7/30/2019

RE-PLAY

Support of paediatric rehabilitation through mobile coaching and interactive playground

Roessingh

Centrum voor Revalidatie

Roessingh

Research and Development

UNIVERSITY OF TWENTE.

Wesley Everlo

ROESSINGH RESEARCH AND DEVELOPMENT

Study and thesis information
Master: Health Sciences
Track: Personalised monitoring and coaching
Title: RE-PLAY – support of paediatric rehabilitation through mobile coaching and an interactive playground.

Student:
W.R. Everlo | s1598341

Institutions:
University of Twente
Roessingh Research and Development
Roessingh Centre for Rehabilitation

Supervisors:
University of Twente
Dr. ir. B.J.F. van Beijnum
Dr. ir. M. Tabak

Roessingh Research and Development
Dr. ir. M. Cabrita

Preface

This thesis is the final part of my Master's degree in Health Sciences at the University of Twente, where the focus has been on Personalized Monitoring and Coaching. The assignment started at Roessingh Research and Development, and Roessingh Centre for Rehabilitation in Enschede. A period of hard work, patience and optimism resulted in a proudly presented thesis called *"RE-PLAY: support of paediatric rehabilitation through mobile coaching and interactive playground."*

I have learned a lot during my period at Roessingh Research and Development. This has been mainly due to the guidance and support of my supervisors. I would like to thank dr. ir. B.J.F. van Beijnum, my first supervisor, for his support and critical, valuable feedback. Secondly, I would like to thank dr. ir. M. Tabak and dr. ir. M. Cabrita for their enthusiastic and critical guidance at Roessingh Research and Development. Thirdly, I would like to thank A. Dijkstra, who was closely involved with the RE-PLAY project and made sure the participants were reached. The doors of all four supervisors were always open whenever I had questions and they provided me with useful answers, which ensured the successful completion of this Master's thesis. Finally, I would like to thank dr. J. Driessen, who allowed me to finish my thesis by granting me the time necessary to do so during my time at OCON.

Furthermore, I would like to thank all participants (the physiotherapists, the children and their parents). Without you, this thesis would not have been possible.

Finally, I would like to thank my family and friends for their support, especially the "RRD-family" in the student-room at Roessingh Research and Development for providing great and fun weeks.

Enjoy reading this thesis!

Wesley Everlo

Tubbergen, July 30th, 2019

Abstract

Background: Physical activity is important for all children, including children with cerebral palsy (CP) and developmental coordination disorder (DCD). Reaching the guidelines of physical activity will result in keeping their condition stable, gaining better motor skills, and better daily functioning. By using eHealth as medium, the reach of the therapists can be expanded and the benefits of therapy improved. This study aims to produce a set of requirements needed for such an eHealth application, by eliciting needs, values and wishes of children, parents and therapists. The persuasive systems design (PSD) model will be incorporated in the requirements production, along with an objective assessment of physical activity.

Methods: This study was carried out at Roessingh Research and Development and Roessingh Centre for Rehabilitation. A total of three children with DCD, three parents of these children, and four therapists treating children with CP and DCD participated. Semi-structured interviews were held to elicit the needs, values and wishes of participants. Interview data was transcribed a verbatim and coded using thematic analysis. After coding, requirements were formulated and if possible, linked to components of the PSD model. Additional PSD model requirements for children were obtained through a questionnaire. To gain insight in the physical activity behaviour of the target population, ActiGraph data of children receiving care at Roessingh Centre for Rehabilitation was analysed.

Results: The personalized aspect of RE-PLAY, along with a rewarding system, clarity of task description, use of the Wat-Hoe-Doe-Check methodology and success experience were the most important requirements. P*ersonalization, reduction, tailoring, rewards and self-monitoring* were the most mentioned PSD principles by all participants (three children, three parents, three therapists). The ActiGraph study consisting of 9 children (♂/♀ = 7/2, mean age = 7,8 years, all DCD) showed that on average, children adhere to the guidelines of physical activity with an average step amount of 8763 ± 3716. Moderate-to-vigorous physical activity levels amounted to 13.57%.

Conclusion: This study showed that to adapt AIRplay to RE-PLAY, attention has to be paid to the individual child. The interface and the layout of the application should become customizable to create a personalized and tailored application linked to the interest of the individual child. At last, the application needs to provide information and feedback based on the Wat-Hoe-Doe-Check methodology. Regarding the PSD principles, AIRplay can be adapted by implementing tunnelling and simulation, as well as modifying praise, rewards and reminders. Furthermore, it can add a real-world-feel by allowing parent to communicate with each other through the application.

Table of Contents

1. Introduction

Cerebral Palsy (CP) and Developmental Coordination Disorder (DCD) are both neurodevelopmental disorders that start in the early developmental period of children (1, 2). CP has a prevalence of 2.11 per 1000 live births and has a negative effect on life expectancy, as 27% of patients will reach the 40-year milestone (3). DCD affects an estimated 5-6% of all school-aged children, of which two percent is severely impacted by the disorder (4).

Both disorders are considered paediatric illnesses, while they remain a lifelong disorder, as children do not outgrow their disorder (5-7). CP is described as "a group of permanent disorders of the development of movement and posture, causing activity limitation, which are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain" (8). The movement and posture disorders are generally accompanied by sensory, perceptive, cognitive, communicative, and behavioural disturbances, by epilepsy, and by secondary musculoskeletal problems (9).

A child with DCD has motor coordination below expectations for the chronological age and is often described as 'clumsy'. Difficulties with coordination of gross and/or fine motor movements interfere with academic achievements and everyday living. These difficulties occur despite any medical condition like cerebral palsy, hemiplegia or muscular dystrophy and any mental retardation. DCD is a chronic disorder that will continue to be present when the child becomes an adult. While DCD is a disorder represented worldwide, it is unrecognized by healthcare and educational professionals as such (2, 10).

Children with one of the two disorders have more trouble with and are likely to be less physically active than their typically developing peers. Physical activity happens to be an important aspect in the development of children. Sustaining a stable level of physical activity is important to prevent various chronic diseases occurring in late adulthood. Physical activity can positively influence the decline of CP and can even help children with DCD to improve their motor skills (11, 12). The problem that arises is physical inactivity, because children are less motivated to pick up adequate levels of physical activity (13).

Current treatment of children with CP is focused on increasing daily life skills, linked to what the children want to learn themselves (14). For children with DCD, treatment is personalized as well, through the use of the Cognitive Orientation to daily Occupational Performance (CO-OP) method (15).

Within the world of healthcare, eHealth is an emerging field and increasingly seen as pivotal in redesigning healthcare system to provide safe, effective and convenient healthcare (16). By using eHealth, therapists may be able to extend their impact on the children's lives outside therapy hours. This extended impact could be used to promote health behaviours and their associated outcomes (17). An example of such a technology is AIRplay, an intervention designed for children with asthma to increase their physical activity levels by using an application for monitoring physical activity and an interactive playground within the hospital. The concept of AIRplay was valued positively, children found the experience fun and the current management of asthma among children could be boosted (18). This approach might also be suitable for children with CP and DCD, which caused the incentive to develop the RE-PLAY application, a continuation of the AIRplay system. To develop such an application, it is necessary to determine values that are of importance to children with CP and DCD, their parents and therapists treating this group.

The objective of this study is to determine the requirements needed to adapt the AIRplay system for application in the paediatric rehabilitation of children with CP and DCD, forming the RE-PLAY system. The aim of the RE-PLAY system is to aid children with CP and DCD in reaching a physically active lifestyle. The aim will be realized by answering the following research questions:

1. *What are the needs, values and wishes of children, parents and therapists regarding the use of eHealth technologies in the promotion of physical activity within paediatric rehabilitation?*

2. *Which persuasive features, following the principles of the Persuasive Systems Design model, are of importance when focussing on paediatric rehabilitation, and in particular CP and DCD?*

Approach

A flowchart of the outline of this thesis is depicted in figure 1. Following *research question 1*, a literature research was conducted to create an understanding of the different topics present. This resulted in the background of this thesis (chapter 2). Next, interviews with children who are diagnosed with CP and DCD, parents of children within these groups, and therapists treating children with CP and DCD will be held to gather information on the needs, values and wishes they deem important. By linking the answers interviews to components of the Persuasive Systems Design (PSD) model (19), the persuasive features that are important can be highlighted. In addition, physical activity measurements using ActiGraph data were gathered to create an understanding of the current physical activity levels of children with CP and DCD, so the added value of RE-PLAY can be predicted. *Research question 2* will be derived from the interviews as well, by linking the answers of the interviews to components of the PSD model (chapter 3). The findings from the literature study, the interviews and the physical activity data form the input for the development of the requirements (chapter 4). This thesis is finalised in chapter 5 where noticeable findings will be discussed.

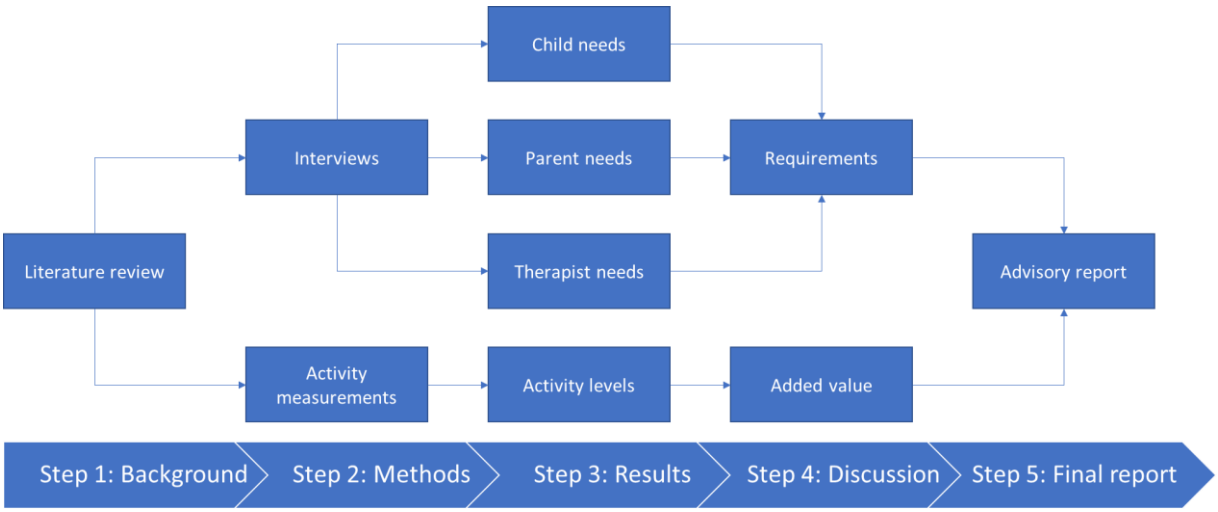


Figure 1 Flowchart of the research process

2. Background

2.1. Cerebral Palsy

Cerebral Palsy (CP) is a neurodevelopmental condition that establishes itself in early childhood and will persist through the entire lifespan of an individual (1). CP is described as a group of permanent disorders of the development of movement and posture, causing activity limitation, that are attributed to non-progressive disturbances that occurred in the developing foetal or infant brain (8). The movement and posture disorders are generally accompanied by sensory, perceptive, cognitive, communicative, and behavioural disturbances, by epilepsy, and by secondary musculoskeletal problems (9).

Many mechanisms have been proposed to explain the cause, nature and timing of the definitive cerebral impairment. However, adverse factors may have been present for some time during the pregnancy. Most cases of CP result from an interference in the development of the brain while in utero. MRI scanning has proven to be useful in understanding this process, because 85% of the CP cases show abnormal MRI scans. The MRI scans can provide an estimate of the timing of the lesion and assist in determination of whether the lesion is responsible for the motor impairment or is an incidental finding (5).

CP is considered to be a paediatric illness, while it is a lifelong disorder. Outcomes in adulthood have been less than positive, as adults with CP are not fully integrated socially, have less experience with relationships, and have lower participation in paid work. This shows the need for clinical practice to adopt a life-long perspective on the disorder (5, 6). Pain, fatigue and depressive symptoms are common in adults with CP as well, and there is evidence suggesting a more rapid ageing in adults with CP (6, 20). Health related quality of life (HRQOL) is lower in individuals with CP than the general population. Clear relations between the severity of CP and HRQOL are present (21).

CP has an estimated overall prevalence of 2.11 per 1000 live births. There is increased prevalence in extremely low birthweight neonates (50 per 1000 live births) and in multiples (7 per 1000 live births) (22). There are a number of factors that may contribute to a decreased risk of CP, such as the use of antenatal corticosteroids, cooling for term-born asphyxiated infants, and the use of magnesium sulphate. The risk of CP decreases significantly when the child is born weighing above 1500 grams (3). Overall, the total rate of CP is relatively stable, although the contribution of premature born children, along with the complications to the prevalence it has, are steadily increasing as a result of improvements in obstetric and neonatal care (22).

The survival and life expectancy of individuals with CP depends on the severities of mental, manual, ambulatory, and visual impairments. If all of these factors are not severely impaired, survival is only marginally less than that of individuals without CP. When the impairments are severe, the life expectancy is reduced approximately in proportion to the number and severity of associated impairments. When a child with CP had four severe impairments at age two, 72% lived to 10 years, 44% to 20 years, 34% to 30 years and 27% to 40 years. Quality of care can be relevant in surviving the first ten years. The most common death cause in 50% of the individuals with CP was CP itself. Pneumonia causes 23% and aspiration 11% of CP deaths (5, 23).

Treatment of CP is focused on the promotion of the most normal, manageable and healthy life possible. A wide variety of treatment options is available for individuals with CP, as diagnosis differs considerably. Contemporaneous management of CP can be broadly categorized into 3 areas of focus. The first area focuses child-active rehabilitation approaches. Here the child is actively practicing real-life tasks during intervention for the purpose of gaining or consolidating real-life skills that they want to learn. The second area focuses on compensatory and environmental adaptation approaches. These approaches involve society changing around the child instead of changing the child. These interventions include provision of environmental and task modifications or specialized equipment to accommodate the disability of the child, promote inclusion, and independence. The third and last area focuses on health and secondary prevention approaches. These approaches are the provision of interventions designed to manage the child's health and comorbidities and prevent or lessen the natural history of CP from worsening the child's outcome (14).

2.2. Developmental Coordination Disorder

Developmental Coordination Disorder (DCD) is a neurodevelopmental disorder. This indicates that the symptoms must begin in the early developmental period and not be the consequence of lesions. A child with DCD has motor coordination below expectations for the chronological age and is often described as 'clumsy'. Difficulties with coordination of gross and/or fine motor movements interfere with academic achievements and everyday living. These difficulties occur despite any medical condition such as cerebral palsy or hemiplegia. DCD is a chronic disorder that will continue to be present in adulthood. DCD is a disorder represented worldwide, yet remains unrecognized by healthcare and educational professionals as such (2, 10).

Several studies have assessed psychosocial, motor and executive functions in adults with DCD. A small-scale study noted that adults with the disorder had significantly high levels of depressive symptoms and anxiety (7), as well as decreased levels of participation in their daily lives, and a lower quality of life and life satisfaction (24).

DCD does not have one discrete aetiology, therefore its boundaries with other behavioural disorders have been questioned. Motor impairments co-occur with other neurodevelopmental disorders in 40% of the case, making comorbidity common in DCD. To allow proper treatment, it is important to look at the fact of comorbidity. The aetiology of DCD is currently thought to be one of multiple factors as no single cause has been identified (2).

DCD affects 5-6% of all school-aged children, of which 2% is severely impacted by the disorder (4). A systematic review concerning school-aged children and the risk of DCD showed the following results: children with a lower birthweight (<1500 grams) or who were very premature (<32 weeks) had significantly greater odds of DCD (25). Boys are 1.7 to 2.8 times more likely than girls to have the disorder. Difficulties with attention, social communication, repetition of unfamiliar words, spelling and reading are additional risk factors of DCD (10).

Children with DCD mostly receive different types of therapies aimed at improving their motor performance. Task-oriented interventions and traditional motor-based skill training yield significant effects. The CO-OP method is one of these task-oriented methods that operates via a top-down approach with a particular focus on the use of cognitive strategies to facilitate skill acquisition. The CO-OP method uses a collaborative, problem-solving approach adapted from cognitive-behavioural therapy. The CO-OP method should be prescribed with some confidence to children who are in need of intervention to improve their motor performance (15). Motor performance is important to children with DCD, physical activity might be a possible intervention to strengthen this weakness.

Observation in practice

In advance of conducting the study and the gathering of data, the opportunity to observe a physiotherapist during one of his practices was taken. The observed children (n=2) were both diagnosed with DCD. The main findings of this observation were that children with DCD were very easily distracted, experienced difficulties with regard to learning when performing and repeating exercises, even when experiencing failure. Furthermore, the children had little to no creativity to come up with solutions for their physical activity difficulties. The full report is depicted in appendix 1.

2.3. Physical activity

Physical activity is an important component in the development of children, as it is associated with many health benefits, even when exercised moderately (26). Furthermore, physically active behaviour in youth is likely to be carried through into adulthood. However, the majority of youth does not meet the recommended physical activity threshold of at least 60 minutes of moderate to vigorous physical activity (MVPA) per day (27). In comparison to healthy children, children with disabilities are more restricted in their participation, have lower levels of fitness, and a higher level of obesity. The health benefits of physical activity are, however, universal for all children, including those with disabilities (28).

Because children spend a considerable amount on consuming digital media, of which a large part is spend on gaming, a shift in lifestyle has occurred. Regarding the physical aspect of this shift, studies have shown an increase in sedentary behaviour of young children in western cultures, which is associated with digital games (29).

Concerning the right amount of physical activity, no consensus has yet been reached. Multiple guidelines regarding physical activity have come and gone. The core, however, has remained quite stable. The physical activity guidelines throughout the years can be seen in table 1, along with the benefits granted by conforming to the guidelines.

Table 1: physical activity guidelines for school-aged children (30)

Source	**Year**	**Recommendations**	**Benefit(s)**
American College of Sports Medicine (31)	1988	Twenty to 30 minutes of vigorous exercise each day	Developing and maintaining functional capability to meet the demands of living and to promote optimal health
International Consensus Conference on Physical activity Guidelines for Adolescents (32)	1994	1. Be physically active daily as part of play, games, sports, work, transportation, recreation, physical education, or planned exercise 2. Engage in at least three sessions of moderate to vigorous activities that last at least 20 minutes	1. Protection from chronic diseases such as cardiovascular diseases, non-insulin-dependent diabetes mellitus, osteoporosis and some cancers 2. Increased quality of life, psychological health, and the ability to meet physical work demands and engage in leisure activities
US National Institutes of Health (33)	1995	Accumulate 30 minutes of moderate physical activity on most days of the week	Protection against the development of cardiovascular diseases
US surgeon General (34)	1996	Accumulate 30 minutes of moderate physical activity on most days of the week	1. Reduced risk of developing coronary heart disease, hypertension, colon cancer, and diabetes 2. Reduced risk of depression and anxiety 3. Increased ability to perform daily tasks throughout the life span
UK Health Education Authority (35)	1998	1. Participate in physical activity that is of at least moderate intensity for an average of 1 hour per day 2. Participate in physical activities that enhance and maintain strength in the musculature of the trunk and upper arm girdle at least twice a week 3. The above recommendation should be met by participating in developmentally appropriate activities	1. Enhancement of psychological well-being and reduce symptoms of depression and anxiety 2. Enhancement of self-esteem 3. Enhancement of moral and social development 4. Reduced risk of overweight and obesity 5. Reduced risk of chronic diseases
Australia Department of	1999	1. At least 60 minutes, and up to several hours, of moderate to vigorous physical activity every day	Not mentioned

Health and Ageing (36)		2. Limit screen time to less than 2 hours per day	
Health Canada and the Canadian Society for Exercise Physiology (37)	2002	1. Increase time currently engaged in physical activity by at least 30 minutes per day, progressing to at least 90 minutes per day 2. The 90 minutes should include both moderate (60 minutes) and vigorous (30 minutes) activities 3. Decrease time spent on sedentary activities, initially by 30 minutes, eventually by 90 minutes	1. Builds strong bones and strengthens muscle 2. Maintains flexibility 3. Achieves a healthy weight 4. Promotes good posture and balance 5. Improves fitness 6. Strengthens the heart 7. Meet new friends 8. Improves physical self-esteem 9. Increases relaxation 10. Enhances healthy growth and development
Weight Realities Division of the Society for Nutrition Education (38)	2003	1. Be active for at least 60 minutes per day 2. Limit screen time to less than 2 hours per day and replace it with more activity 3. Increase strength, endurance, and fitness 4. Learn skills for sports and activities that children will continue and enjoy through life	Not mentioned
US National Association for Sports and Physical Education (39)	2003	1. Accumulate at least 60 minutes, and up to several hours, of age-appropriate physical activity on all, or most days of the week, this daily accumulation should include moderate and vigorous physical activities, with the majority being intermittent in nature 2. Children should participate in several bouts of physical activity lasting 15 minutes or more each day 3. Children should participate each day in a variety of age-appropriate physical activities designed to achieve optimal health, wellness, fitness, and performance benefits 4. Extended periods (2 hours or more) of inactivity are discouraged for children, especially during daytime hours	1. Reduced risk of premature death, lower risk of heart disease, colon cancer, hypertension, diabetes, osteoporosis 2. Improved mental health and physical fitness
American Cancer Society (40)	2005	Engage in at least 60 minutes of moderate- to vigorous physical activity at least 5 times a week	1. Reduced risk of several types of cancer, including breast and colon cancer 2. Helps to maintain a healthy body weight
US Department of Agriculture (41)	2005	Accumulate at least 60 minutes of physical activity on most, preferably all, days of the week	1. Reduced risk of chronic disease in adulthood 2. Manage body weight and prevent gradual, unhealthy body weight gain in adulthood

Divisions of nutrition and physical activity and adolescent and school health of the US centers for Disease Control (42)	2005	1. Participate in at least 60 minutes per day of moderate to vigorous physical activity 2. Activities should be developmentally appropriate, enjoyable, and involve a variety of activities	Beneficial effects on musculoskeletal health, several components of cardiovascular health, and overweight.
World Health Organization (43)	2018	1. Children and youth (5-17 years) should accumulate at least 60 minutes of moderate- to vigorous-intensity physical activity daily 2. Amounts of physical activity greater than 60 minutes provide additional health benefits 3. Most of the daily physical activity should be aerobic. Vigorous-intensity activities should be incorporated, including those that strengthen muscle and bone, at least three times per week	1. Healthy musculoskeletal tissues 2. Healthy cardiovascular system 3. Neuromuscular awareness 4. Maintenance of a healthy body weight 5. Improved health and weight status for children aged 3 to 5 6. Improved cognitive function for children aged 6 to 13 7. Decreased risk of certain cancers, dementia and excessive weight gain for adults 8. Reduced feelings of anxiety and depression in adults 9. Improved quality of sleep for adults

When analysing table 1, an increase of 30 minutes concerning the amount of physical activity is seen over the years. The intensity of physical activity that has to be performed in order to reach health benefits is mostly similar, namely moderate-to-vigorous. The type of physical activity, however, differs from source to source. A global similarity can be observed when looking at the effects of physical activity, namely an improvement in both physical and mental health. In addition, the long-term effects are favourable concerning chronic illnesses. As the guidelines set by the World Health Organisation (WHO) are the most recent ones, these will be referred to in this study. For children with physical impairments like CP and DCD, no specific guidelines have yet been formulated.

2.3.1. Physical activity in CP

Physical activity is a key component in the management of CP. Task-related or other intense upper-limb training paradigms, like constraint-induced movement therapy have shown this effect. There are three major potential outcomes from an activity-based rehabilitation approach. The first is the prevention of secondary musculoskeletal impairments and maximization of physical functioning. The second is the fostering of the cognitive, social, and emotional development of children. The third is the development, maintenance and perhaps restoration of neural structures and pathways (11).

The first potential outcome has the greatest clinical and scientific support when compared with the other two potential outcomes. It is commonly known that regular and fairly intense levels of activity throughout the lifespan are important components of optimal health and functioning of every individual. Muscles of individuals with CP need to be stretched to their limits on a regular basis to maintain length, furthermore they need to be loaded adequately and frequently to maintain strength. The bones need compressive loads to stay strong as well, and the heart and lungs need to be exercised at moderately intense levels on a regular basis to maintain endurance and fitness. individuals with CP face more difficulties when trying to reach adequate levels of physical functioning because muscles, bones and the cardiorespiratory system are not fully developed before brain injury occurs. Hence, individuals with CP are likely to have a lower starting point as well as a slowed progress in the development of these structures (11).

The second potential outcome lays the emphasis on the inherent importance of activity in a child's overall development. Physical activity should be encouraged from early age, while the musculoskeletal and nervous system are the most adaptable. However, the scientific evidence supporting this assumption is weak. The effectiveness has not proven more effective when compared to other alternatives, although there is a randomized controlled trial conducted by Girolami and colleagues (44) that used traditional methods as well as postural strengthening techniques, which did show a significantly positive effect on motor control in the treatment group.

The third potential outcome is related to the increase in recognition of the role of activity in the normal development and maintenance of the central nervous system and its proposed role in stimulating neural recovery in damaged nervous systems. Emerging evidence suggests that physical activity may grant health protective benefits for several neurological diseases (45). Recent breakthroughs in neuroscience have highlighted the importance of motor activity for establishing and reinforcing neural pathways, with the opposite occurring when activity is reduced (11).

Physical therapy, along with orthopaedic surgery, has been the backbone of the rehabilitation management of CP for decades. It is less clear to what extent physical therapy can alter the motor prognosis or make clinically significant changes in the level of disability or participation for any child. Traditional methods have shown the most marginal benefits. Strength or resistance training is an exercise for CP with a clear physiological basis. While the rationale for strength training is straightforward, the use of strengthening for those with reduced muscle strength as result of brain lesion has been far more controversial and was contraindicated until just recently. The main reason for this dawned from neurodevelopmental therapy approaches, where it was believed not to strengthen spasticity because it would only worsen spasticity and make patients stiffer. Due to research evidence, the incorporation of strength training has become more prevalent in physical therapy regimens for people with CP (46). Maintaining an adequate level of physical conditioning requires a long-term commitment to exercise for everyone, including people with disabilities (11).

2.3.2. Physical activity in DCD

Children with DCD are less likely to be as physically active as their typically developing peers. They not only perceive themselves to be less competent in basic physical skills, but also perceive themselves to be less adequate in their overall physical activities (12). Children with DCD are more likely to select sedentary activities over active ones and are less likely to enjoy physical education. When sedentary lifestyles are chosen over active ones, the increased risk of negative health and psychological outcomes

appears. Lower generalized self-efficacy seems to be a key factor accounting for why children with DCD are less likely to participate in physical activities (12).

The psychological factors, such as self-efficacy, are often poorly understood in children with DCD. Children with DCD have lower perceived athletic competence than typically developing peers and tend to avoid participation in sports or active pursuits. This leads to a misperception of being unmotivated or lazy. In a study by Kwan and colleagues (47), the Theory of Planned Behaviour (TPB) was used to see what influences the relation between DCD and physical activity. The TPB is a popular framework that hypothesizes that an individuals' intention is directly influenced by three pre-existing factors:

1) Attitude, representing the positive or negative interpretation of the target behaviour;
2) Subjective norms, reflecting the perceived social pressures to perform the target behaviour;
3) Perceived behavioural control, representing someone's beliefs about factors that could enable or hinder behavioural performance and the control over these factors.

The theory suggests that people are more likely to perform a behaviour if they interpret it positively, believe that other important people think they should perform it, and believe that they can control their behaviour (47).

A study conducted by Barnett and colleagues (48) investigated which factors constrain and facilitate participation in physical activity in teenagers with DCD. The study reported that all participating children with DCD had clear desires to be more active. However, a range of barriers to increased activity was recognized by both the children and their parents. The division was made between internal and external factors contributing to the constraints and facilitators.

Internal constraints fell into three sub-themes: motor skill and confidence, poor motivation and lack of time, and fatigue and pain. Motor skills were recognized by all parents as a difficulty for their child when participating in physical education and team sports. Children are generally aware of their motor difficulties and have been found to report lower physical or athletic competence. Self-efficacy and motivation played an important mediating role regarding physical activity. Fatigue is another possible constraint reported by both children and parents. It might, however, be that fatigue is linked to inactivity rather than DCD (48).

External constraints and facilitators included both physical and social factors, falling into five sub-themes: facilities and transport, peers, family, teachers/instructors and activities/tasks. In regard to facilitation and transport, most children are reliant on their parents. When facilities are in close vicinity, there is far less difficulty. DCD can be very puzzling for teachers, as they may view the child as lazy or disruptive. There appears to be a clear need for information and training of PE teachers. Good instruction may facilitate engagement of children with DCD. It can also increase the understanding of the child's motor difficulties, their level of motor competence and a positive and encouraging attitude towards skill improvement (48).

2.4. Motivation of physically active behaviour

Physical activity promotion in children has focused on beneficial health-related outcomes for many years, such as decreased risk of cardiovascular diseases and obesity. From a psychological point of view, however, the focus on consequences of physical activity prohibits the understanding of the determinants of physical activity behaviour. Especially what motivates children and teenagers to sustain physical activity levels. There is a steep decline in physical activity during adolescence, a matter which needs to be attended (49). A motivational perspective focuses on possible intervention strategies that can be implemented by parents, teachers, coaches and other individuals or groups who play an important role in the lives of the youth. Keeping children motivated to participate in physical activity will then naturally lead to the desired health outcomes (49).

Research on reasons why children and adolescents participate in physical activity, be it leisure-time or organized, consistently points to three major motives. The first one being the development and demonstration of physical competence, like athletic skills, fitness and appearance. The second one being the gain of social acceptance and support, like friendships, group acceptance and approval. The

third and last one being fun, because enjoyment is likely to enhance the attractiveness of physical activity and is recognized as a key factor for motivated behaviour and sustained sports involvement (49, 50). All things considered, these findings suggest that an intervention designed to increase competence, social support and enjoyment will result in children maintaining and increasing their physical activity levels (49).

Competence is perceived as an individuals' judgement about their ability in a particular area such as school, relationships with others or physical activity. Youth who report stronger beliefs about their competence are more likely to enjoy activity and keep interested in it. The competence is affected by outcome, social and internal sources. Outcome sources include performance statistics, external rewards and event outcome. Social sources include feedback and reinforcement from parents, teachers and coaches, and evaluation by and comparison to peers. Internal sources include skill improvement in relation to past performance, enjoyment, effort and achievement of personal goals. Children tend to use their skill, perseverance, enjoyment and feedback from parents as primary means to judge their physical ability. As they grow older, this shifts to peer comparison and coach feedback. In later adolescence, this shifts to internal sources, where teenagers are dependent on their self-set goals and personal improvement (49).

Adults and peers are sources of physical competence and self-worth, sources of enjoyment and determinants of commitment to activity. The feedback and reinforcement of these individuals have great influence on children's perceptions of physical competence, enjoyment of physical activity, self-esteem, motivation, and physically active behaviours. Parents are especially important as transmitters of information about their child's competence and the value of physical activity. Furthermore, the perceptions of a child on their parents' beliefs and behaviours are more strongly related to their self-evaluations and physically active behaviours than parent-reported beliefs and behaviours. Teachers' and coaches' feedback also result in positive outcomes for young sport participants. This does depend on the quality of the feedback. Peer groups and close friends are strong socialisers who contribute beyond the influence of children's psychological development in school and physical activity involvement. Physical competence and peer acceptance are strongly linked to each other (49).

Children need to be stimulated to start physical activity by making it enjoyable and keeping them coming back because of an intrinsic desire to be physically active. Providing experiences that a child finds enjoyable is a potent strategy for increasing activity levels in youth, their attitude about the value of exercise, and in the end long-term health outcomes. Sport commitment is defined as the desire and resolve to continue participation in an activity. Five determinants are of influence to commitment to an activity in a positive or negative way. Sport enjoyment is the first determinant and is defined as a positive affective response to an activity that reflects feelings of pleasure, liking and fun. Involvement alternatives is the second determinant and reflects the attractiveness of other activities that could compete with continued participation in the current activity. Next to these stimulators, there are also barriers preventing physical activity. First, personal investment, which refers to time, effort, energy and any other resource that would be lost if participation in the activity was continued. Second are social constraints, referring to the perceived pressure from significant adults and peers to remain in the activity. At last, involvement opportunities, which are the anticipated benefits granted from continued participation in physical activity such as friendships, interactions with adults, skill mastery and enhanced physical condition or appearance (49, 51).

The article of Weiss has set up 10 commandments for maximizing motivation in children, these are depicted in table 2.

Table 2: Ten commandments for maximizing motivation (Weiss (49))

No.	**Commandment**	**principle**
1	Focus on teaching and practicing skills	Maximize equipment, facilities, instructors; don't introduce competitive play too early – provide variety; make it fun
2	Modify skills and activities	Sequential progressions; modify space, equipment, rules; match activity to the child, not the other way around.
3	Realistic expectations for each child	Individual learning rates and goals
4	Become an excellent demonstrator	A lot of 'show and tell'; repeated demonstrations; multiple perspectives
5	Catch kids doing things correctly	Compliment, instruct and encourage; provide optimal challenge as a follow-up
6	Reduce fears of trying skills	Provide an encouraging atmosphere – performance errors are part of the learning process; reduce fears of getting hurt – show ensured safety; show empathy
7	KISS	Keep Instructions Short and Simple; maximize practice and playing time
8	Be enthusiastic	Smile, interact and listen; make enthusiasm contagious
9	Build character	Be a role model; identify and take advantage of teachable moments
10	Let children make some choices	Involve them in the decision-making process; ask questions

2.4.1. Cerebral Palsy

To understand the motivation of children with CP, and other children with developmental disabilities, another approach may be needed. The concept of mastery motivation could prove useful. Mastery motivation is defined as an intrinsic psychological force encouraging an individual to attempt to master a skill that is at least moderately challenging to that person. This motivation has two elements: instrumental and expressive. The former relating to the degree to which a person will persist to solve a problem or master a skill that requires physical or psychological effort. The latter relating to affective feelings associated with attempting to perform a task (52).

Children prefer to do activities that are the most motivating, which needs to be considered both when setting goals and choosing activities for rehabilitation interventions. This way it can be ensured that the child is maximally challenged. In addition, a lack of motivation to attempt or repeat certain activity types may need to be addressed as part of rehabilitation efforts, to optimize involvement and practice of skills important to development. A lack of motivation could ultimately prevent such children from realizing their full potential (52).

Motivation to keep going when challenged is dependent on past experiences, current abilities, environmental context and intrinsic desires to act and master difficult tasks. Children with CP have shown lower levels of motivation than typically developing peers. Cognitive ability, motor function and functional limitations are associated with a greater level of persistence in everyday tasks. The relationship between positive social behaviours and higher motivation is deemed important. Presence of behavioural difficulties was correlated with lower motivation. A high level of family burden to the child's disability also resulted in lower motivation levels (52).

To improve the potential benefits of the rehabilitation process, children should be presented with the opportunity to choose activities they find enjoyable, but they should be challenging. Treatment goals should be informed by the child's own needs and priorities, as this will increase the motivation efforts. Considering the child's activity preferences and providing choices will ensure that the therapeutic goals and activities selected are intrinsically motivating and pleasurable, making the child actively engaged to and in control of the therapeutic process (52).

In another study, where rehabilitation interventions for children and adolescents with CP were looked at from the motivational point of view, parents and clinicians rated motivation as the most influential personal characteristic determining motor and functional outcomes in children with CP. Motivation can be used to enhance neural reorganization and in turn optimize rehabilitation outcomes (53). On the contrary, lack of motivation may limit children from reaching their functional potential (54).

2.4.2. Developmental Coordination Disorder

Children with DCD are at risk for developing a negative attitude towards physical activity, leading to an inactive lifestyle as adults. Long-term consequences for DCD include reduced motivation for participation in physical activity and reduced opportunities for the development of motor skills and fitness (55).

The desire to withdraw from activity may be reinforced by negative judgements about the overall motor performance of children with DCD by their parents, teachers and peers. However, positive influences of family, friends and community may break this negative cycle. This cycle is also referred to as the cycle of failure. A factor recognized by this model is motor competence, which is lower in children with DCD. Because of this they tend to avoid participation in team games and individual physical activities. This causes reduced physical activity and at the end reduced physical fitness (55).

2.4.3. Parental influence

Parental influence is an influential factor of physical activity and might be a key factor in a child's behaviour. Children will learn their habits and attitudes towards all types of subjects, including physical activity, very early on. Parental influence is particularly strong during the early childhood years, as this developmental period is the foundation of creating healthy habits (56). When children with an early interest in physical activity, it is very likely that this pattern will continue in adulthood and result in major health benefits. Parental influence is pivotal in this case, because most children imitate their parents. Aspects that promote physical activity in children are role modelling, which includes a parent's interest in physical activity and their efforts to be active. Another aspect is the parental support, referring to encouragement, involvement and facilitation for the child to be active (56, 57). Because parents have a great impact on their child's development, they play an important role in encouraging children to be more physically active.

2.5. eHealth

Information technology, such as eHealth, and its exploitation is increasingly seen as pivotal to redesigning healthcare systems to be able to deliver safe, effective and convenient healthcare. eHealth applications may also be used to support evidence-based practice both generally, such as guideline-linked reminders, and more specifically through advice on the management of individual patients. Furthermore, eHealth can facilitate care from a distance, be used in epidemiological research and healthcare management activities such as quality improvement initiatives (16).

eHealth can take various forms, one of which being interactive e-therapies. This includes health apps, virtual reality systems, serious health games or certain types of training. Even though these e-therapies are still early in use, both physical and psychological serious health games have shown that their use results in improvements in illness-related knowledge, information-seeking behaviour and physical or psychological symptoms in children and adolescents with long term conditions (58).

In a systematic review focusing on self-management interventions for youth with health conditions, consistent evidence was found leading to improvements in symptom or disease control. There is, however, limited evidence with regard to the impact of these interventions on health care utilization, knowledge and quality of life outcomes (59).

There are some eHealth interventions developed for children and young people with long-term physical conditions. Most of these studies focus on compliance with medical treatment, education about medical conditions and improving aspects of medical care. A few studies have particularly addressed the perspectives of children and young adults with long-term physical conditions (58). One of these studies, conducted by Stinson and colleagues (59), found consistent evidence that eHealth interventions lead to improvements in symptom or disease control, yet there still remains limited evidence regarding their impact on healthcare utilization, knowledge and quality of life outcomes.

In the study conducted by Thabrew and colleagues (58) researchers tried to describe the psychological experiences of children and young people with long term conditions, their families and clinicians and to explore if these may be improved using eHealth interventions. The children, young adults and their families used eHealth interventions in a limited manner. The reasons for this included a combination of patient-related, technology-related and clinician-related factors. Trustworthiness, technological appeal and ease of access appeared to be important for the optimization of the eHealth uptake by children, young adults and their families as well as the recommendation of such eHealth interventions by clinicians (58).

For paediatric health, Cushing and colleagues (17) conducted a study examining the role of eHealth on behaviour change and disease outcome in paediatric healthcare. eHealth interventions can produce small effect sizes for behaviour change or their associated outcomes. Interventions using behavioural principles like self-monitoring, goal setting and immediate feedback are responsible for the significant effect size, while educational interventions did not significantly contribute to health behaviour change or disease outcomes. Clinicians may be able to extend their impact in clients' lives outside the hospital or therapy room both by using technology as stand-alone intervention or as an adjunct to existing face-to-face techniques. This extended impact could be used to promote health behaviours and associated health outcomes by using continued application of behavioural principles. eHealth interventions have succeeded in changing health behaviour outside the reach of a clinician by deploying behavioural principles (17).

2.5.1. eHealth therapies in Cerebral Palsy

Maher and colleagues (60) have investigated whether an 8-week internet-based intervention focused on promotion of physical activity for adolescents with CP is effective. The results provided modestly promising evidence for the use of an online physical activity self-management intervention in adolescents with CP. The program had a positive short-term impact on physical activity and knowledge. Furthermore, it was well received and well used, which is promising for further, more in-depth studies (60).

Another study focused on the development of rehabilitation technology for children with CP in a home-based setting. The aim was to develop a game with force feedback, in order to assist children with arm movement difficulties to complete useful therapeutic exercises. The designed technology was perceived to be of benefit and the process by which opinions on the use of technology were obtained was considered pleasing (61).

The use of eHealth interventions within children is still relatively new, but is growing substantially. However, there is still little evidence on the quality and safety of these eHealth interventions, which also impacts the amount of information available for children, including those with CP (62).

2.5.2. eHealth therapies in Developmental Coordination Disorder

Just as with CP, there is not a lot of information available on the effects of eHealth in children with DCD. A pilot study conducted by Miyahara and colleagues (63) focused on whether it was possible to develop and implement a family-focused intervention program that can improve the coordination of children with DCD. This family-focused eHealth intervention program seems to be satisfactory and feasible when supporting children with DCD. The degree of participation was, however, less than

expected. It proved difficult to identify obstacles that prevent children from reaching a goal through tele-consultation. Additional clinic appointments, home visits or group support meetings may prove beneficial (63).

Hocking and colleagues (64) conducted a meta-analysis evaluating the use of active video games in children with developmental disabilities. Active video games improved gross motor skills, yet the support was weak for improving balance and functional mobility. There is a need for more RCTs with high methodological quality within the area of active video games for children with developmental disabilities. Furthermore, these studies should focus on the cognitive, social and academic domains as well (64).

2.5.3. eHealth and interactive gameplay

Computer games and simulations have been recognized as a motivational tool in rehabilitation for several years. Games can help to motivate patients, develop skills and serve as a distractor in pain management. Most rehabilitation programs consist of various predictable and repetitive techniques that require practicing at home, and children in particular tend to find task repetition boring (65). Especially in physiotherapy and occupational therapy it is important to keep patients motivated and, in the end, allow them to practice at home without the constant supervision of therapists (66, 67).

An interactive game is a novel type of game that aims to retain elements of digital gaming like improved reaction time, hand-eye coordination or attention allocation. This is done through interactive technology. Interactive games aim to promote physical activity, encourage social interaction, or steer behaviour in a certain direction. Technological elements that are used in this type of games can be classified as sensors, actuators or logic processors. Sensors obtain information from the environment and the players within that environment, and include camera's and touch-sensitive surfaces. Actuators are elements such as projectors, speakers or lights, and are used to provide feedback to the players. Logic processors gather the information of sensors, process this information, and decide what feedback to give through the actuators. There is a feedback loop between all three elements in which data is measured, processed, acted upon, and measured again (29).

One type of interactive game are interactive playgrounds. Interactive playgrounds are interactive installations with the aim to combine traditional play with interactive elements to retain all the benefits of traditional play, while enhancing the engagement, entertainment and immersion of the players. Interactive playgrounds are room-sized installations where multiple players play together, using natural interactions as input for the system (29).

In general, interactive games are designed to provide a fun and engaging gaming experience, while supporting other goals at the same time. The most common goals are:

1) engagement and fun, where the goal is to elicit happiness and provide a fun experience. In the case of children, this might be easier as they are more open to new experiences;
2) Physical activity, where elements are added to motivate players to explore and interact in a physically active way;
3) Social interactions. Interactive games can be designed to trigger social interactions between players and bring them closer together;
4) Education and learning. Play can be used to improve learning for people of all ages, such as a supportive factor for learning specific educational themes and goals like learning maths or words;
5) Rehabilitation. Interactive games are an attractive tool in the rehabilitation of disabilities, because they present opportunity to address cognitive and emotional processes during the duration of the intervention. Especially because rehabilitation programs are long and difficult, leading to possible frustration, loss of motivation and even abandonment (29).

If interactive gaming were to be implemented in practice, it should be flexible and support the tasks of the therapists. They should allow the therapist to be more effective by supporting the tasks they perform and taking over tasks that can be automated, like tracking a patient's performance. Interactive games should, however, not be seen as a replacement for the therapist. The presence of the therapist

will, as considered by the author, always be necessary for the patients to ensure the game is played correctly and to provide support during gameplay (67).

Next to the therapist and the child, the role of the parent is also likely to change with the introduction of gaming in the rehabilitation process. It has been found that parents generally have a positive attitude towards the use of gaming as a form of home rehabilitation program. Furthermore, parents express their confidence in the potential of using games in rehabilitation. The social aspects of gaming and the reduced coaching role of the parent were considered especially positive. Better individualization of the physical performances to challenge the specific needs of each child would be a point of improvement for further implementation of gaming in the rehabilitation process (68).

2.5.4. AIRplay

Following the concept of interactive gameplay, AIRplay was created. AIRplay aimed to improve the physical conditioning of children with asthma by combining mobile monitoring of daily physical activity with behaviour change strategies in gamification elements. The interactive playground at Medisch Spectrum Twente was designed and used for this project, where children had to use their projected avatar to tag or catch their opponent. AIRplay made use of 1) a wearable physical activity sensor, 2) a tablet application, and 3) an interactive playground (18).

AIRplay focusses on three main areas where technology could be used to improve the current management of asthma among children. The first area focuses on the importance of physical conditioning, as the maintenance of a physically active lifestyle is of utmost importance for the management of asthma symptoms. The second area focuses on the use of and adherence to medication, as better disease control is associated with adherence to asthma medication. The third and last area focuses on the self-management support, and in which way technology can aid in this matter (18). The first and third area were the main focus of the AIRplay project.

Playing in the traditional playground setting causes children to freely develop their motor skills while creating and maintaining positive social bonds with their peers and/or family. Playing in such places and interacting physically and socially with peers without the imposed constraints of adults, is important for children (29). Combining traditional play with gameplay elements was the concept of AIRplay.

To improve the physical fitness of children participating in the AIRplay project, each child was provided with personal goals in the form of the amount of steps to be reached per day. This target number was based on their capabilities. The amount of steps counted by the sensor is send to the tablet application. The application will then show which percentage of their goal has been reached, and tries to stimulate the user to increase their fitness (18). Figure 2 until 5 show the technology that was used in the AIRplay project, where figure 2 shows the interactive playground, and figure 3 until 5 shows the application.

The integration of a coaching application in combination with an interactive playground allowed for the creation of a fun way in which children can interact with the system to improve the current management of their asthma. The AIRplay concept could be improved by implementing knowledge from the field of persuasive technology and behaviour change support systems in a more structured way. Multiple principles from the Persuasive Systems Design (PSD) model, a framework created by Harjumaa and Kukkonen (19) to reinforce behaviour change, can already be found in the design of AIRplay. The PSD model could be used to further improve the system to maximize the impact on the management of asthma amongst children or to apply and translate the concept into applications for other conditions (18).

The RE-PLAY system, which is a translated version of the AIRplay system, will be a hybrid intervention focused on improving physical activity in children with CP and DCD. This will be accomplished by combining wearables, an application and smart environments, taking into account aspects of the daily routine. Firstly, physical activity will be promoted by a suite of videogames that can be played on an interactive playground, using a tracking system made possible by camera projection. Secondly, a mobile app registers the activity of users in daily life via a smart wearable and

provides feedback in several ways. This is meant to increase self-management, social interaction, teamplay and competition. Finally, the physical activity levels from daily life will be linked to virtual world of RE-PLAY.

Figure 2: Children using the interactive playground

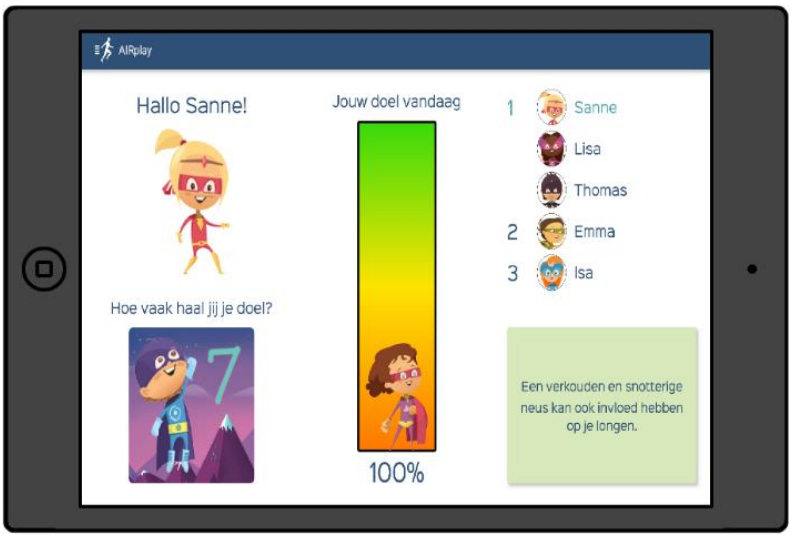


Figure 3: Home-screen of the application

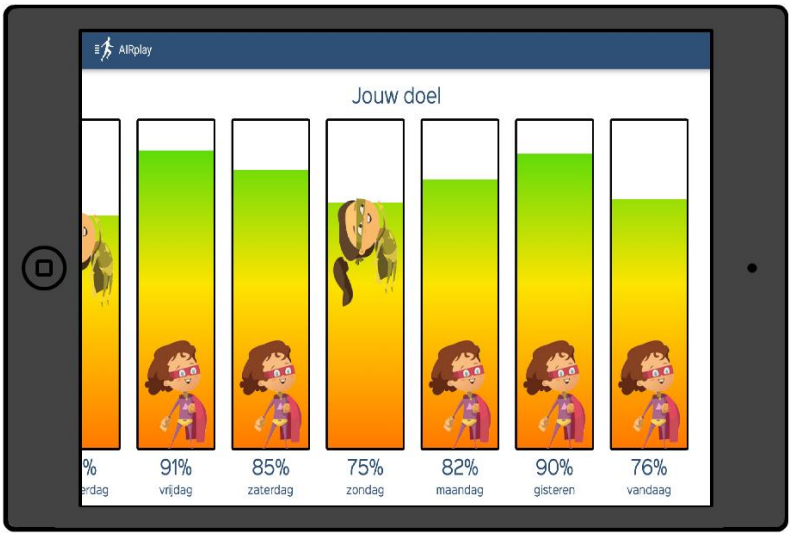


Figure 4: Daily progress of physical activity of the past days until today

Figure 5: Social interaction between the children using the application.

2.6. Persuasive systems design

The AIRplay proof-of-concept has been positively accepted by all participants. The concept itself however, can be improved by implementing knowledge from the field of persuasive technology and behaviour change support systems in a more structured way (18). One of these models is the Persuasive Systems Design (PSD) model. The PSD model uses a framework designed by Oinas-Kukkonen and Harjumaa (19). The PSD model concerns itself with Behaviour Change Support Systems (BCSS), which are systems designed to form, alter or reinforce attitudes, behaviours, or an act of complying without using deception, coercion or inducements (69). The PSD model is based upon seven principles that need to be addressed when designing or evaluating persuasive systems, these are depicted in table 3.

Table 3: principles for information system design (19, 69)

1.	Technology is never neutral, it influences attitudes and behaviour.
2.	People like their views about the world to be organized and consistent.
3.	Persuasion is often incremental. This means that persuasion goes stepwise; all steps contribute to the goals to be realised.
4.	Direct and indirect routes are key persuasion strategies. Persuasion will depend on the ability and motivation of people to process information. The background, context and other factors can influence the routing of information.
5.	Persuasive systems should be unobtrusive. That is, the system should avoid being disturbing while the user is performing tasks.
6.	Persuasive designs should be open. That is, designers should make the ideas behind and the goals of persuasion transparent.
7.	Persuasive systems should be user-friendly.

The seven principles form the backbone of the PSD model. This model advocates the systematic evaluation of these principles, of the persuasion context and of the persuasive system factors. Analysis of the persuasion context consists of looking into 1) the intention, meaning the intended change of compliance, behaviour or attitude, 2) the event (the use, user and technology context) and 3) the strategy (the message itself and the route to be used to achieve the change) (19, 69).

At last, the PSD model describes persuasive software features, also called design principles, in the categories of primary task support, human computer dialogue support, perceived system

credibility and social influence. Primary task support concerns itself with techniques that support carrying out the primary activities. Dialogue support refers to human-computer interaction and techniques to achieve the goals set for using the BCSS. The perceived system credibility design principles relate to the believability of design and trustworthiness of the system. Finally, the social influence principle describes how to design a system in order to motivate users by leveraging social influence (19, 69).

All 4 categories include principles related to the specific category. In table 4, each of these principles are shortly discussed as what the system should do per principle. These categories and principles define the final PSD model, which is shown in figure 6.

Table 4: Categories and principles of the PSD model (19, 69)

Primary task support	
Reduction	Making complex behaviour/tasks as easy as possible by reducing them into simpler tasks to help the user perform the target behaviour.
Tunneling	Guiding users through a process or experience provides opportunities to persuade along the way.
Tailoring	Information will be more persuasive if it is tailored to the needs, interests, personality, usage context, or other factors relevant to a user group. With this principle, the information users will receive will be relevant to their interests.
Personalization	Offering personalized content through e.g. customization of the interface.
Self-monitoring	For a system to be persuasive, users should be able to keep track of their performance or status to support users in achieving their goals.
simulation	Simulations enable users to observe the immediate link between cause and effect of a certain behaviour.
Rehearsal	Rehearsing behaviour enables people to change attitudes or behaviour in the real world.
Dialogue support	
Praise	By offering praise as feedback, a system can make users more open to persuasion. Praise can come in the form of words, images, symbols or sounds.
Rewards	Systems that reward target behaviour may have great persuasive powers. Rewards can come in the form of privileges and badges.
Reminders	Reminding users of their target behaviour makes the users more likely to achieve their goals.
Suggestion	Offering fitting suggestions will have greater persuasive powers. Such as offering suggested questions when the user asked a similar question.
Similarity	People are more readily persuaded through systems that remind them of themselves in some meaningful way.
Liking	Visual attractiveness of a system is likely to be more persuasive.
Social role	If a system adopts a social role, users will more likely use it for persuasive purposes.
Perceived system credibility	
Trustworthiness	A trustworthy system will have greater persuasion.
Expertise	Incorporating expertise in a system will have greater persuasion.
Surface credibility	Based on a first-hand inspection, people make initial assessments of the system credibility.
Real-world feel	Highlighting of people or organization behind its content or services will have more credibility.

Authority	Leveraging the role of authorities will have enhanced powers of persuasion.
Third-party endorsements	(Well-known) third-party endorsements boost perceptions on system credibility.
Verifiability	Credibility perceptions will be enhanced if a system makes it easy to verify the accuracy of site content via outside sources.
Social support	
Social learning	Users should be able to observe other users performing their target behaviour in order to see the outcome of such behaviour. In this way, users will be more motivated to perform the target behaviour.
Social comparison	Users are more motivated to perform target behaviour if they can compare their performances with others.
Normative influence	Using leverage of normative influence or peer pressure to increase the possibility of persuading a user to adopt a target behaviour.
Social facilitation	Target behaviour is more easily achieved when others are performing the same target behaviour along with the user.
Cooperation	Motivate users to adopt target behaviour by leveraging the natural drive of humans to cooperate.
Competition	Motivate users to adopt target behaviour by leveraging the natural drive of humans to compete.
Recognition	By offering public recognition for individuals or groups, the likelihood of adopting a target behaviour is increased.

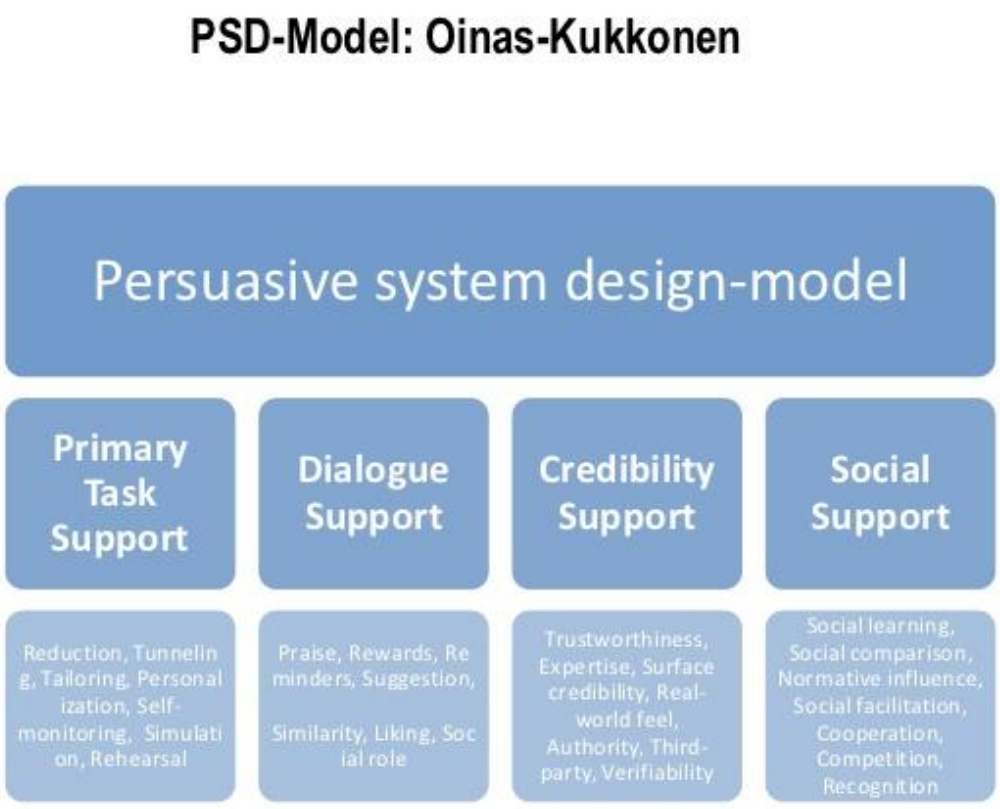


Figure 2: PSD model (Oinas-Kukkonen)

2.7. Literature findings

In conclusion, the literature research provided relevant findings in the areas of treatment, physical activity, motivation of physically active behaviour and eHealth. These findings prove helpful in laying the foundation for this study, and for reflection with previous studies.

2.7.1. Treatment

Treatment of both CP and DCD was focused on gaining skills necessary for the daily life activities of children. Task-oriented approaches must be implemented to reach successful therapy outcomes. The CO-OP method is a task-oriented approaches and can be prescribed with certain confidence as it has proven its success (15). A similar approach might be useful in the creation of RE-PLAY, resulting in better adaptation and reaching faster results.

2.7.2. Physical activity

The recommended amount of physical activity is to accumulate at least 60 minutes of MVPA per day. This guideline accounts for children with CP and DCD as well, as no distinction is made between this group and their typically developing peers. Bone and muscle strengthening activities are also recommended to be implemented at least three times per week (43).

Concerning CP, the traditional methods have shown the most marginal benefits. Strength or resistance training is important, strength training has become more prevalent in physical therapy for people with CP (46).

Concerning DCD, there appears to be a clear need for informing and training of PE teachers, as this group has trouble understanding DCD. Good instruction may facilitate engagement of children with DCD and can also increase the understanding of the child's motor difficulties, their competence level and an encouraging attitude towards skill improvement (48).

RE-PLAY can, just as AIRplay, focus on the area of physical conditioning to reach the 60 minutes guideline on MVPA per day. Incorporating strength training and clear instructional feedback to children and those assisting them would further increase the understanding and acceptance of both the disorders and technology.

2.7.3. Motivation of physically active behaviour

Feedback and reinforcement of peers and adults has great influence on the child's perceptions of physical competence, enjoyment of physical activity, self-esteem, motivation, and physically active behaviour. Parents are especially important as transmitters of information about their child's competence and the value of physical activity. Furthermore, an article by Weiss created a list of ten commandments for maximizing motivation (49).

To improve the potential benefit of rehabilitation, children should be presented with the opportunity to choose activities they find enjoyable, but challenging. Treatment goals should be informed by the child's own needs and priorities, as this will increase the motivation efforts (52).

Principles from the PSD model, especially from the dialogue and social support category are helpful in motivating children. Already present in AIRplay, these principles could prove valuable in RE-PLAY too.

2.7.4. eHealth

In order for eHealth technologies such as AIRplay to be accepted, trustworthiness, technological appeal and ease of access appear to be important for the uptake by children, young adults and their families as well as the recommendation of such eHealth interventions by clinicians (58). Self-monitoring, goal setting and immediate feedback are responsible for significant effect sizes in behaviour change. The PSD model plays an important part as well, already providing AIRplay with at least twenty principles. This research' results will investigate whether RE-PLAY will need to incorporate the same principles, or whether to change some of the AIRplay principles.

3. Methods

This study was conducted at Roessingh Research and Development and Roessingh Centre for Rehabilitation in the period of February 2018 until July 2019. This study originated from the eHealth research group. To investigate what was needed to adapt the AIRplay system for application in the paediatric rehabilitation of children with CP and DCD, to reach a physically active lifestyle for these children, the following methodology was used.

3.1. Participants

Participants of this study are children diagnosed with CP and DCD receiving paediatric treatment at Roessingh Centre for Rehabilitation, located in Enschede, Netherlands. The children were selected based on their age and intellectual capability to carry out the assessment. This selection was carried out by therapists of Roessingh Centre for Rehabilitation. Another group of participants consisted of parents of the selected children. Therapists treating children within these diagnose groups complete the participants group. Children and parents were selected on suitability and willingness to participate, after being mobilized by a therapist at Roessingh Centre for Rehabilitation. The children were included if they 1) were aged 6 to 16 years old, 2) were diagnosed with CP type 1 or DCD and 3) were suspected by therapists of having insufficient physical activity levels. Parents were included if they had at least one child diagnosed with CP type 1 or DCD. Therapists were included if they were specialised in paediatric rehabilitation, and were currently treating children with CP type 1 or DCD. All participants were informed by means of a letter and informed consent was provided on site.

3.2. Measures

To answer the research questions, semi-structured interviews were conducted with children and parents of children diagnosed with CP and DCD, as well as therapists treating this group. A retrospective analysis of physical activity levels of children was done additionally using ActiGraph data stored at Roessingh Centre for Rehabilitation.

3.2.1. Interviews

To investigate the needs, values and wishes of children and parents of children diagnosed with CP and DCD, semi-structured interviews were carried out. All interview data was collected by using a questionnaire (appendix 3) appropriate to each interview group. The interviews stopped when all predetermined questions were asked, and the participants had no further questions or remarks left. The predetermined questions focused on aspects of physical activity, motivation, rehabilitation, guidance and eHealth. The questions were modifiable based upon the interviewer's perception of what seemed most appropriate. Because of this flexible attribute of semi-structured interviews, they prove particularly useful for exploring the views of a person towards a certain topic (70).

All interviews were conducted once per child and parent, and once per therapist, happening in a face-to-face situation. Both child and parent were interviewed simultaneously in order to reduce the power differential between the researcher and the child, as a researcher has control over the research process and the interviews. With children, this differential is even higher due to the difference in age. This differential will be reduced when a parent is present and will be supporting the child in answering the questions, making the child more comfortable during the interview (71). Children were handed a questionnaire containing some PSD principles, to elicit their opinion on what they found important principles to be embedded into the system of RE-PLAY. This questionnaire is depicted in appendix 4.

Parents of children with CP and DCD were asked similar questions as those that the child received, with additional questions about their involvement in the care of their child and opinion on care at Roessingh Centre or Rehabilitation. Therapists were asked additional questions about the rehabilitation process and their more in-depth knowledge about CP and DCD.

Prior to the interviews, a small group of four children without CP and DCD (♂/♀ = 2/2) were interviewed in a group setting to test for content-validity and usability ('do they understand the questions?') and feedback in general. Based on the outcomes, the format was slightly adjusted (see appendix 2).

3.2.2. Physical activity

To gain insight in the physical activity levels of children with CP and DCD, ActiGraph GT3X data stored at Roessingh Centre for Rehabilitation was used. After permission was granted by the children and their parents, the data files were provided by the corresponding therapist. The results of this objective measurement were used to get an idea on how physically active these children were, and to what extent these physical activity levels correspond to the guidelines of physical activity. Furthermore, these results were used to predict the added value of an eHealth addition to the current rehabilitation programme. The children had to wear the ActiGraph for one week, and data was used for analysis when children had worn the ActiGraph for at least four days, as this will ensure a reliability of 0.80 on children's physical activity levels (72).

3.3. Data analysis

3.3.1. Interviews

The interviews were transcribed a verbatim in Microsoft Word, and were later coded using ATLAS.ti 8. The method used for coding was derived from thematic analysis, which is a method used for identifying and analysing patterns of meaning within datasets. The end result of a thematic analysis highlights the most noticeable patterns of meanings within a dataset (73, 74). The data was read and re-read, for familiarisation with the data. Afterwards, codes were generated for data features of interest to label them. The codes were later clustered into code groups for summarization. These groups were reviewed to check if the codes were clustered correctly. After clustering, codes within code groups were merged if they had significant overlap, generating a final set of codes. The requirements were ranked from high to low priority. This ranking was based on how many times something related to that specific requirement was said, and how many sources mentioned it. When possible the generated codes were linked to the PSD model, in order to highlight PSD principles that were emphasized. The full list of generated codes is depicted in appendix 5.

Based upon the thematic analysis, requirements were generated according to a requirements notation template specifically developed for eHealth technologies by Van Velsen and colleagues (75). This approach ensures that requirements are documented in such a way that it enables programmers to understand what needs to be made and why. Furthermore, it serves as the starting point for evaluations. The complete requirements documentation is depicted in appendix 6.

3.3.2. Physical activity

The ActiGraph data was analysed using Excel and IBM SPSS statistics 25. Data on the amount of steps and the level of physical activity (sedentary, light, moderate, vigorous, very vigorous) was analysed, as this data was used most by the therapists in order to create a profile for the physically active lifestyle of the child. This profile was used to create personalized treatment programs of children at Roessingh Centre for Rehabilitation. Minimum ActiGraph wear time was set to 13 hours per day, as this amount is needed to ensure a valid measure of daily physical activity (76). Descriptive statistics analysis of the selected parameters was carried out, resulting in an overview of physical activity levels of the participants.

Thresholds of acceptable physical activity will be at least 60 minutes of MVPA, and an amount of 10.000 steps per day. The 60 minutes MVPA is a guideline set by the WHO (43), and the 10,000 steps per day is a guideline set by the therapists at Roessingh Centre for Rehabilitation.

4. Results

4.1. Baseline characteristics

4.1.1. Children and parents

Three children (♂/♀ = 3/0) diagnosed with DCD participated in this study. Each child was accompanied by one parent (♂/♀ = 0/3). All children received physical therapy at Roessingh Centre for Rehabilitation.

4.1.2. Therapists

Four therapists treating children with CP and DCD participated in this study. Three therapists were employed at Roessingh Centre for Rehabilitation, and one at a private-owned clinic. Their average experience within the paediatric rehabilitation is 23.5 years. Their reasons for choosing paediatric rehabilitation were mainly the developmental aspect and their need to be creative; one therapist stated that "Rehabilitation is like a puzzle, everyone adds their own piece to eventually create the best possible treatment."

4.2. Interview results

4.2.1. Children

The children themselves cared most for the aspect of a personalized application that used a rewarding system to keep them motivated. The children interviewed in this study all showed interest in gaming. The type of games they played varied vastly from each other, ranging from car games to shooters and platform games. What the games did have in common was that they all needed to incorporate a certain amount of action to keep the child entertained and interesting. The personalized aspect was of great importance, as was observed in the interviews.

In terms of active gaming, all children had familiarity with the concept, yet their true interest in active gaming is doubtful, as was observed in the interviews when their responses where not fully positive, with one parent even shaking her head when the child said he would probably like active gaming. The idea that an active game was being developed for them did trigger positive responses and they were eager to start playing such a game.

Personal aspect

During the interviews with the children, the personal aspect was brought forward a lot. Children were creative in their answering and although there were only three children interviewed, the diversity of their answers made it very clear that if a game would be developed for the children, they will have to be able to identify themselves with it. The game should therefore feature personalized content linked to the interest of the user.

Questionnaire

All children completed the questionnaire. The principles *personalization* and *reward* were rated the highest by all three children. The principles *reduction, recognition, cooperation, social comparison, trustworthiness* and *competition* were rated high by two out of three children. The children did not care much for the principles *suggestion, verifiability, rehearsal, tailoring* or *self-monitoring.* When having to choose between *praise* or *reward*, *reward* was favoured. 2 out of 3 children preferred playing alone instead of together with someone else.

4.2.2. Parents

All parents that were interviewed described their involvement in the care of their child as a full-time commitment. “Next to him being at school and asleep, I have to give him all the attention possible”, was a remark from one of the parents. The children often had trouble with organizing their free time, which would then become a task for the parents, in order to keep their child occupied.

All parents emphasized the need for clarity and creating clear tasks, timeframes and rewards. Clarity is a concept that parents rely on in daily life, where their involvement is immense. In the care of their children clarity is an aspect that simply cannot be ignored. The parents tried to accomplish this by setting clear boundaries and rules for their children. Using rewards helped a lot in making sure their children stuck to the rules.

All parents made clear that personalization was an important aspect, as the interests of their child varied from day to day, and there was no distinctive method in motivating their child.

Parents acknowledged the fact that gaming has a great influence in the daily life of their children. While their children did play games daily, the parents tried to limit this amount and tried to make their children participate in more active activities too. This participation does depend on the time and day, as became clear in the interviews when parents mentioned the availability during weekdays. The implementation of active games was greeted with mixed enthusiasm. The parents did encourage the fact that gaming while being active was good for their children, but the question remained if their children would adhere to this. Adherence to video games is an important aspect in the consistency of use and the effectiveness of therapy.

Parental role

The parental role was deemed pivotal by therapists, as they are the incentive for physical activity in the daily living situation. When parents are not motivated enough, therapy will never have all the benefits that were expected at the beginning of the therapy. One therapist stated that “when parents are not motivated, you can forget the entire purpose of therapy.” Parents are involved a lot in the therapy, yet therapists deem it not as much as they would like. Therapists would like to include parents in the making of therapy plans for their child and actively partake in carrying out those plans, because “half an hour of therapy per week is simply not enough”. Therapists would like parents to become more aware of the situation their child is in, as they have often experienced parents that were unaware of what their child was capable of.

Parents on the other hand state that the care for their child is a full time commitment. The parents were “apart from school and bedtime” fully engaged in the care of their child. “It takes a lot of time, how much? That I do not know, but I think that when you keep track of it, you will be shocked.” In terms of physical activity, all parents were aware of the positive effects and tried to keep their child as active as possible, when possible.

Clarity

Children with DCD need clarity in their daily life routine, at school, therapy and in their free time. Without a clear schedule of the day, the parents mentioned that their child did not know what was expected of them. One parent mentioned that packing the sports bag of their child needed to happen in a specific order. The aspect of clarity was paired with a rewarding system, to make sure their child adhered to the schedule made by the parents.

4.2.3. Therapists

During the interviews with the therapists, a lot became clear about the way children are treated at Roessingh Centre for Rehabilitation. The rehabilitation of children is not just the physical therapy part but also a multidisciplinary approach. All different therapies need to work together to make sure they have the best possible treatment for the child. The one thing most of the therapies have in common is the methodology they use, namely the Wat-Hoe-Doe-Check methodology. The Wat-Hoe-Doe-Check methodology is a variant of the CO-OP approach and it is used to create stability in the treatment of

the child, and to make the child aware of its actions. It was also of importance to let the children see the smaller steps of their actions. This part is handled in the second step of the methodology. By letting the children check their actions, they can improve and do better the next time they try it. Another important aspect of therapy was the experience of success by children. Over the years, these children have built up a negative attitude with regard to physical activity. This is mainly due to being less competent than their typically developing peers, and because they need more rehearsal to acquire a new skill, which can demotivate after multiple failures. The children that receive therapy at Roessingh Centre for Rehabilitation are mostly in such a condition that the regular physical therapist cannot treat the child well enough, which is also a factor that demotivates the children, because this means they experience lots of trouble due to their disorder. In the beginning of the therapy, the experience of success is one of the most important aspects, that is why therapists will start off easy and will not directly challenge the child's capabilities, to let the child regain a positive attitude towards being physically active. At last, therapy needs to be fun. This is accomplished by asking for the preferences of the child. By doing something a child prefers, the therapy will become more pleasurable and the outcomes could prove more beneficial.

Concerning the encounters with eHealth, therapists acknowledged the rapid growth of it. Step-counters, coaching apps and virtual reality are examples of eHealth applications already in use for child rehabilitation at Roessingh Centre for Rehabilitation. The experience with eHealth was positive, although most of the therapists were not that much into it. Concerning the implementation, the application should not come with a big user manual, meaning it should be easy to understand and to use. One of the therapist quoted "When you start with something new, you need to take laymen into account." This highlights the importance of keeping it simple, just as the Keep It Short and Simple (KISS) commandment mentioned in the study done by Weiss (49). It should also have the possibility to periodically monitor user behaviour. All in all, the concept of RE-PLAY is judged by therapists as positive and "could really add something". It is an addition to the therapy with the idea to be used outside of therapy hours, or as a follow-up process.

Therapists at Roessingh Centre for Rehabilitation use the same guidelines concerning physical activity, 60 minutes per day (43), but they do mention that it is mostly a process of reaching the 60 minutes guideline and keeping it stable. This means they will not always start with directly imposing this guideline. They also mention it is important for parents and school teachers to use the same methods they use at Roessingh Centre for Rehabilitation, as this will create stability in treatment and makes sure parents and teachers are aware of how they should approach the children with CP and DCD. For motivation, they also stress the importance of parents in keeping children motivated and letting them enjoy physical activity. The aspects of eHealth in literature findings find agreement with what therapists find of importance about treatment, physical activity and motivation.

Wat-Hoe-Doe-Check

According to therapists, it was important to use the Wat-Hoe-Doe-Check methodology when treating children with CP and DCD. This methodology is a variant derived from the cognitive orientation to daily occupational performance (CO-OP) method. The importance of this method was stressed as being the backbone of child rehabilitation, but at school and home as well. Therapists use this approach in every aspect of therapy to create stability. The therapists would like to see this approach being used not only in therapy, but also in school and at home, so the children will learn to use this strategy whenever they try to learn or carry out something. This approach consists of four steps:

1) The goal: what is the person going to do?
2) The plan: how is the person going to do it?
3) The action: the actual performance
4) The check: reflect on how well the performance worked out.

This methodology holds overlap with the aspect of clarity mentioned by all parents, and the behaviour of children observed in the interviews who had the tendency to ask for the how and why.

Success experience

The experience of success in therapy is of major importance according to the therapists, “especially in the beginning of the therapy.” To motivate children, and to keep children motivated in their therapy, it is important to show them what they can do, which starts with the experience of success. To achieve the experience of success, therapists often lower the threshold in the first few weeks, and from there on the children are challenged gradually to improve their motor skills.

Attractiveness

Children need to have fun during their therapy, because therapy is often monotonous and the progress is slow. A therapist addressed that therapy needs to be “something a child finds interesting and fun, something they want to learn or perfect.” This was emphasized by children and parents as well, but, as mentioned by one of the parents, “the games should not be too childish”. The aspect of fun was deemed important to motivate children, and to keep them motivated in the long run, not only in therapy but in practicing and carrying out daily life tasks as well.

4.2.4. Persuasive systems design model

A lot of principles from the PSD model were mentioned at least once, yet the principles within the category system credibility support were mentioned far less than the other three categories (primary task support, dialogue support and social support). The full report of the PSD principles is depicted in appendix 5.

The principle mentioned the most is the *personalization* principle. This principle focuses on offering personalized content. Therapists pointed out that personal care was of considerable importance within paediatric rehabilitation, because every child is different, struggles with different problems and has different goals and interests. This aspect is substantiated by a quote of a therapist, who pointed out that “you should not compare the abilities of one child to that of another”. The personal aspect was observed and heard in all three interviews with children and their parents as well, as the interests of the children varied from games with cars and trains to action and shooter games, as well as parents claiming that the interest of their child differs from day to day, stating that “when we think we have the method to motivate him, it works counterproductive the next time.”

The *reduction* principle has been mentioned a lot as well. This principle focuses on making complex tasks as easy as possible by reducing them into simpler tasks. Both parents and therapists mentioned the reduction principle as an important aspect of daily living and therapy, stating that “if you explain too much at the same time, they will not always understand their objective.” Children had to learn everything in small and clear steps, especially in the beginning. The earlier mentioned aspect of clarity is directly in line with this principle, as it makes children aware of the steps that must be accomplished, and in which order they have to be carried out.

The third most mentioned principle is the *tailoring* principle. This principle focuses on providing relevant and personal information. Information linked to the child’s interests has a better chance of success. This principle stresses the importance of personal care once again. When a child is provided with information relevant to their situation or personal interests, it has the potential to be more motivational, which is confirmed by a therapist pointing out that “you always try to find the right trigger for that particular child.” Just as with the personalization principle, children’s attitudes differ from day to day, which means that the approach taken to the children will need to differ as well.

The *rewards* principle is the fourth principle and focuses on using rewards as persuasive feedback, as children are very sensitive to rewards. Rewards can work motivational for children in letting them know what they are doing the exercises for. Children are very susceptible for a rewarding system, as became clear during the interviews, when positive reactions were given to questions like “if you could get a new racing car when you complete a level.” Rewards helped in getting the therapy started and keeping the child interested. In the home setting, the children were kept interested in doing activities by means of a rewarding system as well. However, creativity is deemed important in choosing the right rewards as “it really depends on where the child is interested in at that moment.”

Fifth, and last is the *self-monitoring* principle, focusing on keeping track of user achievements and activity, which was deemed an influential factor for children and a motivator for physical activity, as children are found to be curious. Offering children the option to see their actions and achievements makes them more aware of their actions and could be a motivational factor for short and long term programmes. This is done by therapists by looking back and asking children "what have you just accomplished, and did it go well?" As children with DCD are known to not implement self-monitoring on themselves, an application that does this for them could improve effectiveness of therapy. Another helpful tool in achieving better self-monitoring is the already mentioned CO-OP method, which is able to support children to self-monitor their behaviour by letting them reflect on their actions.

4.3. Physical activity

4.3.1. ActiGraph

One child was excluded from the data analysis due having an insufficient amount of wear time. ActiGraph data of 9 children (♂/♀ = 7/2, mean age = 10.67 ± 5.17 years) was analysed, after informed consent was given by their parents. The ActiGraph was worn for 6.67 ± 0.94 days on average. The average step count amounted to 8763 ± 3716 steps per day, with activity level divisions of 77.36% sedentary, 9.84% light, 11.68% moderate, 0.89% vigorous and 0.23% very vigorous. The full report is depicted in table 5.

Table 5 step count and physical activity levels

Child	**Average steps per day (Mean ± std)**	**Sedentary minutes per day (Mean ± std)**	**Light minutes per day (Mean ± std)**	**Moderate minutes per day (Mean ± std)**	**Vigorous minutes per day (Mean ± std)**	**Very vigorous minutes per day (Mean ± std)**
1	10532 ± 1231	945.46 ± 187.92	130 ± 12.26	266.89 ± 47.36	27.61 ± 6.20	1.43 ± 0.69
2	9902 ± 4591	1180.03 ± 116.10	98.44 ± 45.09	153 ± 73.20	8.10 ± 3.70	0.34 ± 0.41
3	12670 ± 9106	977.91 ± 129.85	67.51 ± 32.16	157.13 ± 106. 86	31.97 ± 28.72	18.81 ± 16.02
4	7439 ± 2159	1099.28 ± 205.57	99. 84 ± 18.42	147.97 ± 36.02	9.74 ± 5.45	1.61 ± 1.81
5	6420 ± 3391	586.86 ± 265.25	66.69 ± 42.23	75.45 ± 47.01	4.46 ± 4.72	0.12 ± 0.16
6	6272 ± 2436	991.49 ± 136.27	380.51 ± 99.01	8.01 ± 4.91	0	0
7	9729 ± 4589	695.99 ± 51.65	66.75 ± 16.61	134.55 ± 45.28	2.63 ± 1.40	0.06 ± 0.15
8	5824 ± 4074	1314.25 ± 49.28	39.70 ± 14.76	72.97 ± 35.14	12.73 ± 11.25	0.37 ± 0.68
9	10081 ± 1870	548.87 ± 45.77	105.95 ± 16.78	177.03 ± 32.85	4.65 ± 2.10	3.53 ± 4.80
AVG	**8763 ± 3716**	**926.68 ± 131.96**	**117.27 ± 33.04**	**132.56 ± 47.63**	**11.32 ± 7.06**	**2.92 + 2.75**

The physical activity measurement showed that on average the children were not adherent to the guidelines of the therapists on physical activity, and individual results showed that one third makes at least 10,000 steps per day. When looking at the individual results, it is seen that children do not reach the recommended amount of steps. A very small amount (14.24 minutes) of the active time was spent on vigorous and very vigorous activity. MVPA amounts to 143.88 minutes per day on average. Overall,

the results show great variability due to large standard deviations in the results, indicating that children vary a lot from day to day in their physically active behaviour.

4.3.2. Interviews

All three children participating in the interviews participated in a sport. One child played a team sport, whereas the other two practiced individual sports. All children practiced sports at least twice a week. Aside from sports, one child was characterised as active in daily life as well, when given clear time frames for activities. The other two children were more prone to gaming and inactive behaviour in their free time.

4.4. List of requirements

The needs, wishes and values of children, parents and therapists were, after translation in the requirements notation templates, formulated into requirements for the RE-PLAY system. The requirements are depicted in Table 6, the detailed notation templates in appendix 6.

Table 6 requirements list of RE-PLAY

High priority		
Nr.	Type	Requirement
1.	Functional	The system works on a tablet
2.	Functional	The system works on both IOS and Android
3.	Content	The system describes exercises through the steps of the Wat-Hoe-Doe-Check methodology
4.	Content	After the exercises, the system offers questions about the completed exercises to the children following the Wat-Hoe-Doe-Check methodology
5.	Content	The system sets goals based on a baseline measurement done by therapists using on ActiGraph data
6.	Content	The system will make the exercises gradually more difficult per week, based on the baseline measurement
7.	Content	The system will reward the child with badges whenever a goal is reached
8.	Content	The system features exercises linked to the interest of the child
9.	Organizational	The system presents exercises that can be done at therapy and at home
15.	Content	The system reduces complex exercises into simpler ones
16.	Content	The system offers content linked to the needs of the child
17	Content	the system offers modification of the layout and interface by the user
20.	Content	The system gives information tailored to the child's interest
21.	Content	The system reminds children to start their exercises via pop-up messages
22.	Functional	The system features a multiplayer option
25.	Functional	The system has the option to rehearse exercises
26.	Content	The system shows achievements of all children
28.	Functional	The system has the option to let parents communicate to other parents via messaging
38.	Functional	The system offers multiple games for children to choose from
Medium priority		
Nr.	Type	Requirement
10.	Content	The system shows the goal(s) of the child whenever the app is launched
11.	Content	The system shows which exercise has to be completed to reach the next goal
18.	Functional	The system keeps track of user activity data
19.	Content	The system shows user activity data
23.	Content	The system suggests activities linked to the personal interest of the child
24.	Content	The system suggests activities linked to the current location of the child
27.	Content	The system shows a list of all user activity
Low priority		
Nr.	Type	Requirement
12.	Usability & user experience	The system offers a weekly reflection format for children to fill in with their parents
13.	Content	The system gives information about physical activity, linked to the personal interests of the child
14.	Content	The system coaches the child during the gameplay by giving positive encouragements
29.	Content	The system praises the child when a goal is reached through positive pop-up messages
30.	Content	The system gives the best player of the week recognition
31.	Functional	The system simulates real-life situations as exercises
32.	Content	The system offers children to see which children are performing the same exercise
33.	Functional	The system groups children
34.	Functional	The system sets group goals
35.	Content	The system explains the benefits of the exercises the children need to do
36.	Functional	The system creates a leader board
37.	Content	The system creates a leader board showing the points of every child

Adaptations needed to translate the AIRplay system to the RE-PLAY system are depicted in table 7.

Tabel 7 AIRplay adaptations

Nr.	Type	Requirement
High priority		
3.	Content	The system describes exercises through the steps of the Wat-Hoe-Doe-Check methodology
4.	Content	After the exercises, the system offers questions about the completed exercises to the children following the Wat-Hoe-Doe-Check methodology
6.	Content	The system will make the exercises gradually more difficult per week, based on the baseline measurement
9.	Organizational	The system presents exercises that can be done at therapy and at home
15.	Content	The system reduces complex exercises into simpler ones
17	Content	the system offers modification of the layout and interface by the user.
21.	Content	The system reminds children to start their exercises via pop-up messages
28.	Functional	The system has the option to let parents communicate to other parents via messaging
Medium priority		
23.	Content	The system suggests activities linked to the personal interest of the child
24.	Content	The system suggests activities linked to the current location of the child
Low priority		
12.	Usability & user experience	The system offers a weekly reflection format for children to fill in with their parents
13.	Content	The system gives information about physical activity, linked to the personal interests of the child
14.	Content	The system coaches the child during the gameplay by giving positive encouragements
30.	Content	The system gives the best player of the week recognition
31.	Functional	The system simulates real-life situations as exercises
32.	Content	The system offers children to see which children are performing the same exercise
34.	Functional	The system sets group goals
35.	Content	The system explains the benefits of the exercises the children need to do

5. Discussion

This study researched what the needs, values and wishes of children, parents and therapists were regarding eHealth use in the promotion of physical activity within the process of paediatric rehabilitation. Additionally, the matching persuasive features from the PSD model could be derived from this. The main results show that the RE-PLAY system must approach the children in a personalized way that is familiar to them. This approach should feature the Wat-Hoe-Doe-Check methodology used at Roessingh Centre for Rehabilitation. Lastly, the PSD principles of *personalization, reduction, tailoring, rewards and self-monitoring* were requirements of importance.

5.1. Preferences of children

Regarding children, it is important that an application has a personalized touch, something children can identify themselves with. This is not surprising, as every individual has different interests, different character traits and different needs. Children are found to do activities that are most motivating to them, as was also observed in a study by Majnemer and colleagues (52).

The personal aspect of a game can be derived from personal preferences of the child, and the amount of game playing experience present in the child. The preferences and game play duration have multiple influencing factors on child development, as was found in a study done by Sherry and colleagues (77). This study found that age alters gaming preferences in kids, marking simulation games as popular in children aged ten to fourteen. This is especially the case for girls. Play style, social interaction and temperament were marked additionally as important influencing factors of gaming preference.

When looking at the concept of eHealth itself, personalization is all about providing tailored output to individuals. Tailored output is based on unique characteristics, needs, or contexts affecting children. Personalization can be applied in the design of eHealth to:

1) Increase usefulness by providing individually selected features that are based upon an individual's needs, wishes and context;
2) Increase persuasiveness by providing individually tailored persuasive messages that are based upon an individual's characteristics and context;
3) Increase usability by providing an individually tailored interface and interaction design that is based upon an individual's needs, wishes and context;
4) Increase accessibility by providing an individually tailored interface and interaction design that is based upon an individual's disabilities.

However, personalization can contradict specific rules of thumb for good usability. Privacy is the first and foremost issue contradicting with a personalized design. The users' privacy preferences should be in line with the collection, interpretation and storage of personal and professional data. User control is related to the privacy issue. Designers of eHealth systems have to determine what degree of control users want regarding personalization, and how this process is influences by users (69).

The positive responses and an eagerness to use the RE-PLAY application is a finding that has overlap with observations of previous studies. The study by Weiss showed that when children are involved in the decision making, they are more motivated to participate in similar activities (49). The involvement of children within the design process has proven its value as well, as was seen when a game had to be developed to aid children in washing their hands (78). Within the design of this game, the aspect of fun was important, just as was found in this study. The study done by Reid and colleagues found that most of the children did not convey feedback on learning (78). However, Research done by Higgins (79) showed that if information is given to children, it should be formative feedback, as this will trigger deep learning. Regarding this formative feedback, more emphasis could be laid on explaining to children why feedback is important and required in games. Another way to design and develop serious games is to include other stakeholders such as teachers or educational technologists in the design phase to ensure crucial aspects are not overlooked (79).

Within the current study, parents or therapists might help with complementing the requirements gained from children's preferences. To investigate whether the needs, values and wishes

of the children were well understood, a suitable approach should be selected. One such approach could be the Center for eHealth Research (CeHRes) roadmap (80, 81). A human-centred design as well as a business modelling focus is incorporated in the CeHRes roadmap to ensure the creation of value-adding and sustainable eHealth technologies. Based upon the requirements, prototypes will need to be created and tested on the children. Requirements can be tested through roughly three kinds of evaluations (75):

1) Acceptance testing. In this evaluation very simple prototypes, such as paper and pencil sketches, demonstrate the main functionality and look and feel of a technology, and its associated working routing. User and stakeholder acceptance can be determined early on when acceptance testing is carried out (82).
2) Usability testing. In this evaluation users or experts interact with a clickable prototype that approximates the final version of the technology in terms of functionality and interface and interaction design. Usability issues are identified when carrying out this evaluation, which drives the modification of interface and interaction design (83).
3) Testing for effect. When a technology is launched, its effect and return on investment can be assessed. This type of evaluation is difficult to carry out, as it is influenced by multiple factors outside the technology itself. The concept of attribution theory (84) could provide a solution by making evaluations of a technology focus on lower level outcomes that can be directly linked to a feature, and indirectly to the overall goal of the technology.

When evaluating the requirements of children, acceptance and usability testing will most likely produce the most desirable effect. This is due to the fact that, according to social science, children can work through their concerns or understand the impact of something or someone. Clinicians and social scientists have always used toys, clay, and drawings to elicit the children preferences. Furthermore, the elaboration of ideas between adults and children is fruitful in understanding their world (85). Working with prototypes and visually showing these children what is being designed should therefore be done in order to achieve better implementation and acceptance of RE-PLAY.

5.2. Preferences of parents

The considerable involvement of parents within the rehabilitation process has been known and confirmed in this study. Literature review showed that the role of parents is of major importance in the development of their children, impacting paediatric rehabilitation as well. This has a great deal to do with the amount of influence parents have on the behaviour of their child, including physical activity. Next to the copying of behaviour, parents also play a role in the support of their child. Encouragement, involvement and facilitation are factors for a child to be supported in what they do, or want to do (56, 57).

As mentioned in the background of this study, parental influence plays a key part in the behaviour of a child (56). This is why their preferences concerning game design and development should play a role. As the use of videogames is extensive, particularly in children and young adolescents, the necessity of responsible adults able to manage this use starts with the parents themselves (86).

This study reported that parents found clarity an important aspect, noting that children were more adherent when the objective was clear. A study researching gamification concepts to promote therapy adherence in children with growth hormone deficiency acknowledged this fact as well. Providing information in a format that children understand and accept will play an important role in adherence, just as providing a way to lower the fears of trying along with a positive feedback system (87). These findings overlap considerably with the findings and commandments of Weiss (49), emphasizing fear reduction and positive feedback.

Just as with children, acceptance testing and usability testing is a suitable option to evaluate the requirements set up by parents (75). Different prototypes focused on feedback and clarity can be used to differentiate between the right type and amount of feedback and clarity given to a child. This is however a personal approach, as each child has different needs. An idea could be to let parents

evaluate the prototypes simultaneously with their child and make sure that a mutual agreement about feedback and clarity is created.

5.3. Preferences of therapists

The literature findings show a great deal of agreement on the Wat-Hoe-Doe-Check methodology used at Roessingh Centre for Rehabilitation, a variant on the CO-OP method (15). Taylor and colleagues (88) found that the CO-OP method is promising, especially in children with motor deficits. The CO-OP method is suitable even for younger children, as this group does not necessarily show poorer metacognition. Besides, younger children are able to use metacognitive strategies to improve on tasks meaningful to them. The effect of the CO-OP strategy is however dependent on the enthusiasm of the therapist, who has to ensure variability of tasks to keep the children's attention and focus (88). Multiple studies that assessed the CO-OP method found significant increases in motor performance between pre- and post-measurements (89, 90). However, the CO-OP method is a method designed specifically to focus on the cognitive domain, improving problem-solving skills and organization of daily activities. The CO-OP method is not designed to enhancing the motor skills performance, especially the finer coordination of movement. Furthermore, the CO-OP method is dependable on the cognitive and language abilities of the child, requires commitment from parents and children, and needs effective communication skills from therapists to be successful (89, 90). These effective communication skills require highly cognitive orientation and clear verbal guidance. As the child's abilities improve, the verbal guidance should gradually fade out. The process of fading out is especially difficult for parents, yet they should try to learn this process. Both therapist and parent should be aware of the fact that the CO-OP method is a child-centred framework. The child should not be forced to do tasks he or she is not motivated in. At last, both therapists and parents should have excellent skills in task analysis in order to enhance the problem solving skills of the child (89).

Experiencing success was deemed important as well, just as the aspect of fun when teaching children new skills. This will keep children motivated to adhere, not only to therapy, but on other challenging tasks in daily life as well. This finding is in line with the commandments of Weiss (49), showing that activities need to be matched to the child and not the other way around if motivation is your goal. The aspect of personal interest plays a key role in this, as every child is different.

AIRplay should thus be modified to the approaches taken at Roessingh Centre for Rehabilitation, implementing the Wat-Hoe-Doe-Check methodology to create stability and unity in the paediatric rehabilitation process of the child. This should then be combined with a positive feedback and rewarding system, creating positive stimulation and motivation of the child. It is important that parents and therapists have a similar approach to the children, so that no misunderstanding occurs.

5.4. PSD model

The PSD model found a lot of overlap with the needs, values and wishes expressed by all participants, covering 21 of the 28 principles, with personalization, reduction, tailoring, rewards and self-monitoring the most mentioned ones. The PSD model is a helpful tool in creating eHealth that has more potential and will most likely last longer, as well as grouping preferences within categories and principles, facilitating design and development. Implementing PSD principles mentioned by multiple target groups for which a game is developed will therefore increase adaptation within this group (19).

Personalization is important for children, thus creating games with a personal aspect where children can identify themselves with will increase acceptance. The study done by Weiss (49) confirms the importance of a personalized aspect, remarking that realistic goals have to be set per individual child. Offering children choices and involving them in the decision making is a great way of personalizing the process of rehabilitation and physical activity motivation as well. Large (91) and colleagues have stressed personalization as well. Firstly, it is important that children can change the interface and interaction with the RE-PLAY application, because the reaction to mascots, colours, layout and animation are personal and will differ from child to child. These differences are likely to be stronger among children than adults, making children more drawn to the application. Secondly,

personalization appeals to age groups, and what is attractive to one group might be too childish or too grown up for other age groups. Thirdly, there is evidence that suggests that presentation is related to gender, and personalization is a way to cater the tastes of both boys and girls (91).

Reduction has significant overlap with the Wat-Hoe-Doe-Check methodology used at Roessingh Centre for Rehabilitation, where children learn to dissect their tasks and problems in order to reduce a big, complex task into smaller, simpler tasks. The KISS commandment underlines this principle as well, emphasizing the importance of giving short and simple instructions, allowing more focus on the aspect of practice and play time (49). When developing the RE-PLAY application, reduction should be enforced. Clarity of instructions is critical for any user, but children in particular. This is due to the fact that children have a smaller vocabulary range and reduced reading abilities. The interface should use language that is age-appropriate and understandable in order to reduce confusion and distress (92).

Concerning tailoring, providing feedback and information based on unique or individual characteristics has been proven to work effectively (93). In terms of health care education, video games can offer unlimited opportunities for repetition and rehearsal. This can be done by individualizing messages to children and keeping them motivated (94). The mistake that is often made when targeting specific people or patients is that a group-based approach is used. A customizable approach more specific to individuals within a target group is believed to be important in behaviour-change processes (95). The RE-PLAY application could implement tailoring by sketching a user profile that holds the interests of the child using the application. In this way, the application can approach the child appropriately using familiar words and sentences to keep the child motivated.

A rewarding system is deemed important for children diagnosed with DCD, as this group is found to be extra sensitive to it. Children with DCD show heightened sensitivity to immediate reward, yet this also implies greater impulsivity. Caution must be taken when linking rewards to tasks that can be chosen, as children are more sensitive in choosing the highest reward, even if that means they must perform a task they are hardly capable of (96). RE-PLAY should reward the children more frequently in the beginning to facilitate the acceptance of the application and the progress of the therapy. The rewards should however be appropriate to the task performed, and increase gradually along with the task.

Offering children the option to see their actions and achievements makes them more aware of their actions and could be a motivational factor for short and long term programmes. As children with DCD are known not to implement self-monitoring on themselves, an application that does this for them could improve effectiveness of therapy. Another helpful tool in achieving better self-monitoring is the already mentioned CO-OP method, which is able to support children to self-monitor their behaviour (97). By keeping track of the progress and achievements of the child, the RE-PLAY application can implement self-monitoring as a way to show the child and the parents what is achieved, and what still has to be done.

Earlier research done within the field of eHealth and paediatric rehabilitation has been done with the creation of the AIRplay system. Although the AIRplay system has not explicitly used the framework of the PSD model in its design, it embedded several principles of the framework after revision. After post-hoc evaluation of the system, the following principles were found. The principles from the *primary task support* include *reduction, tailoring, personalization, self-monitoring,* and *rehearsal.* The most mentioned principles from the interviews clearly find overlap in the principles already in use by the AIRplay system. AIRplay did lack the tunnelling principle as researchers did not specify how activity goals will be changed over time (18). This can be changed by implementing requirements 6 and 14, where the exercises will gradually become more difficult as the child progresses, along with positive guidance during gameplay. Simulation could be added to AIRplay by implementing requirement 31, where exercises are simulated by the application, to be repeated by the child.

Regarding the *dialogue support* principles, *suggestions, similarity, liking,* and the *social role* were taken into account. The principles *praise, rewards* and *reminders* were found to be interesting as possible additions (18). Praising already happened in the playground, but the app itself could use some

more praising when a child reached a goal, as AIRplay would only praise the winning team and not the individual result. *Rewards* was something AIRplay incorporated as well, yet these rewards were for other games than AIRplay. RE-PLAY can focus on implementing in game rewards, like badges that hold the achievement of children, making them want to collect them all. *Reminders* can be added through requirement 21, using pop-up messages to remind children to start their exercises, or be more active.

Regarding *System Credibility Support*, the system embedded the principles *trustworthiness, expertise, authority, third-party endorsements* and *surface credibility.* This was mainly due to the involvement of a health care professional (18). Adding a *real-world-feel* could be added by granting parents the opportunity to contact each other via the application, sharing their problems and coming up with ideas.

Many principles from *Social Support* were included as well, this was mainly due to the ranking system and the social play aspects. *Social learning, social comparison, cooperation, competition* and *recognition* are included in the system (18). The PSD model can be efficiently used to provide valuable suggestions to the improvement of the application, even when linked to a playground. The PSD model could be used for translation and application of the AIRplay concept to applications for other (chronic) conditions, such as the RE-PLAY concept.

5.5. Physical Activity

The results on physical activity showed an adherence of one third of the children to the therapists' guideline of 10,000 steps. When looking at the time spent on MVPA (132.56 ± 47.63) it amounts to roughly 2 hours per day. This amount exceeds the recommended amount of 60 minutes per day sufficiently, indicating that children should be active enough on a daily basis (43). This finding is however contradicted in a systematic review done by Rivilis and colleagues (98), who found that poorer motor competence was negatively associated with physical activity. Individual results show great variability between subjects as well as the size of the standard deviation. This indicates that children vary vastly from day to day in terms of physical activity, and that a personalized approach is needed to support each individual child in their pursuit to a physically active lifestyle. Therapists can therefore use RE-PLAY to create personalized training programmes using realistic goals, stimulating the children to reach goals they are capable of reaching, thus increasing their motivation.

The use of the ActiGraph should be continued, as it has proven itself to be reliable and valid in the monitoring of walking activity in children, even when diagnosed with cerebral palsy (99). Furthermore, a good indication can be given on what the child's current physical activity status is. This data can be useful in designing the RE-PLAY application, as they will give therapists an overview of the current status of the child, assisting in the development of a personalized rehabilitation programme. This solidifies the need for the personalized requirements within the RE-PLAY application.

The amount of days does not seem to influence the physical activity data, as four to five days of monitoring is sufficient to achieve a reliability of 0.8 in activity monitoring of children (72). As all children were monitored for at least five days, the effect that the novelty of the ActiGraph could have had should not influence the results that much. Baselines of children could thus be formed relatively quick, as wear time of an ActiGraph would only need a week.

All participants were children diagnosed with DCD. Children with CP are hereby left out of the physical activity research. Activity levels in CP depend on the type of CP children are diagnosed with and the additional possibility of a learning disability, as these factors can be activity limitations (100). Children with CP are expected to have lower levels of physical activity, as they must cope with multiple disadvantages concerning physical functioning. It has been found that seven to eight percent of children with CP will reach the recommended guidelines for physical activity (101). Typically developing children show very different results concerning physical activity levels as well, accumulating to 59 minutes per day for boys, and 46 minutes per day for girls. The amount of steps seems to be more closely related to this study, as boys and girls respectively amount to 12,121 and 10,327 steps per day (102).

The physical activity results provide insight in the wish for an application such as RE-PLAY. This study showed good physical activity stats of the children that participated, yet according to scientific evidence, children with CP and DCD are still less physically active then their typically developing peers (103, 104). RE-PLAY could assist children with CP and DCD in reaching a higher level of physical activity, to eventually reach, or surpass the same level as their typically developing peers. For this assistance, the application should really look at the individual and create realistic goals.

5.6. Limitations

Limitations of this study include the sample size, as only three children, three parents and four therapists were interviewed. Although there was more than enough overlap in the findings, additional interviews might have gathered information that is of equal value than what has been gathered already, but simply did not reach this study. The sample size forms a limitation in the ActiGraph research as well, as such a small number will hardly represent the entire population, just as the amount of days measured. Another limitation could be the participants that were interviewed, as most came from Roessingh Centre for Rehabilitation, with the exception of one therapist. This could form difficulties in the implementation and translation to other rehabilitation centres, reducing the generalisability of the RE-PLAY application.

Concerning the children that were interviewed, all three were boys. When girls would have been interviewed, this could have generated vastly different results, and create a different view on the needs and wishes of the potential user groups. This difference became clear in the demo version that was performed (appendix 2), and was later found in the study by Sherry and colleagues (77). The girls were far more detailed in their answering, whereas the boys focused more on the whole of subjects. Next to the gender difference, the children that were interviewed were all diagnosed with DCD, leaving CP out of the picture just as in the physical activity part. Yet regarding the impairment, CP and DCD do seem to fall on a continuum. This could mean that interventions made for children with DCD, could influence children with CP in the same way, and vice versa (105).

5.7. Future research

Additional studies should lay more emphasis on children with CP, as this population has not been investigated in this study. However, the inclusion of children with CP was intended to at the start. With the addition of preferences from children with CP, a more broader range of children experiencing motor difficulties can be assisted through applications like RE-PLAY. This is because CP and DCD are common umbrella terms for multiple disorders affecting motor development (105). The RE-PLAY system could certainly be of assistance in helping more kids reach the guidelines of physical activity, using the AIRplay system as solid background and reflection material. The concept of eHealth within healthcare is however, relatively new and upcoming. This implies that, when looking to the future, eHealth will most likely be playing a bigger role than it already does. To maximize the implementation of RE-PLAY, further research will need to be done to fully understand the effect of RE-PLAY, such as running a RCT among larger user groups where girls and children diagnosed with CP are included. The promise of a system like RE-PLAY being of added value is, as told by therapists, certainly there, as is the eagerness and enthusiasm of the children that could be using the system. By using the PSD model, persuasive elements are better understood and this may help users to engage and keep motivated in their endeavours.

5.8. Conclusion

This study showed that to adapt AIRplay to RE-PLAY, attention has to be paid to the individual child, the disorder that is present, and the approach that they are familiar with. The interface and the layout of the application should become customizable to create a personalized and tailored application linked to the interest of the individual child. At last, the application needs to provide information and feedback based on the WAT-Hoe-Doe-Check methodology in order to create a clear and unambiguous

approach. Regarding the PSD principles, AIRplay can be adapted by implementing tunnelling and simulation, as well as modifying praise, rewards and reminders. Furthermore, it can add a real-world-feel by allowing parent to communicate with each other through the application.

References

1. Rosenbaum P, Paneth N, Leviton A, Goldstein M, Bax M, Damiano D, et al. A report: the definition and classification of cerebral palsy April 2006. Developmental medicine and child neurology Supplement. 2007;109:8-14.
2. Gomez A, Sirigu A. Developmental coordination disorder: core sensori-motor deficits, neurobiology and etiology. Neuropsychologia. 2015;79:272-87.
3. Oskoui M, Coutinho F, Dykeman J, Jetté N, Pringsheim T. An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. Developmental Medicine & Child Neurology. 2013;55(6):509-19.
4. Missiuna C, Rivard L, Campbell W. Developmental coordination disorder. Handbook of DSM-5 Disorders in Children and Adolescents: Springer; 2017. p. 431-50.
5. Colver A, Fairhurst C, Pharoah POD. Cerebral palsy. The Lancet. 2014;383(9924):1240-9.
6. Roebroeck ME, Jahnsen R, Carona C, Kent RM, Chamberlain MA. Adult outcomes and lifespan issues for people with childhood-onset physical disability. Developmental Medicine & Child Neurology. 2009;51(8):670-8.
7. Hill EL, Brown D. Mood impairments in adults previously diagnosed with developmental coordination disorder. Journal of Mental Health. 2013;22(4):334-40.
8. O'Shea TM. Diagnosis, treatment, and prevention of cerebral palsy in near-term/term infants. Clinical obstetrics and gynecology. 2008;51(4):816.
9. Potharaju NR. Seizures in cerebral palsy. Indian Journal of Cerebral Palsy. 2016;2(1):3.
10. Harris SR, Mickelson EC, Zwicker JG. Diagnosis and management of developmental coordination disorder. CMAJ : Canadian Medical Association journal = journal de l'Association medicale canadienne. 2015;187(9):659-65.
11. Damiano DL. Activity, activity, activity: rethinking our physical therapy approach to cerebral palsy. Physical therapy. 2006;86(11):1534-40.
12. Cairney J, Hay JA, Faught BE, Wade TJ, Corna L, Flouris A. Developmental coordination disorder, generalized self-efficacy toward physical activity, and participation in organized and free play activities. The Journal of pediatrics. 2005;147(4):515-20.
13. Bart O, Jarus T, Erez Y, Rosenberg L. How do young children with DCD participate and enjoy daily activities? Research in developmental disabilities. 2011;32(4):1317-22.
14. Novak I. Evidence-based diagnosis, health care, and rehabilitation for children with cerebral palsy. Journal of child neurology. 2014;29(8):1141-56.
15. SMITS-ENGELSMAN BC, Blank R, VAN DER KAAY AC, MOSTERD-VAN DER MEIJS R, VLUGT-VAN DEN BRAND E, Polatajko HJ, et al. Efficacy of interventions to improve motor performance in children with developmental coordination disorder: a combined systematic review and meta-analysis. Developmental Medicine & Child Neurology. 2013;55(3):229-37.
16. Majeed A, Black A, Car J, Anandan C, Cresswell K, McKinstry B, et al., editors. The Impact of eHealth on the Quality and Safety of Healthcare. International Conference on Communications Infrastructure Systems and Applications in Europe; 2009: Springer.
17. Cushing CC, Steele RG. A meta-analytic review of eHealth interventions for pediatric health promoting and maintaining behaviors. Journal of pediatric psychology. 2010;35(9):937-49.
18. Klaassen R, Van Delden R, Cabrita M, Tabak M, editors. AIRPlay: Towards a'Breathgiving'Approach. BCSS@ PERSUASIVE; 2017.
19. Oinas-Kukkonen H, Harjumaa M. Persuasive systems design: key issues, process model and system features. Routledge Handbook of Policy Design: Routledge; 2018. p. 105-23.
20. Van Der Slot WM, Nieuwenhuijsen C, VAN DEN BERG-EMONS RJ, Bergen MP, Hilberink SR, Stam HJ, et al. Chronic pain, fatigue, and depressive symptoms in adults with spastic bilateral cerebral palsy. Developmental Medicine & Child Neurology. 2012;54(9):836-42.
21. Vargus-Adams J. Health-related quality of life in childhood cerebral palsy. Archives of physical medicine and rehabilitation. 2005;86(5):940-5.

22. Stavsky M, Mor O, Mastrolia SA, Greenbaum S, Than NG, Erez O. Cerebral Palsy—Trends in Epidemiology and Recent Development in Prenatal Mechanisms of Disease, Treatment, and Prevention. Frontiers in pediatrics. 2017;5:21.
23. Reid SM, Carlin JB, Reddihough DS. Survival of individuals with cerebral palsy born in Victoria, Australia, between 1970 and 2004. Developmental Medicine & Child Neurology. 2012;54(4):353-60.
24. Tal-Saban M, Ornoy A, Parush S. Young Adults With Developmental Coordination Disorder: A Longitudinal Study. American Journal of Occupational Therapy. 2014;68(3):307-16.
25. Edwards J, Berube M, Erlandson K, Haug S, Johnstone H, Meagher M, et al. Developmental coordination disorder in school-aged children born very preterm and/or at very low birth weight: a systematic review. Journal of Developmental & Behavioral Pediatrics. 2011;32(9):678-87.
26. Janssen I, LeBlanc AG. Systematic review of the health benefits of physical activity and fitness in school-aged children and youth. International journal of behavioral nutrition and physical activity. 2010;7(1):40.
27. Cooper AR, Goodman A, Page AS, Sherar LB, Esliger DW, van Sluijs EM, et al. Objectively measured physical activity and sedentary time in youth: the International children's accelerometry database (ICAD). International journal of behavioral nutrition and physical activity. 2015;12(1):113.
28. Murphy NA, Carbone PS. Promoting the participation of children with disabilities in sports, recreation, and physical activities. Pediatrics. 2008;121(5):1057-61.
29. Celleri AMM. From traditional to interactive playspaces: Automatic analysis of player behavior in the interactive tag playground. 2016.
30. Janssen I. Physical activity guidelines for children and youth. Applied Physiology, Nutrition, and Metabolism. 2007;32(S2E):S109-21.
31. American College of Sports Medicine Opinion Statement on Physical Fitness in Children and Youth. Medicine & Science in Sports & Exercise. 1988;20(4):422-3.
32. Sallis JF, Patrick K. Physical Activity Guidelines for Adolescents: Consensus Statement. Pediatric exercise science. 1994;6(4):302-14.
33. Health NIo. NIH consensus development panel on physical activity and cardiovascular health: physical activity and cardiovascular health. Jama. 1996;276:241-6.
34. Manley AF. Physical activity and health: A report of the Surgeon General: Diane Publishing; 1996.
35. Biddle S, Cavill N, Sallis J. Policy framework for young people and health-enhancing physical activity. 1998.
36. Australia A. National physical activity guidelines for Australians. Canberra, Commonwealth Department of Health and Aged Care. 1999.
37. Irwin JD, He M, Bouck LMS, Tucker P, Pollett GL. Preschoolers' physical activity behaviours. Canadian Journal of Public Health. 2005;96(4):299-303.
38. Berg F, Buechner J, Parham E. Weight realities division of the Society for Nutrition Education Guidelines for childhood obesity prevention programs: promoting healthy weight in children. Journal of nutrition education and behavior. 2003;35:1-4.
39. Corbin C, Pangrazi R, Beighle A, Le Masurier G, Morgan C. Guidelines for appropriate physical activity for elementary school children: 2003 update. Reston: NASPE Publications. 2003.
40. Byers T, Nestle M, McTiernan A, Doyle C, Currie-Williams A, Gansler T, et al. American Cancer Society guidelines on nutrition and physical activity for cancer prevention: reducing the risk of cancer with healthy food choices and physical activity. CA: A Cancer Journal for Clinicians. 2002;52(2):92-119.
41. Health UDo, Services H. Dietary guidelines for Americans 2005. http://www health gov/dietaryguidelines/dga2005/document/default htm. 2005.
42. Strong WB, Malina RM, Blimkie CJ, Daniels SR, Dishman RK, Gutin B, et al. Evidence based physical activity for school-age youth. The Journal of pediatrics. 2005;146(6):732-7.
43. Health UDo, Services H. 2018 Physical Activity Guidelines Advisory Committee Scientific Report. Office of Disease Prevention and Health Promotion, Washington, DC; 2018.

44. Girolami GL, Campbell SK. Efficacy of a neuro-developmental treatment program to improve motor control in infants born prematurely. Pediatric Physical Therapy. 1994;6(4):175-84.
45. Dishman RK, Berthoud HR, Booth FW, Cotman CW, Edgerton VR, Fleshner MR, et al. Neurobiology of exercise. Obesity. 2006;14(3):345-56.
46. Dodd KJ, Taylor NF, Damiano DL. A systematic review of the effectiveness of strength-training programs for people with cerebral palsy. Archives of physical medicine and rehabilitation. 2002;83(8):1157-64.
47. Kwan MY, Cairney J, Hay JA, Faught BE. Understanding physical activity and motivations for children with Developmental Coordination Disorder: An investigation using the Theory of Planned Behavior. Research in developmental disabilities. 2013;34(11):3691-8.
48. Barnett A, Dawes H, Wilmut K. Constraints and facilitators to participation in physical activity in teenagers with Developmental Co-ordination Disorder: an exploratory interview study. Child: care, health and development. 2013;39(3):393-403.
49. Weiss MR. Motivating kids in physical activity. President's Council on Physical Fitness and Sports Research Digest. 2000.
50. McCarthy PJ, Jones MV, Clark-Carter D. Understanding enjoyment in youth sport: A developmental perspective. Psychology of sport and exercise. 2008;9(2):142-56.
51. Scanlan TK, Carpenter PJ, Simons JP, Schmidt GW, Keeler B. An introduction to the sport commitment model. Journal of sport and exercise psychology. 1993;15(1):1-15.
52. Majnemer A, Shevell M, Law M, Poulin C, Rosenbaum P. Level of motivation in mastering challenging tasks in children with cerebral palsy. Developmental Medicine & Child Neurology. 2010;52(12):1120-6.
53. Cramer SC, Sur M, Dobkin BH, O'brien C, Sanger TD, Trojanowski JQ, et al. Harnessing neuroplasticity for clinical applications. Brain : a journal of neurology. 2011;134(6):1591-609.
54. Tatla SK, Sauve K, Virji-Babul N, Holsti L, Butler C, Van Der Loos HFM. Evidence for outcomes of motivational rehabilitation interventions for children and adolescents with cerebral palsy: an American Academy for Cerebral Palsy and Developmental Medicine systematic review. Developmental Medicine & Child Neurology. 2013;55(7):593-601.
55. Katartzi ES, Vlachopoulos SP. Motivating children with developmental coordination disorder in school physical education: the self-determination theory approach. Research in developmental disabilities. 2011;32(6):2674-82.
56. Zecevic CA, Tremblay L, Lovsin T, Michel L. Parental influence on young children's physical activity. International journal of pediatrics. 2010;2010.
57. Alderman BL, Benham-Deal TB, Jenkins JM. Change in parental influence on children's physical activity over time. Journal of physical activity and health. 2010;7(1):60-7.
58. Thabrew H, Stasiak K, Garcia-Hoyos V, Merry SN. Game for health: How eHealth approaches might address the psychological needs of children and young people with long-term physical conditions. Journal of paediatrics and child health. 2016;52(11):1012-8.
59. Stinson J, Wilson R, Gill N, Yamada J, Holt J. A Systematic Review of Internet-based Self-Management Interventions for Youth with Health Conditions. Journal of pediatric psychology. 2008;34(5):495-510.
60. Maher CA, Williams MT, Olds T, Lane AE. An internet-based physical activity intervention for adolescents with cerebral palsy: a randomized controlled trial. Developmental Medicine & Child Neurology. 2010;52(5):448-55.
61. Weightman APH, Preston N, Holt R, Allsop M, Levesley M, Bhakta B. Engaging children in healthcare technology design: developing rehabilitation technology for children with cerebral palsy. Journal of Engineering Design. 2010;21(5):579-600.
62. Slater H, Campbell JM, Stinson JN, Burley MM, Briggs AM. End User and Implementer Experiences of mHealth Technologies for Noncommunicable Chronic Disease Management in Young Adults: Systematic Review. J Med Internet Res. 2017;19(12):e406-e.

63. Miyahara M, Butson R, Cutfield R, Clarkson JE. A pilot study of family-focused tele-intervention for children with developmental coordination disorder: development and lessons learned. Telemedicine and e-Health. 2009;15(7):707-12.
64. Hocking DR, Farhat H, Gavrila R, Caeyenberghs K, Shields N. Do active video games improve motor function in people with developmental disabilities? A meta-analysis of randomized-controlled trials. Archives of physical medicine and rehabilitation. 2018.
65. Caro K. Exergames for children with motor skills problems. ACM SIGACCESS Accessibility and Computing. 2014(108):20-6.
66. Omelina L, Jansen B, Bonnechère B, Van Sint Jan S, Cornelis J, editors. Serious games for physical rehabilitation: designing highly configurable and adaptable games. Proceedings of the 9th International Conference on Disability, Virtual Reality & Associated Technologies; 2012.
67. Annema J-H, Verstraete M, Vanden Abeele V, Desmet S, Geerts D, editors. Videogames in therapy: a therapist's perspective. Proceedings of the 3rd International Conference on Fun and Games; 2010: ACM.
68. Sandlund M, Dock K, Häger CK, Waterworth EL. Motion interactive video games in home training for children with cerebral palsy: parents' perceptions. Disability and rehabilitation. 2012;34(11):925-33.
69. van Gemert-Pijnen J, Peters O, Ossebaard HC. Improving eHealth: Eleven international publishing The Hague; 2013.
70. Van Teijlingen E, editor Semi-structured interviews. PGR Workshop December; 2014.
71. Eder D, Fingerson L. Interviewing children and adolescents. Handbook of interview research: Context and method. 2002;1:181-203.
72. Trost SG, Pate RR, Freedson PS, Sallis JF, Taylor WC. Using objective physical activity measures with youth: how many days of monitoring are needed? Medicine & Science in Sports & Exercise. 2000;32(2):426.
73. Harper D, Thompson AR. Qualitative research methods in mental health and psychotherapy: A guide for students and practitioners: John Wiley & Sons; 2011.
74. Clarke V, Braun V. Thematic analysis. Encyclopedia of quality of life and well-being research. 2014:6626-8.
75. Van Velsen L, Wentzel J, Van Gemert-Pijnen JE. Designing eHealth that matters via a multidisciplinary requirements development approach. JMIR research protocols. 2013;2(1):e21.
76. Herrmann SD, Barreira TV, Kang M, Ainsworth BE. How many hours are enough? Accelerometer wear time may provide bias in daily activity estimates. Journal of Physical Activity and Health. 2013;10(5):742-9.
77. Sherry JL, Lucas K, Greenberg BS, Holmstrom A. Child development and genre preference: Research for educational game design. Cyberpsychology, Behavior, and Social Networking. 2013;16(5):335-9.
78. Read JC, Sim G, Gregory A, Xu DY, Ode J-B. Children Designing Serious Games. EAI Endorsed Trans Serious Games. 2013;1(1):e5.
79. Higgins R, Hartley P, Skelton A. The conscientious consumer: Reconsidering the role of assessment feedback in student learning. Studies in higher education. 2002;27(1):53-64.
80. van Gemert-Pijnen JE, Nijland N, van Limburg M, Ossebaard HC, Kelders SM, Eysenbach G, et al. A holistic framework to improve the uptake and impact of eHealth technologies. J Med Internet Res. 2011;13(4):e111.
81. Nijland N. Grounding eHealth: towards a holistic framework for sustainable eHealth technologies. 2011.
82. Rudd J, Stern K, Isensee S. Low vs. high-fidelity prototyping debate. interactions. 1996;3(1):76-85.
83. Lim Y-K, Stolterman E, Tenenberg J. The anatomy of prototypes: Prototypes as filters, prototypes as manifestations of design ideas. ACM Transactions on Computer-Human Interaction (TOCHI). 2008;15(2):7.

84. Mayne J. Addressing attribution through contribution analysis: using performance measures sensibly. Canadian journal of program evaluation. 2001;16(1):1-24.
85. Druin A. Children as codesigners of new technologies: Valuing the imagination to transform what is possible. New directions for youth development. 2010;2010(128):35-43.
86. Bellotti F, Berta R, De Gloria A. Designing effective serious games: opportunities and challenges for research. International Journal of Emerging Technologies in Learning (iJET). 2010;5(2010).
87. Radovick S, Hershkovitz E, Kalisvaart A, Koning M, Paridaens K, Kamel Boulos M. Gamification concepts to promote and maintain therapy adherence in children with growth hormone deficiency. J. 2018;1(1):71-80.
88. Taylor S, Fayed N, Mandich A. CO-OP intervention for young children with developmental coordination disorder. OTJR: Occupation, Participation and Health. 2007;27(4):124-30.
89. Chan DY. The application of cognitive orientation to daily occupational performance (CO-OP) in children with developmental coordination disorder (DCD) in Hong Kong: A pilot study. Hong Kong Journal of Occupational Therapy. 2007;17(2):39-44.
90. Ward A, Rodger S. The application of cognitive orientation to daily occupational performance (CO-OP) with children 5–7 years with developmental coordination disorder. British Journal of Occupational Therapy. 2004;67(6):256-64.
91. Large J, Beheshti J. Interface design, web portals, and children. Library Trends. 2005;54(2):318-42.
92. McKnight L, Fitton D, editors. Touch-screen technology for children: giving the right instructions and getting the right responses. Proceedings of the 9th international conference on interaction design and children; 2010: ACM.
93. Napolitano MA, Marcus BH. Targeting and tailoring physical activity information using print and information technologies. Exercise and sport sciences reviews. 2002;30(3):122-8.
94. Lieberman DA. Interactive video games for health promotion: Effects on knowledge, self-efficacy, social support, and health. Health promotion and interactive technology: Theoretical applications and future directions. 1997:103-20.
95. Marcus BH, Nigg CR, Riebe D, Forsyth LH. Interactive communication strategies: Implications for population-based physical-activity promotion. American journal of preventive medicine. 2000;19(2):121-6.
96. Rahimi-Golkhandan S, Piek JP, Steenbergen B, Wilson PH. Hot executive function in children with Developmental Coordination Disorder: Evidence for heightened sensitivity to immediate reward. Cognitive Development. 2014;32:23-37.
97. Hyland M, Polatajko HJ. Enabling children with Developmental Coordination Disorder to self-regulate through the use of Dynamic Performance Analysis: Evidence from the CO-OP approach. Human Movement Science. 2012;31(4):987-98.
98. Rivilis I, Hay J, Cairney J, Klentrou P, Liu J, Faught BE. Physical activity and fitness in children with developmental coordination disorder: a systematic review. Research in developmental disabilities. 2011;32(3):894-910.
99. O'Neil ME, Fragala-Pinkham MA, Forman JL, Trost SG. Measuring reliability and validity of the ActiGraph GT3X accelerometer for children with cerebral palsy: a feasibility study. Journal of pediatric rehabilitation medicine. 2014;7(3):233-40.
100. Beckung E, Hagberg G. Neuroimpairments, activity limitations, and participation restrictions in children with cerebral palsy. Developmental medicine and child neurology. 2002;44(5):309-16.
101. Zwier JN, van Schie PE, Becher JG, Smits D-W, Gorter JW, Dallmeijer AJ. Physical activity in young children with cerebral palsy. Disability and rehabilitation. 2010;32(18):1501-8.
102. Colley RC, Garriguet D, Janssen I, Craig CL, Clarke J, Tremblay MS. Physical activity of Canadian children and youth: accelerometer results from the 2007 to 2009 Canadian Health Measures Survey. Health reports. 2011;22(1):15.

103. Bjornson KF, Belza B, Kartin D, Logsdon R, McLaughlin JF. Ambulatory physical activity performance in youth with cerebral palsy and youth who are developing typically. Physical therapy. 2007;87(3):248-57.
104. Green D, Lingam R, Mattocks C, Riddoch C, Ness A, Emond A. The risk of reduced physical activity in children with probable developmental coordination disorder: A prospective longitudinal study. Research in developmental disabilities. 2011;32(4):1332-42.
105. Williams J, Hyde C, Spittle A. Developmental coordination disorder and cerebral palsy: Is there a continuum? Current Developmental Disorders Reports. 2014;1(2):118-24.

Appendix 1 – observation in practice

Date: 13-3-2018
Time: 11:00-12:00
Subjects: 2 children diagnosed with DCD

I had the possibility to accompany a physiotherapist, Allard Dijkstra, during one of his practices. During this practice I observed two children who carried the diagnosis of DCD. The children carried out several tasks, including a variant of bowling, a one on one contest for fine motor skills and a game of basketball.

During the variant of bowling the children were handed five cones each, which they could place in any manner they pleased. Afterwards they could choose any possible ball and any possible distance to hit all cones in the least possible tries. As I observed, a couple of things I found surprising. They placed all cones against the wall and next to each other, which can make it more difficult to hit them all at once. The children both chose a ball of considerable size, which seemed logical. What did surprise me the most was that they proceeded to stand at the opposite site of the gym to try and hit the cones.

The second exercise was a competition between the two children. Each of them had to place six small cones over the whole length of the gym. Afterwards they were given six tennis balls, of which they had to place as many as they could on top of the cones. They were given 30 seconds to complete this task, this timespan was later reduced to 20 seconds. The first thing that stood out was that they were not able to place the cones over the whole length of the gym, and when asked to change they would put the last cone at the end and leave the rest be. When the timer started, meaning the children could start to put as many tennis balls as they could on the cones. One of them started at the last cone, instead of the one closest to him.

The third and last exercise consisted of a basketball competition between the two children. They could throw until one of them scored five times. What struck me was that they would throw the basketball in a straight line to the basket.

From the observation of the three tasks carried out by the children, and the discussion I had afterwards with the physiotherapist, I had renewed information about DCD. The children I observed had very little insight. After rehearsal of the exercises, adaptation to make it easier for themselves did not come from themselves. Because of this, the exercises took longer, causing the children to become distracted and start doing other things.

From the discussion I had with the physiotherapist afterwards, several remarks were made concerning children with DCD. The children have major difficulties making up their own games, often causing early disinterest and turning to gaming. Gaming in particular causes great satisfaction among children with DCD, as they are far less incompetent on this part. This, however, causes considerable amounts of sedentary time.

To counter this problem, gaming should be more active to encourage children with DCD to be more physically active. The main focus should lie on the increase of high intensity activity among these children. According to the physiotherapist, the game should act as a facilitator to eventually let the children play without technology. The games would need to be designed to look similar to games children can play outside with friends, without the use of technical features.

Another problem mentioned by the physiotherapist was one of environmental nature. The parents and others close to the child often do not understand the condition of the child. On top of that, most parents have their own obligations and responsibilities, which can cause them to pay less attention to their child. When their child is gaming, both parties are satisfied. There is more need of adequate support at home to keep the child encouraged to become and stay physically active.

Appendix 2 – interview demo

Demo-version interview
Date: 4-5-2018
duration: 40:18
Participants: 2 boys and 2 girls

Before conducting the actual interviews with children at Roessingh Centre for Rehabilitation, a demo was conducted first. This demo was carried out with 4 children, all aged 10-11 years old, playing together in the same football team and going to the same elementary school. These children did not have the conditions DCD or CP, one of them did understand the condition, because an acquaintance of her is diagnosed with CP. The children are however, of similar age and most likely share the same knowledge and interests as children with DCD or CP in terms of gaming.

The demo was conducted to find strong and weak points in the concept of the interviews, to see if something was overlooked or unnecessary. With the results of the demo, refinements can be made to the concept and creating the actual design that will be used in the interviews at Roessingh Centre for Rehabilitation. The following text will highlight some of the interesting points and deductions that were made during and after the demo.

During the demo, several things became clear. In terms of gaming, they liked similar games, which were played mostly on PlayStation. When asked about games by which you need to move/exercise, they said they would probably like and play those games. They only gamed when they were bored or had nothing to do at the moment. But they also mentioned some children within their class who were, as put in their words, “addicted to playing games” and “could play for hours on end”. It did help that the children had lots in common, because they almost immediately knew what the others were talking about.

During the conversations I had with the children, I was able to derive some tips for myself to be used in the actual interviews. The children were not easily triggered to answer a question when it was aimed at the whole group. Until one of the children started talking, a sometimes uneasy silence went by. When one of the children did start giving his/her opinion, however, the other kids were more eager to respond. When directing a question to a specific child, answers were more rapidly formulated and discussion was reached earlier. Discussion was also reached earlier when I responded to their answers, and asking the why and how behind it.

In regard to the questions, it depended on the manner in which the questions were asked. I learned that I had to ask the questions in such a manner that the children would understand it. This was often done by giving examples, this mostly triggered an ‘aha’ reaction and they were more capable of answering the question afterwards. The fact that I have known these children for three years helped with knowing what examples I could give to make them understand different subjects. When giving examples, I sometimes gave them examples from my own youth experience. This was something that was often badly understood, so that is something that will not come in handy to make children understand a subject. Prejudices are not recommended to be used as well.

I included a questionnaire and a mind map to be used at the end of the interview. The questionnaire included most principles from the Persuasive System Design (PSD) model, and the mind map was used to get the children to write down keywords they deemed important for a game they would use. The questionnaire turned out to be of some added value when gathering objective information about the PSD model. The surface credibility support category gained the least favour. They hardly understood these features, and one of the children said: “why do I care what organisation made it?” they did mention that trustworthiness was something to be implemented, but from what source this information came was not that important. Verifiability was also a point of discussion, one child said: “I would like to check how or why something is said.” The mind map was very confusing for the children, at first they did not know where to start or what to write down, this I found striking. After more specific explanations and examples, the children started writing, although I could still see three

of the four children struggling. They often looked at each other, not knowing what to write down. The mind map will need to be elaborated more clearly if it is to be used in the interviews.

After the interview, I asked the children what they thought about it. They said they liked to participate and were very eager to know if these games became available for them as well. One of them asked if “it will also be made for children who game a lot, so they get their movement as well”. This reflects back at the remark made at the beginning, where they talked about classmates who gamed a lot. When asking for some general tips about the development of the game, one child pointed out that “it should be something children like, because then you want to know more about it”. Something that is hyped should stay interesting, or children will lose interest quickly, this derived when giving the example of ‘Pokémon Go’, a game that triggered children to go outside and ‘catch Pokémon’s’. The child said Pokémon Go was an outdated game, on which the others agreed. This child also mentioned the option to change the language of the game, not only for the children, but also for the parents, because she knew someone with CP whose mother was German and in this way “his mother could also understand the goal of the application”. Another child mentioned that a help button should be implemented whenever something on the app was unclear for them. This child also mentioned that an option to ask question should be implemented.

Altogether, the interview was useful in deriving opinions from the children on different subjects. The manner in which the questions were asked is important when trying to make the children understand the different subjects. By asking personally and giving examples, answers were more quickly given and discussion was reached earlier. The examples should, however, be relevant to the children’s experience and not that of the researcher. The questionnaire and mind map are of added value. The former has been adjusted to the principles the children understand, the latter needs to be explained very well to the children.

Appendix 3 – interview schemes

Kinderen

Vraag	**Antwoord**
Wie ben jij? Weet je waarom je hier bent? Weet je wat we straks gaan doen?	
Wat vind je leuk? - Vind je sporten leuk? Wie vindt 'bijv. voetbal' leuk?	
Wat vind je niet leuk?	
Vind je het leuk op het Roessingh? - Waarom wel/niet? Vind je revalidatie leuk? - Waarom wel/niet?	
Wat vind je lastig om te doen? - Vind je sporten lastig?	
Wat doe je in je vrije tijd?	
Wat doe je als je je verveelt?	
Speel je veel? - Met je ouders? - Met je vriendjes?	
Vind je gamen leuk? - Hoe vaak game je? - Wanneer game je meestal? - Welke games vind je leuk? - Vind je actieve games leuk, zoals Wii/Kinect?	
Zou je het leuk vinden om te gamen voor de revalidatie? - Hoe moet zo een spelletje er uit zien?	

Ouders

Vraag	**Antwoord**
Wie bent u? Wat doet u in het dagelijks leven?	
Hoe betrokken bent u bij de zorg voor uw kind?	
Hoe actief bent u in het kader van sport?	
Hoe actief vindt u uw eigen kind?	
Welke activiteiten doet u met uw kind? - Bent u actief met uw kind? - Hoe ziet een typisch weekend eruit bij u?	
Hoe vaak is uw kind inactief? - Waar wordt het grootste deel van deze tijd aan besteed?	
Wat zijn verbeterpunten in de huidige (revalidatie)zorg van uw kind?	
Komt uw kind de aanbevelingen voor revalidatie na? - Waarom wel/niet?	
Bent u op de hoogte van de positieve effecten van fysieke activiteit tijdens de ontwikkeling van uw kind?	
Bent u op de hoogte van de negatieve effecten van inactief gedrag tijdens de ontwikkeling van uw kind?	
Wat motiveert uw kind? Hoe motiveert u hem/haar? - Werkt het vaak?	
Wat is uw mening over de invoering van gaming binnen het revalidatieproces? - Waar zou zo een spel aan moeten voldoen? - Wat zou zo een spel niet moeten bevatten? - *Verplaats u in uw kind, wat vind hij/zij leuk*	

Therapeuten

Wie ben je? - Hoe lang werkt u al bij het Roessingh? - Hoe bent u bij het Roessingh gekomen? - Wat vindt u het leukst aan kinderrevalidatie?	
Hoe ziet de huidige situatie van kinderrevalidatie eruit?	
Hoe meewerkend zijn kinderen tijdens de revalidatie? - Wat zijn redenen voor het wel/niet naleven van de aanbeveling voor revalidatie?	
Welke factoren zijn van belang wanneer kinderen gemotiveerd moeten worden voor revalidatie?	
Hoe kunnen kinderen ervaring opdoen met betrekking tot zelfmanagement? - Hoe kan technologie hierin helpen?	
Wat is uw advies voor de mate van fysieke activiteit van kinderen met DCD en CP? - In tegenstelling tot de richtlijnen voor een gezond kind?	
Wat is uw mening over de rol van ouders in het revalidatieproces?	
Is er enige ervaring met eHealth binnen het revalidatieproces? - Was deze ervaring positief/negatief? - Wat werkt (niet)?	
Wat zijn verbeterpunten in het huidige revalidatieproces?	
Hoe ziet de ideale situatie van kinderrevalidatie eruit?	
Hoe ziet u de mogelijkheden van een game-element binnen het revalidatieproces? - Waar moet zo een systeem aan voldoen? - Wat moet het meten? - Hoe vaak moet het meten? - Hoe zouden de resultaten het best gebruikt kunnen worden?	

Appendix 4 – objective PSD questionnaire

Standaard jongen of meisje

of

Zelf je poppetje maken

Alleen gamen

of

Samen gamen

Goed gedrag aanmoedigen

of

Beloning krijgen voor goed gedrag

Beste gebruiker,

Vergeet u vandaag niet om te denken aan uw dagelijkse beweging.

Bericht 1

of

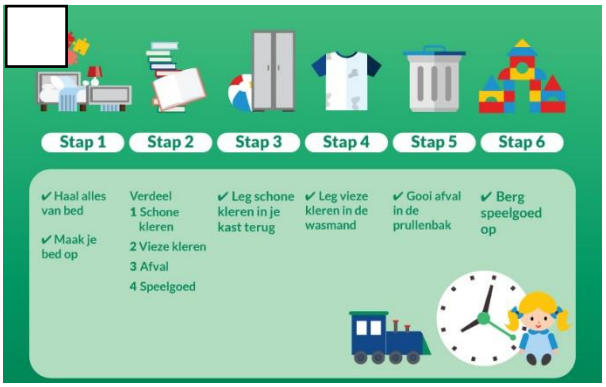
Ha Stijn,

Hoe is ie vandaag, zin om weer ff lekker te spelen? Je score van gisteren smaakt naar meer!!

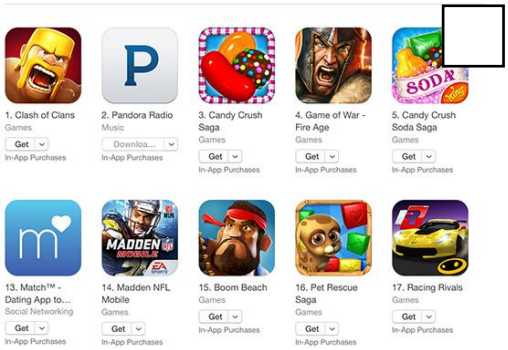
Bericht 2

Ruim je kamer op.

Je krijgt 1 taak zo uitgelegd



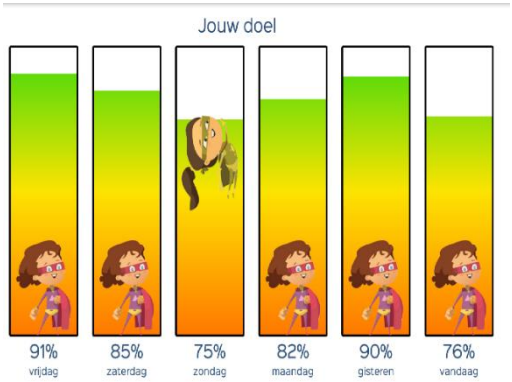
Je krijgt 1 taak zo uitgelegd

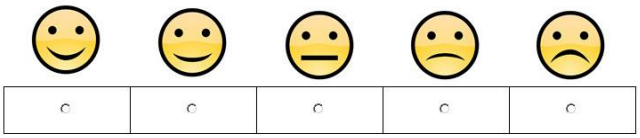


De app geeft je een lijst met van alles wat

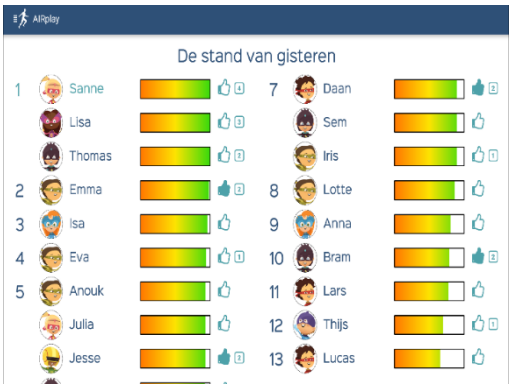
of

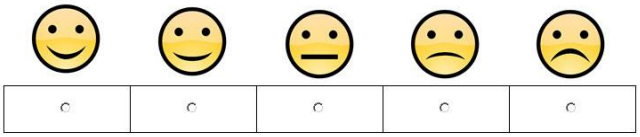
De app selecteert spelletjes en apps die jij leuk vind



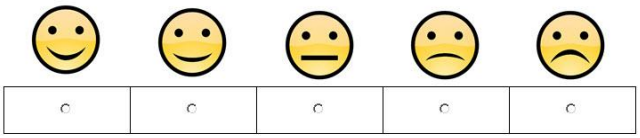


Je kunt zien hoeveel je elke dag hebt gedaan





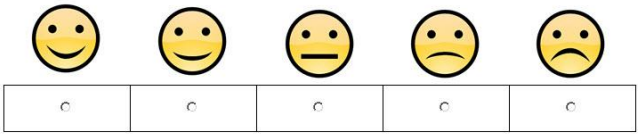
Je kunt zien hoe goed anderen het doen



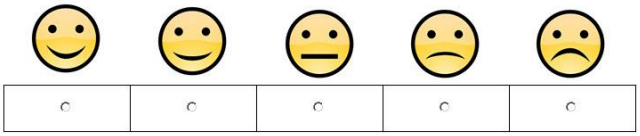
Je kunt elke week de beste speler worden,

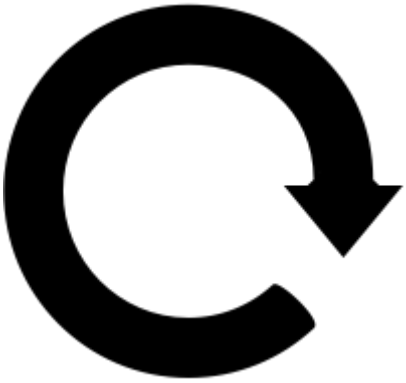
als je maar goed genoeg je best doet

Met elkaar samen spelen

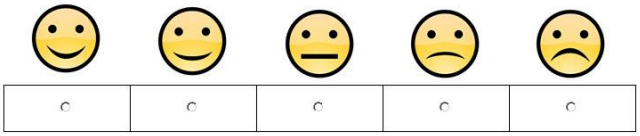


Tegen elkaar spelen



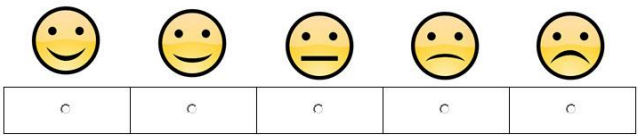


Je mag oefeningen opnieuw doen als je dat wil

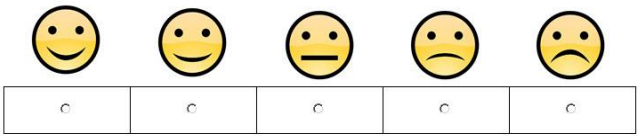


Oefening A3 is vandaag een goede om mee te beginnen vandaag.

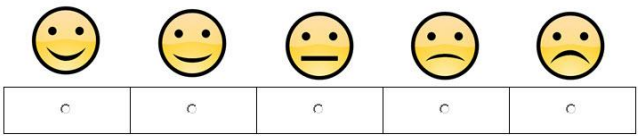
De app zoekt voor jou een gepaste oefening uit



Alles wat de app jou verteld moet eerlijk zijn.



Als de app bepaalde dingen zegt moet je dit terug kunnen vinden op het internet. Denk aan moeilijke woorden of moeilijke levels die je niet snapt.



Appendix 5 – The code schemes

PSD model		
Code	**Description**	**Example fragment(s)**
PTS_Personalization	All statements that cover the importance of personalized content and services	"You compose a top five and start working on it, and objectives can differ, in terms of what they want to learn." "It should be fun, but it should be something that triggers them, something so motivating they use it without external motivators."
PTS_Reduction	All statements that cover the reduction of complex tasks into simpler tasks to help the user	"Everyone hits the ball at first try, and then you start to add direction to the hits. That is where the therapy starts, how should I position myself? How should I hold the bat? This applies to all tasks, what steps should I take to achieve my goal?" "We won't try the same thing a hundred times until succession, you adjust the situation in such a way that succession is reached. Later on the tasks can be made more difficult."
PTS_Tailoring	All statements that cover personalized information of the system	"Sort out what a child needs, what it wants to learn, in order to let motivation play a huge role." "If we think we have the motivational method for him, it works counterproductive the next time."
DS_Rewards	All statements that cover the use of a rewarding system	"I always work with a rewarding system, children are very, very sensitive to rewards." "There should be a challenge, if you play a lot you'll enter the next level and receive something extra, like some coins to spend on extra features within the game."
PTS_Self Monitoring	All statements that cover the monitoring of activity	"Looking back on something you did, and is that part going well?" "Such an application could work very motivational, when a child can see exactly what we have done."

SS_Cooperation	All statements that cover playing together	“Playing together with other children could cause the children to stimulate each other and promote interaction.” “It would be great that you have a level that stimulates cooperation, that you must work together to reach your goal.”
DS_reminders	All statements that cover the concept of reminding	“At a certain moment you should see progression, and refer to that, to see if it works: are you succeeding in cycling to grandpa and grandma? Or: are you able to maintain this task all by yourself?” “What would also be nice is when a kid has been on the tablet for a couple of hours, that a sound awakens the child and tells him to get to work.”
DS_Suggestion	All statements that cover the use of suggestion	“I always try to link activity to daily activities. Like when they own a dog, walk the dog, go grocery shopping twice a week, go to school by bike instead of by car.” “It would be nice if there was something that if the application could help children come up with activities. Like when they take a picture of three trees, the app would give three possibilities, like aiming a ball. Something to help the children think of games they can do by themselves.”
PTS_Rehearsal	All statements that cover repetition	“Here you practice, at home you need to apply it.” “You have children who learn to cycle, and if they don’t do it, they lose the ability.”
SS_Social Comparison	All statements that cover the comparison of results	“Link user behaviour to the behaviour of other users and that it is visible on a scoreboard.”
DS_Social Role	All statements that cover the adoption of a social role	“I think that, if you bring people together that have much in common, you can come up with a lot of ideas to solve problems. To stimulate others to think, so that it won’t all come down to just the therapist.”

		“That you can use it as feedback with parents, like how are things going now? What is difficult?”
SS_Social Facilitation	All statements that cover carrying out behaviour simultaneously	“When you have a running group and you have to do something with others, then you have to be there and you’re much more likely to participate than when you’re running individually.”
SS_Social Learning	All statements that cover the ability to see achievements of others	“Let’s say we start with a group, 5000 steps is the goal, and that you are able to see who has completed this task.” “If you can see that someone else reached level 2, you also want to reach it.”
DS_Praise	All statements that cover the element of praise	“The child can’t climb the entire stair, but made the first few steps. You can show him how far he’s come, to motivate him just by stating his progress and letting him know he’s doing well.”
SS_Recognition	All statements that cover recognition of accomplishments	“If a child sees achievements of others, he must also get to work, to become the best of the week.” “The kids are already performing poorly outside of the rehabilitation, you want to prevent them becoming the worst.”
PTS_Simulation	All statements that cover simulation	“What I would like to see is what you see in the real world as well. Like when you are cycling, you can see your hands and the steering wheel. This gives your sense of your own body back.”
SCS_Verifiability	All statements that cover the ability to verify information	“At a certain moment you have to know what it’s good for, like why do I have to walk 10.000 steps.”
SS_Competition	All statements that cover the aspect of competition	“You need competition, it is important that you are motivated by each other, the downside is that competition can also demotivate.”

SS_Normative Influence	All statements that cover peer pressure	"When you can do something in a group, where everyone is on the same level of performance, they can motivate each other."
SCS_Third-Party endorsements	All statements that cover the involvement of third parties	**"What do you think would not work?"** – "*commercials, and paying extra"*
SCS_Surface Credibility	All statements that cover the look and feel of a system	"Those games are way too old, they should be more detailed."
Recommendations		
Code	**Description**	**Example fragment(s)**
Child_Clarity	All statements that cover the aspect of clarity	"You should give them a clear goal, so that they know what is expected of them."
Reflect	All statements that cover the ability to reflect on behaviour	"What I find an important part is the ability to stop every now and then, look back at what just happened, reflect on that, and then continue."
Enjoyment	All statements that cover the aspect of enjoyment and fun	"when talking about playing, it should be something interactive and attractive." "Yesterday we practiced something that he really liked, and you can see hem shine and even come up with his own twists to the game."
Success Experience	All statements that cover the aspect of experiencing success	"Finding success in what you do is important, especially in the beginning of the treatment."
Continuity	All statements that cover the continuation of rehabilitation recommendations	"Eventually, it should become a daily routine for children." "It is important that it will be something for the long term."
Control	All statements that cover letting children have control over their situation	"You don't want them to be overwhelmed by everything, but that they retain a grip on the situation."
Personal information		
Code	**Description**	**Example fragment(s)**
Therapist_Experience	All statements that cover the working experience of the therapist	"I have been working here for 8 years now, I started in 2010."

Therapist_Motivation	All statements that cover the therapist's reasons for child rehabilitation	"The developmental aspect makes it more difficult, but extra interesting, you have to be creative."
Group characteristics		
Code	**Description**	**Example fragment(s)**
Child_Characteristics	All statements that cover the characteristics of children	"These children not only have motor problems, but experience developmental problems as well, meaning they have behavioural problems too." "In sports he is quite fanatical, but in daily life he really needs constant stimulation."
Parental Role	All statements that cover the role of parents during the rehabilitation process	"*Don't forget the parents"* – **"the parents are an important factor?"** – *"In my opinion they are."* "We are putting a lot of time in the care of our child, I do not know how much, but I think that if you keep track of it, it will shock you."
Child_Interest	All statements that cover the interests of the children	"I mostly play shooting games." "He is lyrical about anything with wheels, cars, trucks you name it."
Child_Activities	All statements that cover the daily activities of the children	"He likes riding his kart when he is playing outside." "When I have to make a division of active/inactive, I would say he is more inactive."
Parent_Rules	All statements that cover the rules parents have for their children	"You can let him use the IPad all day, but I won't let him." "I might be the only parent against all that gaming, but that is just not happening in my house."
Child_Rehab_Followup	All statements that cover the child's and parents' experience of the rehabilitation	"In terms of recommendations he is really persistent, and they know that they won't have to remind my child, because he will remind us when we don't."
Child_ActiveGaming	All statements that cover the experience with active games	**"do you know of active games, like a Wii?" –** *"yes but I don't have that at home."* – "But mommy is thinking of buying one."
External Factors	All statements that cover the influence of external factors	"Children remain very dependent on their environment, so a little guidance in those situations is welcome."

Parent_Awareness	All statements that cover the awareness of parents concerning physical activity	"Physical activity is good for anyone, I have experienced it myself because I was treated here as a child as well."
Current situation		
Code	**Description**	**Example fragment(s)**
Therapy_Approach	All statements that cover the approaches of therapists during rehabilitation	"You should always try to give an overview of the situation, that they will know when they have completed a certain task." "That is the trick of paediatric rehabilitation, you have to investigate the needs of a child, what he or she wants to learn, and then make that motivation play a big role."
Therapy_eHealth Experience	All statements that cover previous or ongoing experiences with eHealth technologies	"You are amazed when you see what all those technical students can create, it was better then I had expected, but it is not entirely the same as the real deal."
Therapy_Guidelines	All statements that cover the current guidelines or changes in guidelines concerning physical activity	"I would advise the same guidelines for children with DCD as for 'normal' children." "I am surprised to see how much people do not reach the guideline of 10.000 steps per day, they barely make 3000."
Implementation		
Code	**Description**	**Example fragment(s)**
Implementation of eHealth	All statements that cover implementation tips for new eHealth systems	"It has to be easily applicable, and it has to be an added value." "The four steps of the Wat-Hoe-Doe-Check methodology should be present somewhere in the application, as this is the methodology the children learn to apply."

Appendix 6 – list of requirements

User expression	Value	Attribute(s)	Requirement(s)
“a part of our population really likes to use the tablet.”	Applicability	Where the system should be applicable to	The system works on a tablet
“what I do notice is that when children come home, they will reach for the tablet or computer to play games.”			The system works on both IOS and Android

Requirement #: 1	**Requirement type:** functional
Value: Primary Task Support	**Attribute:** where the system should be applicable to
Description: the system works on a tablet	
Rationale: because most of the children in the rehabilitation process are eager to reach for tablets when at home, the system should be able to work on the thing that triggers the children, to reach better acceptation.	
Source: interview 1 & 3	
Fit criteria: 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 30 2018	

Requirement #: 2	**Requirement type:** functional
Value: Primary Task Support	**Attribute:** where the system should be applicable to
Description: the system works on both IOS and Android	
Rationale: because there are different types of tablets using different operating systems,	
Source: interview 1 & 3	
Fit criteria: 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 30 2018	

User expression	Value	Attribute(s)	Requirement(s)
“We use de CO-OP, it is a strategy you learn, how to cope with wat I want to do.”	guidance	An approach following the Wat-Hoe-Doe-Check methodology	The system describes exercises through the principles of the Wat-Hoe-Doe-Check methodology
“We have the Wat-Hoe-Doe-Check, what are we going to do, how do you			After the exercises, the system offers

do it, that's making the plan, then you do it and you evaluate, that is really typical."			questions about the completed exercises to the children following the Wat-Hoe-Doe-Check methodology

Requirement #: 3	**Requirement type:** content
Value: Dialogue Support	**Attribute:** an approach following the Wat-Hoe-Doe-Check methodology
Description: the system describes exercises through the steps of the Wat-Hoe-Doe-Check methodology.	
Rationale: therapists at Roessingh Centre for Rehabilitation use the Wat-Hoe-Doe-Check methodology to guide children through the rehabilitation process. It is used to create stability and creating an opportunity for children to make the translation between therapy and daily life.	
Source: interview 1, 2 & 3	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 17 2018, appendix 1	

Requirement #: 4	**Requirement type:** content
Value: Dialogue Support	**Attribute:** an approach following the Wat-Hoe-Doe-Check methodology
Description: after the exercises, the system offers questions about the completed exercises to the children following the Wat-Hoe-Doe-Check methodology.	
Rationale: children need to be questioned and have the ability to reflect on their behaviour, in order to improve that behaviour	
Source: interview 1, 2 & 3	
Fit criteria: 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 31 2018, appendix 1 (4)	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"That's what you're looking for, where are the success experiences." "The success of the things you do is of great importance when you begin the treatment."	Success	Experiencing success when carrying out tasks	The system sets goals based on a baseline measurement done by therapists
"If you slowly build things up from success, you can accomplish a lot."			The system will make the exercises gradually more difficult per week, based on the

			baseline measurement
"Experiencing success is very important, with every child."			The system will reward the child with badges whenever a goal is reached
			The system gives badges related to the personal interests of the children

Requirement #: 5	**Requirement type:** content
Value: Primary Task Support	**Attribute:** experiencing success when carrying out tasks
Description: The system sets goals based on a baseline measurement done by therapists	
Rationale: most children in the paediatric rehabilitation process have negative experiences with physical activity and are demotivated because of it. To counter this, it is important for these children to experience success in the tasks they must perform, when setting goals that are better suited for them and a guarantee for success, they can be motivated in a better way.	
Source: interview 1, 3, 4, 5 & 7	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 31 2018, adjusted on April 15 2019, appendix 2 (1)	

Requirement #: 6	**Requirement type:** content
Value: Primary Task Support	**Attribute:** experiencing success when carrying out tasks
Description: the system will make the exercises gradually more difficult per week, based on the baseline measurement	
Rationale: children are able to start on a level low enough for their abilities to succeed, but will need to be challenged to keep them interested and to improve therapy outcomes, this is why the goals need to be adjusted weekly.	
Source: interview 1, 3, 4 & 5	
Fit criteria: **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 31 2018, adjusted on April 15 2019, appendix 2 (2)	

Requirement #: 7	**Requirement type:** content
Value: Dialogue Support	**Attribute:** experiencing success when carrying out tasks
Description: the system will reward the child with badges whenever a goal is reached	
Rationale: children like getting rewards, this is why bigger success can be reached by rewarding children with rewards like badges, representing their achievement.	

Source: interview 2, 3, 4 & 7	
Fit criteria: 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 31 2018, adjusted on April 15 2019, appendix 2 (3)	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"Make sure that it includes stuff that is enjoyable, to keep them motivated."	Enjoyment	The experience should be positive	The system features content linked to the interest of the child
"It should be, if that is possible, attractive."			

Requirement #: 8	**Requirement type:** content
Value: Primary Task Support	**Attribute:** the experience should be positive
Description: the system features exercises linked to the interest of the child.	
Rationale: to motivate children, it is important to know what they find interesting. This way, the therapy can become more effective.	
Source: interview 1, 2, 3, 4 & 6	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 17 2018, adjusted on April 15 2019	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"The exercises should become part of the daily routine."	Continuity	Exercises that are applicable in daily life	The system presents exercises that can be done at therapy and at home.

Requirement #: 9	**Requirement type:** organizational
Value: Primary Task Support	**Attribute:** exercises that are applicable in daily life
Description: the system presents exercises that can be done at therapy and at home.	
Rationale: It is important for therapist that the exercises they give children during practice hours can also be done at home.	
Source: interview 1, 2 & 4	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	

Priority: high	**Conflicts:** not applicable
History: created on July 17 2018	

User expression	Value	Attribute(s)	Requirement(s)
"You should always try to give an overview, so that children know what it's for, and when they've reached their goal."	Goal-setting	Making clear to children what their goals there are	The system shows the goal(s) of the child whenever the app is launched
"It is a challenge with every child to set the right goals."		Showing the progress	The system shows which exercise has to be completed to reach the next goal

Requirement #: 10	**Requirement type:** content
Value: Primary Task Support	**Attribute:** making clear to children what their goals there are
Description: the system shows the goal(s) of the child whenever the app is launched.	
Rationale: for children it comes in handy to show agreed upon rehabilitation goals, so they will be reminded why they practice.	
Source: interview 2, 3, 5 & 6	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: medium	**Conflicts:** not applicable
History: created on July 17 2018, adjusted on April 15 2019	

Requirement #: 11	**Requirement type:** content
Value: Primary Task Support	**Attribute:** showing the progress
Description: the system shows which exercise has to be completed to reach the next goal.	
Rationale: children can be motivated by letting them see what they have to do before reaching their end-goal.	
Source: interview 2, 3 & 5	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: medium	**Conflicts:** This requirement shows a lot of overlap with the self-monitoring principle.
History: created on July 17 2018, adjusted on 15 April 2019	

User expression	Value	Attribute(s)	Requirement(s)
"Make the children get a grip on their situation, so they won't be overwhelmed."	Control	Letting children in control	The system offers a weekly reflection format for children to

			fill in with their parents
"You want children to learn from their mistakes, by themselves."			

Requirement #: 12	**Requirement type:** usability & user experience
Value: Primary Task Support	**Attribute:** letting children in control
Description: the system offers a weekly reflection format for children to fill in with their parents.	
Rationale: it is of significance to allow children to get a grip on their situation, by making them question their actions and making them more aware of their actions.	
Source: interview 1 & 3	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** a prototype of the questionnaire can be handed prior to the addition of the format, to ensure the parents and children understand the way it works and if it is needed in the first place. 3. **Summative evaluation:** not applicable	
Priority: low	**Conflicts:** this requirement comes relatively close to the Wat-Hoe-Doe-Check methodology requirement, so it could be merged.
History: created on July 17 2018, appendix 3	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"Creating awareness among children is one of the most important things."	Awareness	Creating awareness among children	The system gives information about physical activity, linked to the personal interest of the child

Requirement #: 13	**Requirement type:** content
Value: System Credibility Support	**Attribute:** creating awareness among children
Description: the system gives information about physical activity, linked to the personal interests of the child.	
Rationale: making children aware of their behaviour and showing them the consequences might work better on the long term.	
Source: interview 1, 2 & 3	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: low	**Conflicts:** not applicable
History: created on July 17 2018, appendix 4	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"While we're on the subject of play, something interactive might be of added value."	interactivity	Responsive features to create interactivity	The system coaches the child during the gameplay by giving positive encouragements

Requirement #: 14	**Requirement type:** content
Value: Dialogue Support	**Attribute:** responsive features to create interactivity
Description: the system coaches the child during the gameplay by giving positive encouragements.	
Rationale: by creating an interactive environment, children are triggered to respond, which can enhance the user experience.	
Source: interview 1 & 6	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: low	**Conflicts:** not applicable
History: created on July 17 2018, adjusted on 15 April 2019	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"It are the little things, it doesn't have to be that big, just as practical as possible."	Reduction	Splitting up big complex into simpler ones	The system reduces complex exercises into simpler ones
"It shouldn't become too complicated, do it in steps."			
"You facilitate the task and you take a step back."			

Requirement #: 15	**Requirement type:** content
Value: Primary Task Support	**Attribute:** splitting up complex tasks into smaller ones
Description: the system reduces complex exercises into simpler ones.	
Rationale: children within the rehabilitation programme often experience problems when trying to solve tasks. It is important for therapists to show these children the smaller steps within the big step.	
Source: interview 1, 2, 3, 4, 5 & 6	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 17 2018, adjusted on 15 April 2019 appendix 1 (1,2)	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"You won't offer something you know won't work."	personalization	Personalized content	The system offers content linked to the needs of the child
"I think it varies per child, and you need to see what fits the child."			

Requirement #: 16	**Requirement type:** content
Value: Primary Task Support	**Attribute:** personalized content
Description: the system offers content linked to the needs of the child.	
Rationale: because every child struggles with its own problems and sets its own goals within the rehabilitation process, it is important to guide them individually.	
Source: interview 1, 3, 4, 5, 6 & 7	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** there is overlap with the tailoring requirement
History: created on July 17 2018, adjusted on 15 April 2019, appendix 4	

Requirement #: 17	**Requirement type:** content
Value: Primary Task Support	**Attribute:** personalized content
Description: the system offers modification of the layout and interface by the user.	
Rationale: because every child has their own interests it is important to make the app adaptable to their liking.	
Source: interview 1, 3, 4, 5, 6 & 7	
Fit criteria 4. **Acceptance testing:** not applicable 5. **Usability testing:** not applicable 6. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** there is overlap with the tailoring requirement
History: created on April 16 2019	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"It could work very motivational when a child can see what we have done so far, for instance the amount of steps."	Monitoring	Self-monitoring of activity	The system keeps track of user activity data
"Children find it interesting to see what they have done at the end of the day."			The system shows user activity data

Requirement #: 18	**Requirement type:** functional
Value: Primary Task Support	**Attribute:** self-monitoring of activity
Description: the system keeps track of user activity data.	
Rationale: keeping track of user data proves useful for reflecting on it and checking progress.	
Source: interview 2, 3, 4 & 7	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: medium	**Conflicts:** there is overlap with the goal-setting requirement
History: created on July 17 2018, adjusted on April 15 2019	

Requirement #: 19	**Requirement type:** content
Value: Primary Task Support	**Attribute:** self-monitoring of activity
Description: the system shows user activity data	
Rationale: it is interesting to children when they are able to see what they have done, which can motivate them to keep going.	
Source: interview 2, 3, & 4	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: medium	**Conflicts:** there is overlap with the goal-setting requirement
History: created on July 17 2018	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"With one child you need to make a plan, with the other you need to adjust the performance."	Tailoring	Presented information is linked to interest of user	The system gives information tailored to the child's interests

Requirement #: 20	**Requirement type:** content
Value: Primary Task Support	**Attribute:** presented information is linked to interest of user
Description: the system gives information tailored to the child's interest.	
Rationale: providing information that triggers the child's personal interest is useful for adherence	
Source: interview 1, 2, 3, 6 & 7	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** there is overlap with the personalization requirement
History: created on July 17 2018, adjusted on 15 April 2019, appendix 4	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"To ask if they can still reach the amount of steps."	Reminder	Reminder feature to keep users adherent	The system reminds children to start their exercises via pop up messages
"What would be nice is that if a child has been on the tablet for a few hours and that a noise suddenly pops up telling the kid to work on his goals."			
"I'll tell them to set an alarm, and when it goes off, you need to get to work on the exercise."			

Requirement #: 21	**Requirement type:** content
Value: Dialogue Support	**Attribute:** reminder feature to keep children adherent
Description: the system reminds children to start their exercises via pop-up messages	
Rationale: by reminding the user to start an exercise, children will not forget it, which can cause better adherence	
Source: interview 1, 2, 3, 4, 5 & 7	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 17 2018, adjusted on 15 April 2019	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"It might be an idea to do it together, because otherwise they will keep all by themselves."	Cooperation	Playing together with other children	The system features a multiplayer option
"Playing with other children makes children stimulate each other and promote interaction."			

Requirement #: 22	**Requirement type:** functional
Value: Social Support	**Attribute:** playing together with other children
Description: the system features a multiplayer option	
Rationale: by letting children play together, they can stimulate each other to bring out the best in themselves.	
Source: interview 1, 2, 3, 6 & 7	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 17 2018, adjusted on 15 April 2019	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"What ways are there to reach the daily steps, like walking the dog, walking to grandma, or walk to school instead of taking the car?"	Suggestion	Suggestion of options to the user	The system suggests activities linked to the personal interest of the child.
"I noticed the kid didn't like to play soccer, so I suggested that swimming might be his thing."			The system suggests activities linked to the current location.
			The system suggests activities linked to the current time.

Requirement #: 23	**Requirement type:** content
Value: Dialogue Support	**Attribute:** suggestion of options to the user
Description: the system suggests activities linked to the personal interest of the child.	
Rationale: children within the paediatric rehabilitation process often have trouble coming up with ideas, so it can prove helpful when the system offers some suggestions related to the interests of the child.	
Source: interview 1, 2, 3, 4, 5 & 6	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: medium	**Conflicts:** this requirement could have overlap with the personalization and tailoring requirement.
History: created on July 18 2018, adjusted on 15 April 2019, appendix 5 (1)	

Requirement #: 24	**Requirement type:** content
Value: Dialogue Support	**Attribute:** suggestion of options to the user
Description: the system suggests activities linked to the current location of the child.	
Rationale: children within the paediatric rehabilitation process often have trouble coming up with ideas, it might be easy for them when the system suggests activities that can be done close to the child's location.	
Source: interview 1, 2, 3 & 4	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: medium	**Conflicts:** not applicable
History: created on July 18 2018, appendix 5 (2)	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"You should look at the opportunity to make it possible to let the children rehearse, it is important for most of the children."	Rehearsal	An option to replay activities	The system has the option to replay exercises
"Here you have to practice, but you need to be able to apply it in daily life."			

Requirement #: 25	**Requirement type:** functional
Value: Primary Task Support	**Attribute:** an option to replay activities
Description: the system has the option to replay exercises	
Rationale: children within the paediatric rehabilitation process are in need of rehearsal in order to practice and keep getting better at activities.	
Source: interview 1, 2, 3, 4, 5 & 7	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	

Priority: high	**Conflicts:** not applicable
History: created on July 18 2018, adjusted on 15 April 2019	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"When a child is playing on his tablet and sees that other children have reached their goal, they could be motivated to do it as well."	Social comparison	The option to compare results	The system shows achievements of all children

Requirement #: 26	**Requirement type:** content
Value: Social Support	**Attribute:** the option to compare results
Description: the system shows achievements of all children.	
Rationale: when children can compare their results to others, they can be motivated to reach the same goals as their peers.	
Source: interview 1, 2, 3, 6 & 7	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: high	**Conflicts:** overlap with the social learning requirement
History: created on July 18 2018, adjusted on 15 April 2019	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"You should link something to it, I think it is good that children can see from each other what they have done."	Social learning	Observability of the behaviour of other users	The system shows a list of all user activity

Requirement #: 27	**Requirement type:** content
Value: Social Support	**Attribute:** observability of the behaviour of other users
Description: the system shows a list of all user activity.	
Rationale: children can be motivated when they see what their peers have done, triggering them to get to work as well.	
Source: interview 2 & 3	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: medium	**Conflicts:** overlap with the social comparison requirement
History: created on July 18 2018	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"Let's say we have children with the same problem of inactivity. It would be	Social role	Adoption of a social role	The system has the option to let parents

good if you can bring their parents together and come up with ideas."			communicate to other parents via messaging

Requirement #: 28	**Requirement type:** functional
Value: Dialogue Support	**Attribute:** adoption of a social role
Description: the system has the option to let parents communicate to other parents via messaging	
Rationale: the parents of children within the paediatric rehabilitation process most likely encounter the same problems, which is why it might be useful to share their experiences on this	
Source: interview 2, 3, 6 & 7	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: high	**Conflicts:** not applicable
History: created on July 18 2018, adjusted on 15 April 2019	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"Show the kids that they have completed a part of an exercise, and tell them they are going in the right way."	praise	Praising good user behaviour	The system praises the child when a goal is reached through positive pop-up messages

Requirement #: 29	**Requirement type:** content
Value: Dialogue Support	**Attribute:** praising good user behaviour
Description: the system praises the child when a goal is reached through positive pop-up messages	
Rationale: children have trouble with most motor skills in daily life. Praise by others might help them overcome these troubles and help them with improving their skills.	
Source: interview 2 & 6	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: low	**Conflicts:** not applicable
History: created on July 18 2018, adjusted on 15 April 2019	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"Let a kid become the best of the week, or something like that."	Recognition	Give recognition to users who perform well	The system gives the best player of the week recognition
			The system gives recognition weekly

Requirement #: 30	**Requirement type:** content
Value: Social Support	**Attribute:** give recognition to users who perform well
Description: the system gives the best player of the week recognition	
Rationale: by giving children recognition, they will be more eager to try to reach that same goal again.	
Source: interview 3 & 7	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: low	**Conflicts:** could form overlap with the reward requirement, and could be combined with it.
History: created on July 18 2018, adjusted on 15 April 2019, appendix 9	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"What I would like to see is that it relates to the real situation, that you can see your hand when you move it."	Simulation	Simulation of an exercise	The system simulates real-life situations as exercises

Requirement #: 31	**Requirement type:** functional
Value: Primary Task Support	**Attribute:** simulation of an exercise
Description: the system simulates real-life situations as exercises	
Rationale: simulation can cause children to notice and learn the cause and effect of their actions, which might help them to form a better understanding of their therapy.	
Source: interview 3 & 4	
Fit criteria 1. **Acceptance testing:** not applicable 2. **Usability testing:** not applicable 3. **Summative evaluation:** not applicable	
Priority: low	**Conflicts:** not applicable
History: created on July 18 2018, appendix 6	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"It's like when you're in a runner's group, you can see the others running with you, and that you can stimulate each other."	Social facilitation	Ability to observe users performing the same exercise	The system offers children to see which children are performing the same exercise

Requirement #: 32	**Requirement type:** content
Value: Social Support	**Attribute:** ability to observe users performing the same exercise
Description: the system offers children to see which children are performing the same exercise	
Rationale: when children can see who is doing the same exercise as them, they can become motivated by it, because they know they are not doing it alone.	
Source: interview 2, 6 & 7	
Fit criteria	

1. Acceptance testing: not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: low	**Conflicts:** could form overlap with the cooperation requirement, and could be combined with it.
History: created on July 18 2018, adjusted on 15 April 2019, appendix 7	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"Being in a runner's group kind of forces you to be there, when comparing it to running individually, which could motivate to keep going."	Normative influence	Leveraging peer pressure	The system groups children
			The system sets group goals

Requirement #: 33	**Requirement type:** functional
Value: Social Support	**Attribute:** leveraging peer pressure
Description: the system groups children	
Rationale: by grouping users, children can be encouraged to perform better to let their peers observe their progress.	
Source: interview 2	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: low	**Conflicts:** not applicable
History: created on July 18 2018	

Requirement #: 34	**Requirement type:** functional
Value: Social Support	**Attribute:** leveraging peer pressure
Description: the system sets group goals	
Rationale: by forming group goals, users can be encouraged to give a little extra for their group members, to not let them down, or to become the best of the group.	
Source: interview 2	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: low	**Conflicts:** has overlap with the recognition, the social learning, the social comparison, the normative influence, the social facilitation and the cooperation requirement.
History: created on July 18 2018	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"At a certain moment you want to know what it is good for. Why do you need to take those 10.000 steps, in that way you need to be motivated as well."	Verifiability	The goals and exercises need to be verified	The system explains what the exercises are good for.

Requirement #: 35	**Requirement type:** content
Value: System Credibility Support	**Attribute:** the goals and exercises need to be verified
Description: the system explains the benefits of the exercises the children need to do.	
Rationale: when the thought behind the goals are clear, children can develop a better understanding of why they do something.	
Source: interview 2	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: low	**Conflicts:** not applicable
History: created on July 18 2018, appendix 8	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"You need competition, you need to be motivated by each other."	Competition	Creating a competitive environment	The system creates a leader board
			The system creates a leader board showing the points of every child

Requirement #: 36	**Requirement type:** functional
Value: Social Support	**Attribute:** creating a competitive environment
Description: the system creates a leader board	
Rationale: by creating a leader board, children can see how good they are doing compared to the rest	
Source: interview 3	
Fit criteria **1. Acceptance testing:** not applicable **2. Usability testing:** not applicable **3. Summative evaluation:** not applicable	
Priority: low	**Conflicts:** has overlap with the social learning, the social comparison and the recognition requirement.
History: created on July 18 2018	

Requirement #: 37	**Requirement type:** content
Value: Social Support	**Attribute:** creating a competitive environment
Description: the system creates a leader board showing the points of every child	
Rationale: by showing the points of every child and showing that in a leader board can motivate children to become the best.	
Source: interview 3	
Fit criteria **4. Acceptance testing:** not applicable **5. Usability testing:** not applicable **6. Summative evaluation:** not applicable	
Priority: low	**Conflicts:** has overlap with the social comparison requirement.
History: created on July 18 2018	

User expression	**Value**	**Attribute(s)**	**Requirement(s)**
"To improve the potential benefit of rehabilitation, children should be presented with the opportunity to choose activities they find enjoyable.	Choice	Ability to choose	The system offers multiple games for children to choose from

Requirement #: 38	**Requirement type:** functional
Value: Primary Task Support	**Attribute:** ability to choose
Description: the system offers multiple games for children to choose from	
Rationale: by giving children the choice of what they want to do, they are more likely to do it with pleasure and this benefits the outcome of the therapy.	
Source: Literature finding (52)	
Fit criteria: **4. Acceptance testing:** not applicable **5. Usability testing:** not applicable **6. Summative evaluation:** not applicable	
Priority: high	**Conflicts:** can form a slight overlap with suggestion
History: created on August 8 2018	

Appendix 1

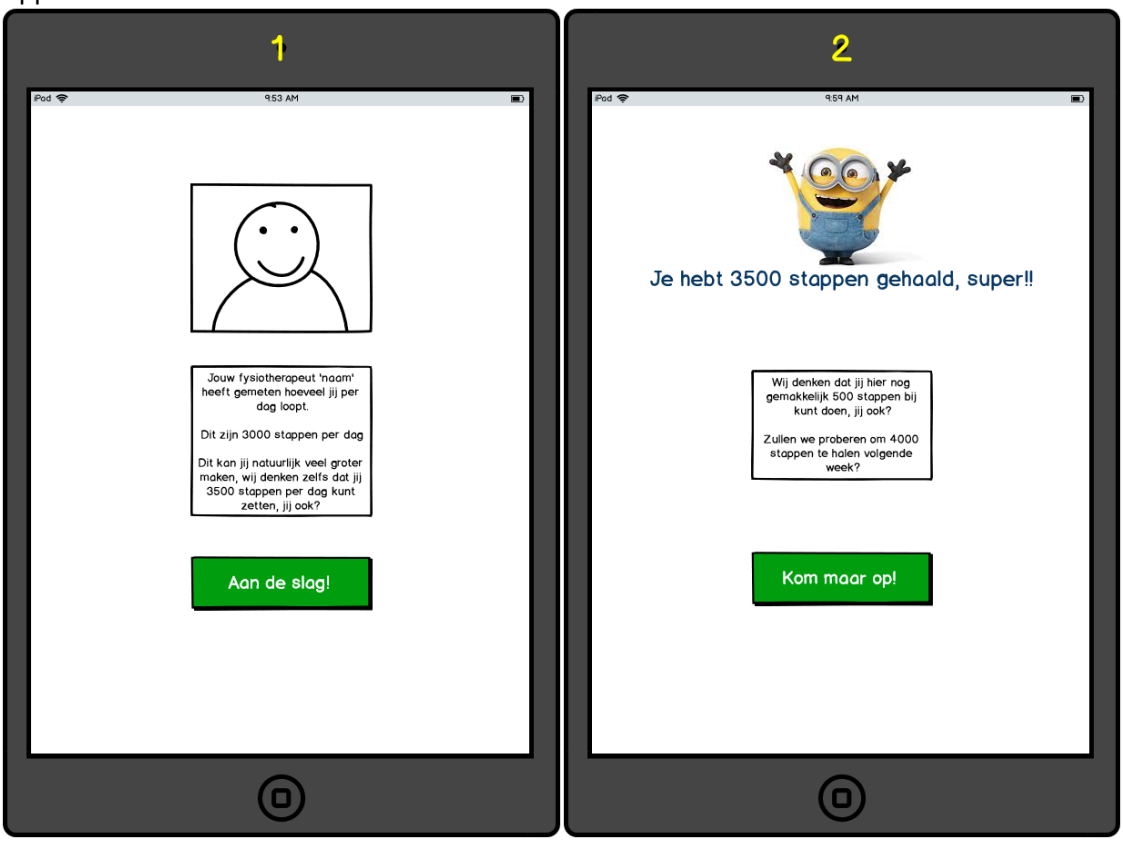
1

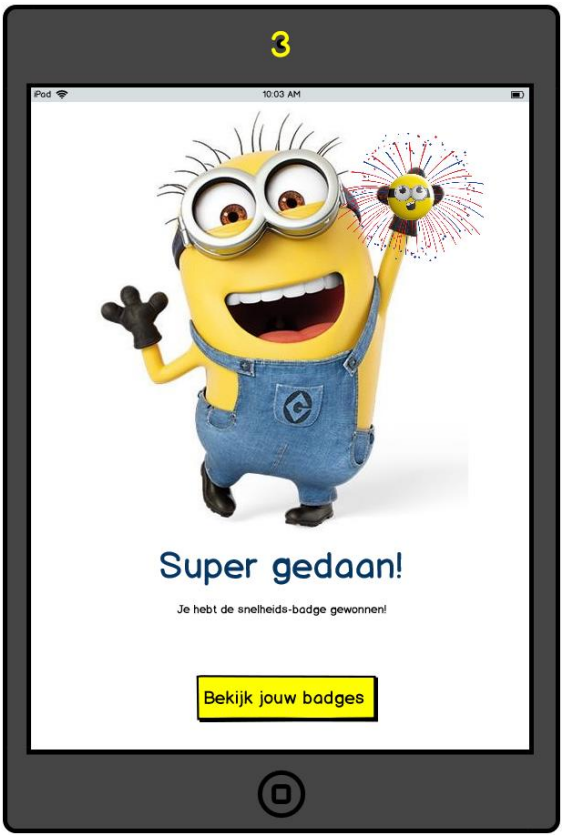
2

3

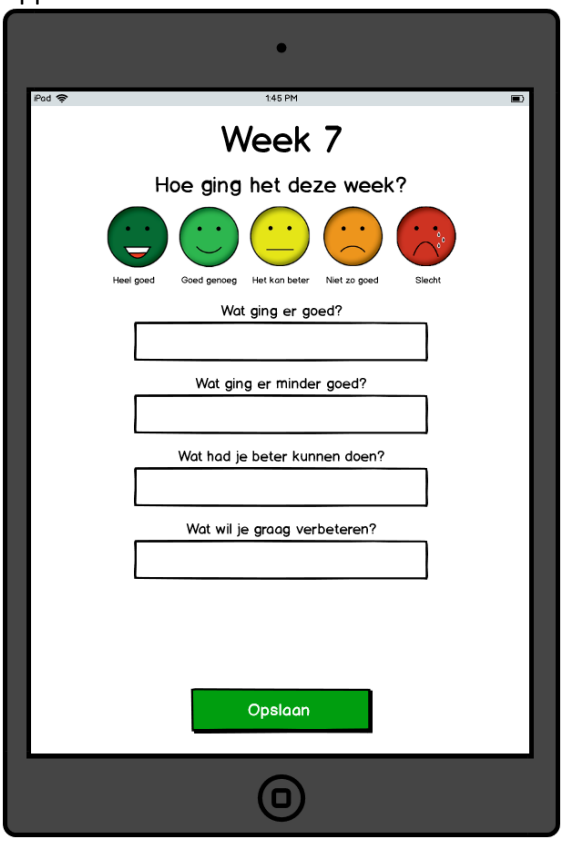
4

Appendix 2


1
iPod
9:53 AM
Jouw fysiotherapeut 'naam' heeft gemeten hoeveel jij per dag loopt.
Dit zijn 3000 stappen per dag
Dit kan jij natuurlijk veel groter maken, wij denken zelfs dat jij 3500 stappen per dag kunt zetten, jij ook?
Aan de slag!
2
iPod
9:59 AM
Je hebt 3500 stappen gehaald, super!!
Wij denken dat jij hier nog gemakkelijk 500 stappen bij kunt doen, jij ook?
Zullen we proberen om 4000 stappen te halen volgende week?
Kom maar op!


3
iPod
10:03 AM
Super gedaan!
Je hebt de snelheids-badge gewonnen!
Bekijk jouw badges

Appendix 3

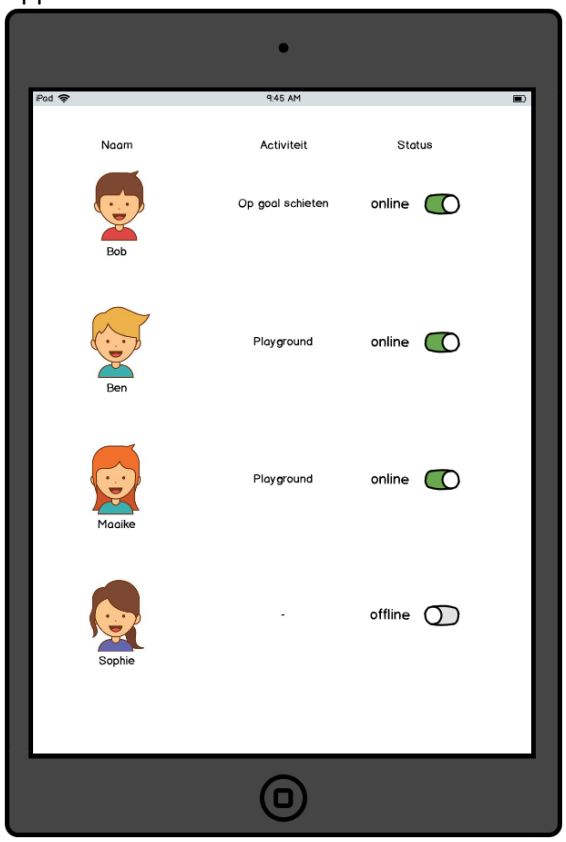


Appendix 4

Appendix 5

Appendix 6:

Appendix 7:



Appendix 8:

Appendix 9: