/parent(s)
3. Offer coffee/tea/lemonade
4. Explain study
5. Have participants sign consent form
6. Ask background questions
7. Put child on bike
8. Have child test game
9. Write down observations
10. Help child get off bike
11. Start interview
12. Thank child/parent(s)
13. Give thank you gift

# Procedures/methods

## Design

## Preparation

### *Materials*

**Hardware**

- HTC Vive or HTC Vive Pro
- PC capable of running VR

**Physical**

- Bike
- Tacx Flow Smart bike trainer
- ANT usb
- Headphones
- Webcam
- Microphone
- Fan
- Animal plushies (cat, dog, bunny)
- Thank-you gift

**Software**

- Demo file
- Unity (2019.3.5)
- SteamVR

### *Method*

**Starting up the Demo**

1. Make sure the PC is turned on and has Internet.
2. Plug in the webcam and microphone. Test them on the pc to check if they work.
3. If using an HTC Vive Pro, ignore the next step.
4. Plug in the headphones.
5. Open the folder with the .exe file and double click the file.

**Connecting the Tacx and bike to the PC**

1. Make sure the front part (front wheel support) of the Tacx is charged.
2. Place the frame and the roller on the ground.
3. Put the bike in the frame. Secure it with the two clicks on the side. Make sure the back wheel is touching the roller and the front wheel is secured in the front wheel support.
4. Plug the back of the frame into a socket for power.
5. Wait for the red light to blink on to make sure the device is turned on.

6. Plug the ANT usb into the a usb port that connects to the PC.
7. Place the usb as close to the Tacx as possible for best connection strength.
8. Start up the demo, choose an animal, click on Start VR.
9. Turn the steering wheel of the bike completely to the left to connect to the PC.
10. Check if the green light next to the front wheel is blinking.
    a. Blinking rapidly: Can't find the connection. Make sure the needed DLLs are in the demo folder and that the PC recognises the plugged in ANT usb or install needed drivers.
    b. Blinking slowly: Connection secured!

**Connecting the Vive Headset**

1. Make sure the controllers are charged.
2. Place the base stations on opposite sides of each other, surrounding the bike, and plug them into a socket for power.
3. Plug the headset into the pc and a socket for power.
4. Check SteamVR to see if the headset, controllers, and base stations connected successfully.
    a. If not, follow the instructions from SteamVR.
5. Perform the room setup for SteamVR.

**Placing the fan**

1. Place the fan somewhere aimed at the child's head.
2. Plug it into a socket for power.

3. Turn on when child is cycling.

## *Informing child*

**Introduction**

Before the session, make sure all equipment is working as needed. If this is not the case, the child can become stressed.

1. When the child and parent(s) enter the room, have them take a seat and start the introduction.
2. Tell them that the child will bike through a virtual environment. A basic explanation of the environment can follow, but do not give away too much detail.
    a. Example of an introduction:

    Good morning/Good afternoon, please take a seat. Thank you so much for being here. (Introduce yourself and colleague(s)) Today, we're going to practise riding a bike. You can see the bike you're going to cycle on standing over there. You will have to put this VR headset on (show them the headset), which makes it possible for you to see the environment. You will have to cycle through that environment. We'll take it easy.

    Firstly, I want to ask you some questions, if that's okay. (Ask background questions)

    Now, what is your favourite animal? (Show them the corresponding animal plushie). This animal got lost, and it's your job to bring them back to their owner. I want to make it clear that I'm not testing you, just the software. I need to see how well this game is designed, so we can make it better. You cannot do something wrong. If at any time you want to stop or take a break, raise your hand in the air or just let me know!

## Execution

### *Method*

**Position**

1. Adjust the position of the bike saddle, if needed.
2. Help the child get on the bike, if needed.
3. Tell them to not start pedalling or turning the steering wheel just yet.
4. Place the VR headset on the child's head. Make sure the headset is not too loose or too tight. You can adjust the headset with the strap on the back.
5. Take place at the pc.

**Starting the Demo**

1. Pick the animal the child preferred.
2. Click on 'Start VR'.
3. Have the child and the steering wheel of the bike face directly forward. Click on "Calibrate Player Position".
4. In case the child has balancing issues, have someone stand next to the child to make sure they don't fall off the bike.
5. The child is ready to start peddling and playing the game.

**During playing**

1. If at any point the child wants to stop or take a break, let them
2. If the child gets nauseous, let them take a break. Help them off the bike and sit them down on a chair or couch. Offer them some water.
3. If needed, give the child directions on where to go in the game, but try and let them figure it out for themselves first.

**After playing**

1. Take the headset of the child's head.
2. Help the child get off the bike, if needed.
3. Tell them they did well and have them take a seat again.
4. Start with the interview.
    a. Example of starting interview:

    "Well done playing the game! Would you like something to drink or take a break before we start the interview? Please take a seat. There is no wrong way to answer these questions, so please be completely honest while answering them. If you don't understand a question, let me know. Shall we begin?"

## *Interview Questions*

| Background Questions | Age: Gender: |
|---|---|
| 1 | Do you like playing video games? |
| 1.2 | What kind of video games do you like to play? |
| 3 | Have you ever played in VR before? |
| 4 | Can you ride a bike? |
| 5 | (Asked to parents about their child) How are their motor skills? |

| Research Questions | | | | | |
|---|---|---|---|---|---|
| 1 | How much fun did you have while playing the game? | | | | |
| |  Very little |  Rather little |  neutral |  Rather much |  Very much |
| 2 | What was the best part of the game? | | | | |
| 3 | How easy or difficult was it to find out where to go? | | | | |
| |  Very difficult |  difficult |  neutral |  easy |  very easy |
| 4 | Did you notice the animal posters? | | | | |
| 5 | If yes, did they help you find out where to go? | | | | |
| 6 | What did you think about the ducks crossing the road? | | | | |
| 7 | What did you think about the cars at the intersection? | | | | |
| 8 | Did you find this level easy or difficult? | | | | |
| |  Very difficult |  difficult |  neutral |  easy |  very easy |
| 9 | What was the easiest/hardest part of the level? | | | | |
| 10 | Would you like to play this game again? | | | | |
| 11 | Do you think you could play this game multiple times and still enjoy it? | | | | |
| 12 | How nauseous did you get while playing the game? | | | | |

| | | | | | |
|---|---|---|---|---|---|
| |  Extremely nauseous (child couldn't continue playing) |  Very nauseous |  nauseous |  Hardly nauseous |  Not nauseous |

| Observations while playing: | | | | |
|---|---|---|---|---|
| | What emotions does the child display? | | | |
| | Anger: | Happiness: | Frustration: | Excited: |
| | Sadness: | Disgust: | Shameful: | Bored: |
| | Fear: | Surprise: | Contempt: | Other: |
| | When did the child display these emotions? | | | |
| | Does it seem like the child has a hard or easy time playing the game?<br>Why? | | | |
| | Does the child seem nauseous or unable to keep balance on the bike? | | | |
| | What comments does the child make while playing the game? | | | |
| | What comments does the child make after playing the game? | | | |
| | Further comments: | | | |

## Study Population

The participants will be children with DCD and ADHD aged 6 – 12, because the children who receive physical therapy for DCD at Het Roessingh have the same age range and disorder(s). The game gets exclusively made for those type of children, and DCD and ADHD change the way the children view the game, so it is vital that the game gets tested by the target group. Whether they are already in treatment for their condition does not matter, since the point of the study is to find out what they think if the game, not how good they are at playing it.

## Case Definitions

Developmental Coordination Disorder (DCD): DCD is a chronic neurodevelopmental disorder affecting 5-6% of children. Because of the disorder, they are unable to perform daily tasks like getting dressed, handwriting, and doing PE in school. In order to get a diagnosis, the child's problems cannot stem from any known physical, neurological, or behavioural disorder

Attention Deficit Hyperactivity Disorder (ADHD): ADHD is a developmental disorder, occurring in about 5% of the population. ADHD symptoms include inattentiveness, distractibility, impulsivity, hyperactivity, low frustration tolerance, shifting activities frequently, difficulty organizing, and daydreaming.

### Risks

There are a few risks for the participants. A small percentage of children can experience motion sickness. This usually happens with children who have no experience with VR and computers and who get motion sickness quickly. For this reason, any potential participants who have extreme sensitivity for motion sickness or have no experience with VR or computers will not be allowed to participate.

If a child does happen to get sick, the testing will be stopped immediately, and the child will have some time to rest on a chair or coach while drinking some water. Once the nausea has been alleviated, they can continue testing, but only if they want to.

Another risk is that children with DCD have balancing issues. This means that there is higher chance for a child to fall off the bike, even if it is stationary. To minimise the risks, a person will be standing next to them the entire time, to help stabilize them.

### Inclusion criteria:

- 6-12 years old
- ADHD
- DCD

### Exclusion criteria:

- Extreme sensitivity for motion sickness
- No experience with computers or VR

### Estimated number of participants

The estimated number of participants will be around 5 children. Because of the timeframe for this study, more children cannot be tested. Testing one participant will take around 30 minutes, and all participants will have to be tested in one afternoon.

### Enrolment

Eligible participants will be enrolled via het Roessingh. Their parents will be contacted and sent the information letter.

### Data Handling and Analysis

All the data will be taken anonymously. Only the age and gender of the participant will be linked to the data. The data will be stored as documents and graphs.

## Glossary

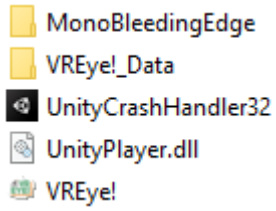
- DCD — Developmental Coordination Disorder
- VR — Virtual Reality
- ADHD — Attention Deficit Hyperactivity Disorder

**Appendix 6.** Instructions Document

# Instructies VReye! Demo

**Opstarten**

1. Klik op de WeTransfer link.
2. Klik op downloaden.
3. Het gedownloade bestand is een '.zip'. Klik met je rechtermuisknop op de map (VReye Demo) en 'unzip' het bestand.
4. Open het mapje. Hierin zie je de volgende bestanden:




5. Start het spel met een dubbelklik op 'VREye!' (het onderste bestand).
6. Het spel start in full-screen modus met het volgende scherm:


7. Klik op 'Hond', 'Kat', of 'Konijn'.
8. Klik op 'Start toetsenbord' om het spel te starten

**Doel van het spel**

Het doel van het spel is om het verloren huisdiertje terug naar het baasje te brengen. Het baasje bevindt zich op de kaart bij het "Einde". Tijdens de route zijn er obstakels die de speler tegenkomt en voor op moet passen. De speler wordt ook beloond met lachende smileys op het scherm wanneer de speler op dingen let die belangrijk zijn, zoals verkeersborden.

**Het spel spelen**

Het spel start met het volgende scherm:


Links zie je het scherm met het spel. Rechts zie je het therapeuten scherm. Dit is een interface dat alleen de therapeut kan zien tijdens het spelen van het spel. Het doel is om bepaalde game instellingen aan te passen om de game moeilijker of makkelijker te maken.

Gebruik de volgende toetsen om het spel te spelen:

- Toetsenbord W/ Pijltje Omhoog: Vooruit Bewegen
- Toetsenbord S/ Pijltje Omlaag: Achteruit Bewegen
- Toetsenbord A/ Pijltje Links: Naar Links Sturen
- Toetsenbord D/ Pijltje Rechts: Naar Rechts Sturen
- Rechtermuisknop indrukken en muis bewegen: Om je heen kijken
- Toetsenbord X: Therapeuten scherm in-/uitschakelen
- Toetsenbord C: Webcam en microfoon aan/uit zetten
- Toetsenbord Escape: Spel Afsluiten

Gebruik de knoppen in het therapeutenscherm als volgt:

- X: Therapeuten scherm in-/uitschakelen
- Eenden: Eenden obstakel in-/uitschakelen
- Auto’s: Auto obstakel in-/uitschakelen
- Webcam en microfoon: Webcam en microfoon aan/uit zetten
- Onder de webcam en microfoon knop kunt u kiezen welke aangesloten webcam en microfoon u wilt gebruiken.
- Stuur: Stuur in-/uitschakelen. Dit helpt tegen motion sickness in VR.
- Vogels: Achtergrondgeluid (vogels) in-/uitschakelen
- Dempen: Al het spel geluid in-/uitschakelen
- Bomen: Bomen in-/uitschakelen
- Calibreer Speler Positie: Positie van speler kalibreren. Dit hoeft alleen in VR.

**Einde van het spel**

Het spel eindigt als de speler de eindlocatie heeft bereikt. Dit is een boerderij aan het einde van een zandweg, waar het baasje staat te wachten op haar huisdier. Vervolgens krijgt u het eindscherm in

beeld. Je kan hier de score zien en het spel herstarten als je wilt. Om het spel af te sluiten, druk op de escape knop op je toetsenbord.

**Appendix 7.** Questions for Expert Review

# Vragenlijst VREye! Demo

Vragen voor de experts zelf:

Wat is uw eerste indruk van het spel?

Zijn er aspecten die u iets veranderd wilt zien? Zo ja, welke en waarom?

Hoe leerzaam is de omgeving?
Niet leerzaam – neutraal – leerzaam
Kunt u uw antwoord toelichten?

Hoe makkelijk was het spel om te gebruiken?
Zeer moeilijk – moeilijk – neutraal – makkelijk – Zeer makkelijk
Kunt u uw antwoord toelichten?

Hoe duidelijk was het therapeutenscherm voor u?
Zeer onduidelijk – Onduidelijk – Neutraal – Duidelijk – Zeer duidelijk
Kunt u uw antwoord toelichten?

Ging er iets mis tijdens het spelen?

Is dit level geschikt als level 1 in het spel?
Zeer ongeschikt – ongeschikt – Neutraal – geschikt – Zeer geschikt
Kunt u uw antwoord toelichten?

Hoe realistisch zijn de verkeershandelingen in het spel?
Erg onrealistisch – onrealistisch – neutraal – realistisch – erg realistisch
Kunt u uw antwoord toelichten?

Stel deze leeromgeving wordt doorontwikkeld naar een erkende behandelmethode. Hoe waarschijnlijk is het dat u deze methode zou inzetten bij de behandeling van de doelgroep?
Zeer onwaarschijnlijk – onwaarschijnlijk- neutraal – waarschijnlijk - zeer waarschijnlijk.
Kunt u uw antwoord toelichten?

Doelgroep: Kinderen met DCD en ADHD van 6 tot 12 jaar.

Vragen over de doelgroep:

Hoe leuk zou de doelgroep het spel vinden?
Helemaal niet leuk – niet leuk – neutraal – leuk – heel erg leuk
Wat zouden ze leuk/niet leuk vinden?

Hoe denkt u dat de doelgroep zal reageren op dit spel?
Erg ongeïnteresseerd - ongeïnteresseerd – neutraal – geïnteresseerd – erg geïnteresseerd
Kunt u uw antwoord toelichten?

Denkt u dat het duidelijk is voor de doelgroep welke kant ze op moeten fietsen?
Erg onduidelijk – onduidelijk – neutraal – duidelijk – erg duidelijk
Kunt u uw antwoord toelichten?

Als het niet duidelijk is, wat zou het duidelijker maken voor de doelgroep?

Denkt u dat de dieren posters duidelijk genoeg zijn voor de doelgroep?
Erg onduidelijk – onduidelijk – neutraal – duidelijk – erg duidelijk
Kunt u uw antwoord toelichten?

Wat zou eraan veranderd kunnen worden aan de posters om het duidelijker te maken, als dat nodig is?

Hoe zal de doelgroep reageren op de eendjes die de weg oversteken?

Hoe zal de doelgroep reageren op het kruispunt met de auto's?

Denkt u dat de doelgroep dit level moeilijk of makkelijk vindt?
Zeer moeilijk – moeilijk- neutraal – makkelijk – zeer makkelijk
Kunt u uw antwoord toelichten?

Hoe gemotiveerd blijft de doelgroep om dit spel meerdere keren te spelen?
Erg ongemotiveerd – ongemotiveerd – neutraal – gemotiveerd – erg gemotiveerd
Kunt u uw antwoord toelichten?

Overige op-/aanmerkingen over het spel:

**Appendix 8.** Test Results

| **Q1** | **Q2** | **Q3** |
|---|---|---|
| Wat is je eerste indruk van het spel? | Zijn er aspecten die je zou willen veranderen? Zo ja, welke en waarom? | Hoe leerzaam is de omgeving? |
| mooie omgeving prettige omgevingsgeluiden (al staat de koekoek wel erg op herhaling :-) | - er lijkt niets te gebeuren als je iets verkeerd doet (over eendjes rijdt, door de boerin rijdt)<br>- weinig smiley's voor goed gedrag (geen belonging bij goed gedrag (bijv. bij stoplicht) ook niet duidelijk wanneer ze uitgedeeld worden<br>- weinig auto's, alleen bij het stoplicht<br>- tweede eendenbord staat in een bocht en niet goed te zien<br>- de link tussen de punten, smiley's en het gedrag is niet duidelijk | Leerzaam |
| Leuke verhaallijn, mooie graphics, leuk dat je laatste stukje ofroad gaat. (Krijg wel erg de verleiding in het water te gaan rijden, maar goed dat dit geblokt is. De struiken aan de linkerkant kun je wel doorheen, geeft hele realistische ervaring alsof je er echt doorheen rijd!) | -Het is me onduidelijk wanneer je nou wel en niet smileys krijgt. Lijkt nu op vaste plekken te gebeuren. Maar het is vreemd als je ene keer goed kijkt naar bord dat je de smileys krijgt en andere momenten, dat je ze verwacht, niet.<br>-Aan het einde kom je aan op de boerderij daar staat iemand klaar.. misschien kan ze wat tegen je zeggen. Nu rij je bij haar in de buurt gebeurd er niks en dan na een paar seconden is het spel ineens afgelopen.<br>-Aan het einde van het spel krijg je een score (maar het is niet duidelijk waar deze uit is opgebouwd). Misschien goed om deze statistics versimpeld te laten zien aan gebruiker en in detail aan zorgverlener.<br>-Je krijgt geen feedback in de game als er iets verkeerd gaat. Op zich snap ik dat deze feedback beter door therapeut gegeven kan worden. Maar misschien wel goed om dit dan aan te geven in het therapeutenscherm. (als je tegen eendjes aanrijd/door rood rijdt of de verkeerde kant op rijdt). | Leerzaam |
| De omgeving ziet er heel mooi uit, leuk dat er veel variatie is in de huizen, bomen/struiken en dergelijke. Het startscherm is ook mooi geworden. | Het zou mooi zijn als je een soort introductie krijgt, dat wil zeggen dat je bijvoorbeeld de hond achterop jouw fiets ziet springen voordat je begint. Ook denk ik dat er meer structuur moet in het scoresysteem. Dat je bijvoorbeeld aan het begin al duidelijk maakt als je naar een verkeersbord of stoplicht kijkt, krijg je smileys en als je stopt voor de eendjes of het rode licht. Misschien ook smileys als je goed op het fietspad blijft?<br>Het zou mooi zijn als je als therapeut ook andere weggebruikers kunt toevoegen/weglaten. | Leerzaam |
| ziet er mooi uit | start storyline, dat je weet wat het doel is van het spel in de spelomgeving zelf. bochten sturen lastig | Neutraal |
| (Ik heb alleen de video kunnen bekijken en dus niet zelf gespeeld.) Leuk! Ziet er leuk uit en er zitten | Ik vind het tempo vrij hoog. Je fietst heel hard. Of ligt dat aan de video... | Neutraal |

| | | |
|---|---|---|
| leuke dingen in (eendjes, bloemen, enz.) | | |

| Q4 | Q5 | Q6 |
|---|---|---|
| Licht je antwoord toe (optioneel): | Hoe makkelijk was het spel om te gebruiken? | Licht je antwoord toe (optioneel) |
| geen auto's die langs rijden, waar je niets mee hoeft te doen, maar die je wel dwingen om netjes op het fietspad te blijven rijden. Weinig en onduidelijke visuele feedback. Ik zie in deze geen mogelijkheid om een kind een deel van het traject opnieuw te laten doen. | Makkelijk | lijkt redelijk intiutief te werken wat een plus punt is. Het is vervelend om als therapeut eerst allerlei handleidingen door te moeten ploegen om iets te kunnen gebruiken. Dat maakt ook vaak de drempel voor het gebruik in de therapie hoog. Je moet dan wel heel gemotiveerd om er mee te gaan werken. |
| Als ik me een kind voor fietstraining inbeeld, denk ik dat dit een mooi basis level is om ervaring op te doen met fietsen in een realistische buitenomgeving. (ervaring opdoen met sturen en trap/snelheid verhouding (al kwam deze snelheid nu in de pc game niet echt naar voren, het was fietsen of stop en kleine vertraging/versnelling en daarna constante snelheid), maar ik neem aan dat bij VR game wel echt afgestemd is op trapsnelheid. | Heel makkelijk | Zeer makkelijk in gebruik. De applicatie opstarten en je kan beginnen. Bij mij werkte het prima, maar het zichtsveld veranderde niet met bewegingen van de muis! Verschillende sneltoetsen om te kunnen schakelen tussen therapeuten scherm en volledig scherm in het spel (maar ook goed dat er ook de optie is om dit met de muis aan te klikken). |
| Het is een goede weergave van de werkelijkheid. Ik denk wel dat het in VR een stuk leerzamer is. | Makkelijk | Het was heel vanzelfsprekend, maar ik denk dat een soort intro/hulp (bijv. "klik op jouw lievelingsdier") wel handig is. |
| neutraal, want ik ben geen behandelaar | Neutraal | bochten zijn lastig |
| Ik ben geen therapeut, dus kan ik niet zeggen | Neutraal | Heb het niet zelf kunnen spelen |

| Q7 | Q8 | Q9 |
|---|---|---|
| Hoe duidelijk was het therapeutenscherm? | Licht je antwoord toe (optioneel) | Is dit level geschikt als level 1 in het spel? |
| Duidelijk | | Geschikt |

| | | |
|---|---|---|
| Duidelijk | Duidelijk bedienbare knoppen. Het enige wat ik dus nog mis is de (realtime) statistics van goed/verkeerd afgewerkte verkeerssituaties (bijv. reactietijd etc) | Geschikt |
| Neutraal | De knoppen onderaan zijn wel duidelijk, maar het is niet zo duidelijk dat je op de stippen in de kaart kan drukken om het aan/uit te zetten | Ongeschikt |
| Duidelijk | | Neutraal |
| Neutraal | niet gezien | Neutraal |

| Q10 | Q11 | Q12 |
|---|---|---|
| Licht je antwoord toe (optioneel) | Hoe realistisch zijn de verkeershandelingen in het spel? | Licht je antwoord toe (optioneel) |
| | Realistisch | - van mij mag er een auto langs rijden, |
| Rustige omgeving weinig afleidingen (geen ander verkeer op de weg). Focus op fietspad blijven en de route bordjes volgen lijkt me erg geschikt voor level 1 | Realistisch | -Stoplicht doet maar 1x zijn werk. Als je namelijk teruggaat blijven de andere stoplichten continu op rood staan. Verder ogen de situaties erg realistisch. |
| Ik denk dat er misschien teveel in zit (eendjes, stoplicht, rotonde). Het is wel goed om met de rechte weg te beginnen. | Realistisch | Het stoplicht voelde wel realistisch |
| ik ben geen behandelaar. Ziet er uit als een mooi level. Ik zou een duidelijk doel(behandeldoel) toevoegen wat je per level kan leren, zodat de behandelaar makkelijk kan kiezen uit de levels? | Realistisch | |
| | Neutraal | |

| Q13 | Q14 | Q15 |
|---|---|---|
| Hoe waarschijnlijk is het dat dit spel wordt ingezet bij de behandeling van de doelgroep? | Licht je antwoord toe (optioneel) | Is er iets mis gegaan tijdens het spelen? Zo ja, wat? |
| Waarschijnlijk | | het kind kan nog omdraaien en de verkeere kant op gaan fietsen. Dit lijkt mij niet |

| | | |
|---|---|---|
| | | overeen komen met de realiteit |
| Waarschijnlijk | In VR kan deze game echt bijdragen aan als brug tussen de praktijk lessen binnen naar het toepassen van geleerde fietstraining in de werkelijke buitenwereld. | ja muisbewegingen lieten gezichtveld niet veranderen |
| Neutraal | Ik denk dat het potentie heeft om te gebruiken, maar dat het nu nog niet gebruikt kan worden. | Nee |
| Neutraal | besturing en misselijkheid zijn cruciaal hierin | niks mis gegaan |
| Neutraal | | Kon het spel niet opstarten op mijn computer... |

| Q16 | Q17 |
|---|---|
| Heb je nog opmerkingen over het spel? | De volgende vragen zijn bedoeld voor behandelaren.<br><br>Ben je werkzaam als behandelaar? |
| zie boven | Ja |
| -Veel beter om het spel zo te spelen ipv in VR (geen misselijkheid ;) ). -Misschien ook nog werken met handen uitsteken bij afslaan? | Nee |
| Nee | Nee |
| nee | Nee |
| Sorry, ik kon niet veel antwoorden geven... | Nee |

| Q18 | Q19 | Q20 | Q21 | Q22 | Q23 |
|---|---|---|---|---|---|
| Hoe leuk zou de doelgroep het spel vinden? | Wat zouden de kinderen wel/niet leuk vinden? | Hoe denk je dat de doelgroep zal reageren op het spel? | Licht je antwoord toe (optioneel) | Denk je dat het duidelijk is welke kant de kinderen op moeten fietsen? | Licht je antwoord toe (optioneel) |

| | | | | | |
|---|---|---|---|---|---|
| Leuk | moeilijk om in te schatten of dit te makkelijk is, maar dat moet de praktijk uitwijzen | Geïnteresseerd | | Duidelijk | de praktijk zal uit moeten wijzen of de kinderen de verkeerborden met de richting er op snappen. |

| Q24 | Q25 | Q26 | Q27 | Q28 | Q29 |
|---|---|---|---|---|---|
| Hoe leuk zou de doelgroep het spel vinden? | Wat zouden de kinderen wel/niet leuk vinden? | Hoe denk je dat de doelgroep zal reageren op het spel? | Licht je antwoord toe (optioneel) | Denk je dat het duidelijk is welke kant de kinderen op moeten fietsen? | Licht je antwoord toe (optioneel) |
| Leuk | moeilijk om in te schatten of dit te makkelijk is, maar dat moet de praktijk uitwijzen | Geïnteresseerd | | Duidelijk | de praktijk zal uit moeten wijzen of de kinderen de verkeerborden met de richting er op snappen. |

| Q30 | Q31 | Q32 | Q33 |
|---|---|---|---|
| Denk je dat de kinderen dit leven moeilijk of makkelijk vinden? | Licht je antwoord toe (optioneel) | Hoe gemotiveerd zouden de kinderen zijn om het spel meerdere keren te spelen? | Licht je antwoord toe (optioneel) |
| Makkelijk | als "leven" level betekent, denk ik dat kinderen dit niet heel moeilijk vinden, maar dat het wel een goed level is om aan de vr-bril en de omgeving te wennen. | Gemotiveerd | als je delen opnieuw kunt doen en niet iedere keer weer naar het startpunt moet gaan. Zijn ze minder gemotiveerd, dan kan het ook betekenen dat ze naar het volgende level moeten gaan. De link tussen gedrag, smiley's en punten is niet duidelijk en zou wel motiverend kunnen werken. |

| Q34 | Q35 | Q36 | Q37 |
|---|---|---|---|
| Denk je dat de dierenposters duidelijk genoeg zijn voor de doelgroep? | Zou je iets aan de dierenposters willen veranderen? Zo ja, wat? | Hoe zouden de kinderen reageren op de overstekende eendjes? | Hoe zouden de kinderen reageren op het kruispunt met de auto? |
| Duidelijk | ik weet het even niet. Moeten we testen op kinderen | lijkt mij goed, de eerste eendjes staan wat in een dondkere berm, de andere eendjes zijn beter van te voren te zien. | lijkt mij prima, ze hoeven er |

| | | | |
|---|---|---|---|
| | | | ook niet heel veel |

## **Appendix 9.** Final Product

The link brings you to a wetransfer site where you can download a .zip containing the .exe file of the game, a video of the game, and an instructions document.

https://we.tl/t-yZM8IhL08X