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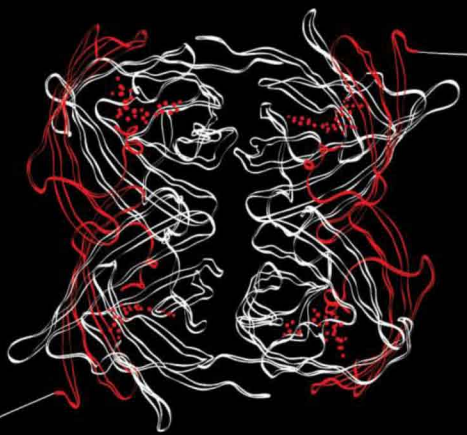
Verslagnummer 5673
14 September 2011
R.W. van Delden
Master thesis
IDE & HMI
s0093831

Design of therapeutic TagTile games

for children with unilateral spastic cerebral paresis



UNIVERSITY OF TWENTE.

‘Design of therapeutic TagTile games for children with unilateral spastic cerebral paresis’

Master thesis – Enschede – 21 September 2011

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“Discontent is the first necessity of progress”

Thomas A. Edison (1847 - 1931)

Samenvatting

Dit onderzoek richt zich op het leveren van nieuwe inzichten in design methodologie, onderzoekstechnieken en spelprincipes in de context van interactieve spellen die gebruik maken van tastbare voorwerpen voor therapie van kinderen met unilaterale Cerebrale Paresis (CP).

CP is een afwijking van houding en/of motorische functie door hersenbeschadiging in het eerste levensjaar. In het unilaterale type is de rechter- of linkerkant beïnvloed. Hoewel CP een ongeneeslijke ziekte is blijkt therapie effectief in het verbeteren van hun mogelijkheden maar kan eentonig zijn door het repetitieve karakter. In een voorgaand onderzoek (Li, Fontijn and Markopoulos 2008) zijn voor dergelijke therapie interactieve spellen ontworpen die gebruik maken van voorwerpen. Hiervoor werd gebruik gemaakt van de TikTegel, een system dat meerdere voorwerpen kan lokaliseren op een oppervlakte door gebruik te maken van RFID labels. Het systeem geeft feedback met *full color LEDs* en het afspelen van geluiden. Deze spellen zijn niet in de therapie ingezet aangezien bewegingen niet op de juiste manier in gang gezet werden voornamelijk vanwege compenserende bewegingen. Maar het gebruik van een dergelijk vermakelijk interactief fysiek spel werd als veelbelovend gezien. De nieuwe set van ontworpen spellen richtten zich dus op het brengen van vermaak en het aansporen van de juiste bewegingen terwijl compenserende bewegingen zoveel mogelijk ontmoedigd werden.

Een iteratief proces is gebruikt om vier gecreëerde spellen te evalueren, verbeteren en te valideren. Therapeuten zijn betrokken in elke stap in het proces. De doelgroep is geanalyseerd met een literatuur onderzoek, interviews en twee korte etnografische sessies. Een nieuwe ontwerptechniek, *acting out movements*, gebaseerd op een combinatie van bestaande technieken zoals *hands-only scenarios*, *interaction relabeling* en *informances* is gebruikt om de eerste drie spellen te ontwerpen. Het vierde spel met een co-design sessie met therapeuten. Het gebruik van ontwerptechnieken in deze casus leidde tot inzichten in design methodologie. Het gebruik van *acting out movements* was zeer waardevol omdat het gat tussen het trainen van bewegingen en ontwerpen verkleind werd. Hiermee konden compenserende bewegingen tot een minimum gehouden worden. In een zeer korte ontwerpsessie met therapeuten bleek SIT, het systematisch inventief denken gebaseerd op terugkerende denkpatronen in het ontwerpen, onpraktisch om te gebruiken. *Interaction relabeling*, een techniek waarbij een interactie geprojecteerd wordt op interactie van een ander object, bleek geschikter. Het gebruik van informele testen met vrienden en familie was effectief voor het vinden van bugs en verbeteringen. Het gebruik maken van meerdere evaluatie sessies en technieken in samenwerking met therapeuten verschafte waardevolle feedback en leidde ook tot verbeteringen. Het gebruik van een langere evaluatie van zeven weken toonde belangrijke problemen bij het daadwerkelijke gebruik die niet gevonden waren in voorgaande evaluatie sessie. Gedurende de evaluaties zijn verschillende criteria onderzocht van Malone&Lepper(1987) die plezier in spellen kunnen verbeteren. Kinderen vinden het gebruik van geluiden leuk en vooral grappige, absurde of extreme geluiden. De doelgroep verbeterde niet in de benodigde tijd om een spel af te maken wanneer feedback gegeven werd op hun prestatie. Kinderen van de doelgroep hebben geen uitzonderlijke problemen met het verliezen van een spel. Een toenemende moeilijkheid bleek niet uniform geliefd of ongeliefd.

De set van spellen traint de gewenste bewegingen en lijkt de gewenste motivatie te leveren. In de langere evaluatie werden spellen in slechts twee sessie gebruikt ondanks eerder veelbelovende evaluaties. De belangrijkste reden om de spellen niet te gebruiken was de benodigde moeite en tijd om de spellen klaar te zetten en op te starten. Een nieuwere versie van de TikTegel werd gebruikt voor het laatste spel. Dit spel en de nieuwere versie lijken veelbelovend en kunnen toegepast worden in de therapie aangezien de versie minder voorbereidingstijd nodig heeft en de spellen motivatie leveren en de verschillende bewegingen in gang zet. Lessen op het gebied van ontwerp- en onderzoekstechnieken kunnen waardevol zijn, zowel in lopend onderzoek als in andere gerelateerd onderzoek en ontwerp activiteiten.

Summary

This research focuses on gaining new insight in design methodology, research techniques and game principles in the context of tangible games for therapy of children with unilateral Cerebral Paresis (CP).

CP is a disorder of posture and or motor function due to brain damage in the first year of life. In the unilateral type of CP the right or left side of the body is affected. Although CP is incurable the therapy for CP patients is effective in increasing their abilities but can be boring because of its repetitive nature. In a previous research tangible games where created for such therapy and made use of the TagTile (Li, Fontijn and Markopoulos 2008). The TagTile is a system that can localise multiple objects on its surface by using RFID tags. This system gives feedback with full colour LEDs and by playing sounds. The games created on this TagTile in this previous research are not implemented in therapy as the proper movements were not triggered enough and compensating movements were observed often. However, the usage of entertaining interactive tangible games was seen as promising. A set of games created in this research thus aim to provide entertainment and triggering the right movements while preventing compensating movements as much as possible.

An iterative process is used to evaluate, improve and validate four created games. Therapists are included in every step in this process. The target group is analysed with a literature survey, interviews and two short ethnographic sessions. A new design technique, acting out movements, is used based on a combination of hands-only scenarios, interaction relabeling and informances. This technique is used to design the first three games. The fourth game is based on a co-design session with therapists.

The usage of design techniques in this case led to new insights into design methodology. The use of acting out movement techniques is found to be very useful as the gap between training movements to design is decreased. In this way compensation could be held to a minimum. In a short design session is of half an hour, it was found to be impractical to use Systematic Inventive Thinking, a technique using often reoccurring thinking patterns in design. Interaction relabeling, a technique in which interaction of object are projected to another, is more suitable for such a session. Using informal tests with friends and family is found to be valuable. Although being a totally different target group it is a very effective way in finding bugs and improvements. Using several evaluation sessions and techniques with cooperation of therapists provided useful feedback and triggered several improvements. The usage of a longer evaluation of seven weeks showed important problems in actual usage that were not found in previous evaluation sessions.

During the evaluations several criterion to increase fun in games from Malone&Lepper(1987) were investigated. Children like sounds but especially funny, absurd or extreme sounds. The target group does not improve completion time when feedback is given on their performance. Children from the target group have no extraordinary problems with losing a game. An increasing difficulty is not uniformly liked or disliked.

All the games combined train all wanted movements and seem to provide the wanted motivation. In a seven week evaluation the games were only used in two sessions although earlier evaluations seemed more promising. The main reasons for not using the games were the effort and time needed to set-up and start the games using an older version of the TagTile. A newer version was used to create the last game. This game and the newer version of the TagTile seem promising and can be used in the therapy as this version needs less preparation time and the game provides motivation and triggers several movements. Lessons on design methodology and research techniques can be valuable in ongoing research on the TagTile as well as other related research and design.

Preface

This master thesis is a result of my research on games for therapy with tangible interaction using the TagTile. This is conducted at the University of Twente and Sint Maartenskliniek in Nijmegen.

First I would like to say thanks to my tutors from the University of Twente: Betsy van Dijk and Julia Garde. For providing feedback, guidance, having discussions and good conversations and therewith bringing a great end to a wonderful time as a student at the University of Twente.

I would like to thank everyone from the Sint Maartenskliniek both therapists and children who guided, helped, tested and made this thesis possible. In special I would like to thank Anke Verhaegh for starting up the process, clarifying the current situation and needs and bringing me into contact with the WikiTherpist consortium. Thanks go out to Ingrid van den Tillaar; for taking over and creating time for her input and feedback and making room for tests in the tight schedule of the Piratengroep at the Sint Maartenskliniek. I would like to thank her again for participating in the interviews and all these evaluations with the children from the Piratengroep. I hope you have welcomed a healthy and happy child to this world and wish you the best of luck and happiness. I also appreciate the feedback of Jan Wielders. As well as that of Ruth van den Heuvel and Pauline Aarts for participating in the evaluations, design session and interviews.

The help of SeriousToys was also very appreciated. Thanks go out for the help in coding and providing the Sint Maartenskliniek with the BlackBoard TagTile and later on also providing them with the BlueBoard TagTile and tags. This made this research possible in the first place.

As there was no or little room for expenses in this project I am very grateful that the company Intellident[1] provided us with more than twenty RFID tags for this project within a very short time span.

Last thanks go out to my flatmates, family and girlfriend for they provided me with a great work environment, help, input & feedback, participation and patience. In special for keeping up with hours of loud music, discussions, cursing, laughter and stress that ultimately led to this accomplishment.

[1] *"Intellident is one of Europe's leading providers of systems based on the use of Radio Frequency IDentification (RFID) technology across our three core sectors of libraries, document management and supply chain. Trading for over ten years as Intellident, we actually have a history that can be traced back almost 20 years to our barcoding days.*

Today, we operate directly out our of three main trading offices in the UK, France and Netherlands, together with hosting a growing Alliance Programme, designed to bring our industry-leading products to market in a range of different countries."

Table of Contents

1. Introduction

This thesis focuses on the creation of motivating interactive tangible games for use in effective physical therapy for children with unilateral Cerebral Paresis(CP).

Unilateral CP is a disorder of posture and or motor function due to brain damage in the first year of life. In the unilateral type of CP the right or left side of the body is affected. Therapy for CP patients is effective but can be boring because of its repetitive nature. Using interactive games could help in bringing additional motivation.

The TagTile can be used for creating interactive tangible games; it is a system that can localise multiple objects on its surface by using RFID tags. This system gives feedback with full colour LEDs and with playing sounds. In a previous research TagTile games where created for usage in the therapy(Li et al. 2008). These games are not implemented as the proper movements were not triggered enough and compensating movements were observed often. However, the usage of entertaining interactive tangible games on the TagTile was seen as promising. Therapists expected that new (the to be created) games on the TagTile using tangible objects could lead to therapy that is more entertaining for the children and properly trigger the to be trained movements. There was however a lack of time and effort to make games that are suitable to use in therapy. The design of the games thus focuses on entertainment and triggering the right movements while preventing compensating movements as much as possible.

This research is done in the context of a specific therapy for CP at the Sint Maartenskliniek. The Sint Maartenskliniek is a hospital specialised in posture and movement. The target group is predefined as children from the so called *Piratengroep*. This is the name of their therapy method for 2½- 8 year old children with unilateral CP. They mimic a wounded pirate hence Piratengroep, which is Dutch for a group of pirates. The method is based on modified Constrained Induced Movement Therapy. In this therapy the activation of the affected limb is triggered by putting the better functioning arm in a sewn shut sling. An opportunity for evaluation of games is a set of five return sessions. In such a session a group of (ex-) Piratengroep children are visiting the Sint Maartenskliniek (again) for only one week.

Only an older version of the TagTile, called the BlackBoard, was available at the Sint Maartenskliniek at the start of the research. A large part of the research therefore focused on developing games for this BlackBoard. The last created game is created on a newer version called the BlueBoard that was provided later on in the research.

The research focuses on gaining new insight in design methodology, research techniques and game principles in the current context. To this end earlier identified game principles are tested which are also used to improve the games and several design techniques are proposed and implemented to create the games. The report contains generated insight in design issues and design techniques, preference of several game features, the resulting interactive games for use in therapy and evaluation hereof. At the implementation level the goal is to deliver usable entertaining games that train the wanted movements and prevent compensation as specified before. It is preferred to let a child play a game on its own without interference of a therapist as most of the times there is at least one more child than therapist during the session.

A participatory design method is used to create four games. This participatory approach is chosen as it is an unfamiliar context where knowledge of the therapists is essential. The four games are created on basis

of requirements found in a literature survey, evaluations, interviews and a short ethnographic study. In total four types of evaluations are performed: a set of informal tests, three tests to investigate three game features, a long term evaluation and a short qualitative test with the fourth game.

In this method a variety of participatory and general design techniques are used. To generate ideas for games the to be trained movements are acted out repetitively with usage of arbitrary props. The resulting games are evaluated on appropriateness by a therapist based on a video prototype. The games are improved based on informal test rounds with friends and family. To investigate and improve the entertainment value of the games, more formal tests using both quantitative and qualitative analysis are done. During this process three game features are investigated: usage of competition by feedback, sound and challenge by difficulty. The first three games are first tested by ten adults in informal tests and six children in a pilot test. Nine children participate in the actual test of the first three games. A fourth game is created together with therapists using interaction relabeling and systematic inventive thinking on a newer version of the TagTile. This game is evaluated during one session with three children.

The lessons learned in this design could be incorporated in ongoing research with the TagTile. Currently a consortium called WikiTherapist is doing research in this context. The described design techniques might be valuable for development of future tools, games and devices for usage in therapy for children with CP. The results can also be used to implement the created games into the daily therapy of children with CP at the Sint Maartenskliniek and other revalidation centres.

1.1 Report lay out

This report starts with a thorough description of CP, what it is and what can be done about it in therapy and how such therapy is done. This is based on a literature survey and a small ethnographic study. This is used to get a proper image of the capabilities of the target group and requirements following from this. It also clarifies the movements which have to be trained and is an inspiration for games.

The next chapter shows the development of the TagTile. Its origin and what games are already created for it. This is also based on a literature survey and personal communication with therapists and the developers of the TagTile. It helps in knowing what can and can't be done with the TagTile and in proposing next steps in development. It shows how tangibles can be used with the board to create games. It also points out why the previous attempt with the board did not succeed and key points to keep in mind to prevent this from happening again.

Some of the features that can be used to make games more motivating, enjoyable and fun according to Malone (1981,1982) and Malone and Lepper(1987) are described shortly in the following chapter. These features are investigated for the given context and are used to improve the games. This chapter is finished with a description of several design techniques that are (partly) used in this research.

The requirements resulting from the short ethnographic study and literature survey are described in chapter six.

The design procedure and description of the games is given in chapter seven. This chapter starts with the used methodology. This followed by the three chosen ideas for games that are developed and implemented.

The first evaluations that have been done in the first two iterations are described in chapter eight. The proposed and implemented improvements are described for both iterations.

A longer evaluation mimicking actual usage is described in chapter nine. This helps to identify what has to be improved to come to really usable games.

The design of the last game is described in chapter ten. It starts with description of the design session and the resulting games. It ends with the further developed game and a short evaluation hereof.

Chapter eleven describes possible development of the TagTile for the short future. The underlying technology roadmapping using TRIZ is described along with possible competition of the TagTile for therapy of children with CP.

The report ends with overall discussion and conclusions on the research.

2. Cerebral Paresis and therapy

The games that will be designed during this research are intended for children with unilateral spastic cerebral paresis. In this context it is important to know what this Cerebral Paresis (CP) is. In this chapter CP and relevant therapy methods will be explained. A literature survey is done to know what has been done in the field of CP and to know what CP is. In order to get more familiar with the context of the therapy sessions two other techniques are also used. The first is having multiple unstructured interviews with the therapists and the second is a short ethnographic study. The conversations with the therapists were also used to gather a set of requirements (see chapter 6). The used set of questions is not included in this report but resemble the research questions below.

During this introduction the following research questions had to be answered:

- What cognitive difficulties are strongly related to CP?
- What physical difficulties result from CP?
- Who are the children present at the Piratengroep?
    - What is their age (range)?
    - What do they find interesting?
    - What cognitive difficulties do they have?
    - What physical difficulties do they have?
- What movements should be trained?
    - Should this be done on an individual level?
    - In what way are the movements currently trained for these children?
- What does a session at the Piratengroep currently looks like?
    - What activities are done?
- What metaphor should be used?
    - What interests can be used as a metaphor for the game?
    - Must the theme of pirates be maintained for the game?

This makes clear for whom and in what context the games will be used. This is used to better communicate with the therapists, it helps in setting the proper requirements and it is used to target the right movements in the games.

2.1 Cerebral Paresis

CP is an umbrella term for a group of disorders in which a permanent abnormality of the brain, caused in the first year of life, results in a disorder of posture and or motor function. The occurrence rate is about 2 to 3 on every 1000 live births making it the most common motor deficiency in early childhood. Compared to Down syndrome for instance CP's occurrence rate is twice as high (Cans and (SCPE) 2000)

The severity ranges heavily. One way to categorise severity is to indicate the affected limbs as can be seen in Table 1. Another way is to look at the involved sides and the muscle responses, as can be seen in Figure 2.1 . Both are used in practice. The Sint Maartenskliniek now uses the term spastic unilateral Cerebral Paresis to identify the category of the children. The Sint Maartenskliniek is the only hospital in the Netherlands specialised in posture and movement.

Table 1 Categories of CP (Kuban, Allred, Oshea, Paneth, Pagano and Leviton 2008)

Terminology	Description
Quadriparesis	Both legs and one arm or both arms and one leg is involved.
Diparesis	Both legs are involved or only one leg is involved.
Hemiparesis, also known as unilateral paresis	Only one side of the body is affected Monoparesis, involvement of one upper limb, is also seen as form of (partial) hemiparesis.

2.2 Therapy

CP can't be healed but therapy and surgery can help in improving the abilities of patients. In the literature two main types of therapists and therapy are mentioned in therapy of CP: Physiotherapist (PT) and Occupational Therapists (OT). A short description of these two is given to better understand their differences and point of view.

PT and OT stand for both the type of therapist and (traditional) therapy done by such a therapist. PT focuses on gross motor skill and mobility such as walking, the physiotherapist is frequently the team leader in therapy. The OT focuses on fine motor skills and sensory processing skills needed in Activities of Daily Life (ADL) such as dressing. (Badejoko 1988; Papavasiliou 2009)

Besides these two main types of traditional therapy there are also other forms of therapy. The kinds of therapy will be explained next.

2.2.1 Modified Constraint Induced Movement Therapy

To improve the abilities of people with CP several forms of therapy can help although CP itself is permanent. To this end a type of modified Constraint Induced Movement Therapy (mCIMT) is used in the Sint Maartenskliniek. This is a version of CIMT modified for usage with children. The activities in the therapy of the Sint Maartenskliniek resemble the activities mentioned by Gordon, Charles and Wolf (2005) in their method for therapy, both are a type of mCIMT. Normal CIMT is a method mainly used for adult cerebral vascular (stroke) and traumatic brain injury patients. This method (CIMT) is modified and made suitable for children (mCIMT). The therapy of Gordon et al. (2005), called mCIMT is described first followed by the method of the Sint Maartenskliniek. The method of Gordon et al. (2005) can be used as inspiration for exercises, shows that somewhat similar methods as that of the Sint Maartenskliniek exist and points out important advantages found in both methods.

Therapy method Gordon et al. (2005)

Gordon et al. (2005) gave a description and results of a pilot test in 2005 but their work began in 1997. They altered the version of the CIMT for adults with hemiparesis caused by brain trauma. It is made more suitable to the needs of children. It is still based on the principles of CIMT which are

- repetitive practice and shaping (extensive use)
- constraining the non-involved arm.

Gordon et al. (2005) try to minimise the social effects of therapy for children by playing in groups of two or three children. At the same time at least a 1:1 child to therapist ratio remains. This allows for personalised guidance of a therapist to improve the movements of the child along with otherwise missed social interaction. The trained movements are selected on joint movements with most potential for improvement.

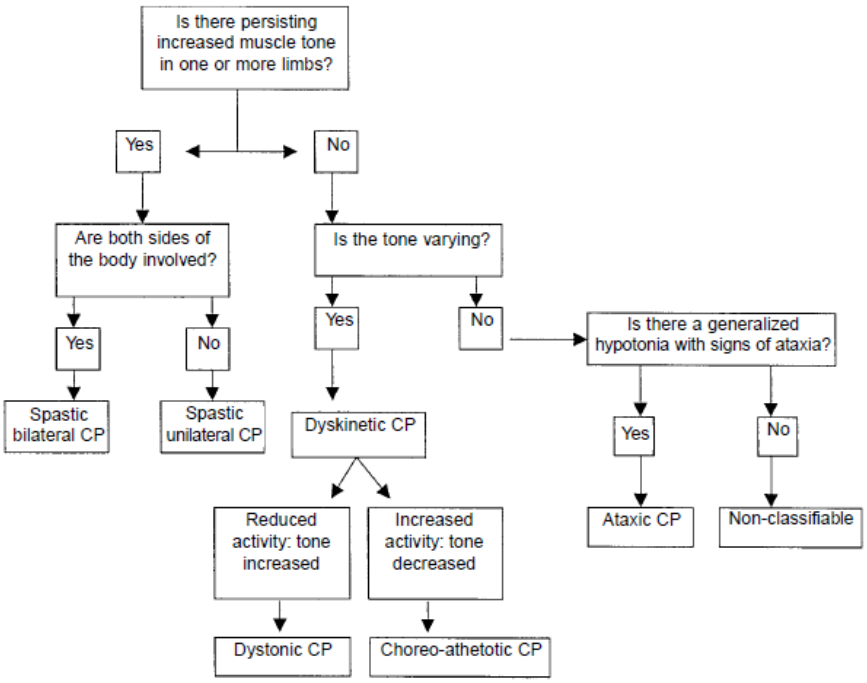

Figure 2.1 Hierarchical classification tree of cerebral paresis sub-types. (Cans and (SCPE) 2000, figure 2 , p. 821)

They chose an intensity of six hours a day for ten days. In the Sint Maartenskliniek however the Piratengroep has an intensity of three afternoons each week for a period of eight weeks. One of the reasons mentioned for altering the original CIMT therapy for children is:

> *" Both repetitive task practice and shaping involve adult-oriented, monotonous tasks (eg, screwing and unscrewing bolts, adult-appropriate functional tasks) that would not likely hold a child's interests for the long period of engagement required. Thus, the types of practice used in adult CIMT need to be modified to be suitable for children." (Gordon, Charles and Wolf 2005, p. 838)*

The constraint is realised by putting the non-affected arm in a sewn shut sling. There are a number of toys and supplies which the children together with the therapists can pick for therapy purposes. This choice is also made with to be trained movements in mind. The activities are made more difficult as the children progress, requiring increased speed, accuracy or amount of repetitions. An overview can be found in Table 2.

> *"Overall, we have established a list of 61 tasks across 7 categories. These tasks include board games (eg, Candyland, Monopoly), card games (eg, Old Maid, Uno), manipulative games (eg, Don't Break the Ice, Battleship), puzzles, arts and crafts (eg, drawing, painting), functional tasks (eg, eating, cleaning table), and gross motor activities (bowling, scatch). We view the choice of specific activities as less important*

> *than the movements they elicit. For example, board games can be used to encourage wrist supination and extension, precision grasp, and grasp maintenance." (Gordon et al. 2005, p. 839)*

Only positive reinforcement is used and at the start a task with direct success is used. The children are also engaged to use their affected arm at home. For safety reasons no sling is used at home. Instead parents are asked to provide activities for their children and keep daily logs of these activities.

Therapy method Naylor and Bower

Another attempt of mCIMT was done by Naylor and Bower (2005). In addition to some of the activities mentioned in Table 2 they use: action songs with hand action, posting boxes, playing with dough, hand puppeteering and five minutes of playing computer games on a touchscreen. Another difference is that the therapists manually hold still the non-affected arm during activities. They use structured activities, play as therapy and verbal instruction (Naylor and Bower 2005).

Therapy method Piratengroep

At the Sint Maartenskliniek a mCIMT is used for six weeks followed by two weeks of goal directed task-oriented bimanual training (BiT). The therapy is an intensive therapy done in a challenging environment preferably with other children. The total mCIMT and BiT (mCIMT-BiT) consists of "3-hour afternoon sessions, 3 days per week for 8 weeks" (Aarts et al. 2010, p. 3). The first six weeks the mCIMT is done using a sling, telling the children they are mimicking a wounded pirate. This is why the group of children is called the "*Piratengroep*", this is Dutch for a group of pirates. Figure 2.2 shows a child in action from the Piratengroep. After the six week period the sling is removed and the two weeks of bi-manual training is started with pre-defined goals set by the parents (using a method called GAS, see Appendix A). In total there is a group of 6 children "4 occupational therapists, 1 physical therapist, and 1 therapy assistant." (Aarts et al. 2010, p. 3)

Figure 2.2 A child from Piratengroep performing hand action during a song (Aarts, Jongerius, Geerdink, van Limbeek and Geurts 2010, Figure 1, p. 3)

A session consists of the following parts:

- 30 minutes of group activity: dressing up as a pirate, singing songs with hand activity such as waving a sword. These hand activities target the movements: shoulder abduction, shoulder external rotation, wrist extension.
- 60 minutes of individual play: shaping and repetitive tasks.
- 30 minutes: eating and drinking.
- A sanitary break.
- 45 minutes: two or three children join in playful activities similar to that of Gordon et al. (2005)
- 15 minutes: changing and prepare to go home

During the sessions it is frustrating for both therapists and children that it is needed to intensively prompt children to properly execute a task. This results in improper execution of training tasks likely due to learned disuse of the affected arm and thus results in a reduction of training results. To improve results and prevent the disuse the parents were asked to often stimulate the affected arm at home as

well. The parents also have to record these activities and their durations in a daily log. (Aarts et al. 2010)

In the one-armed period children are made aware of their generally underestimated capabilities of their weaker arm and hand. With the use of video recordings indirectly their parents are also made aware of their capabilities. (Verhaegh, van den Tillaar and Aarts personal communication, 2010)

Table 2 CIMT activities (Gordon et al. 2005, p. 840), the targeted movements are explained later.

Activity Category	No. of Activities	Shaping	Repetitive Task Practice	Targeted Movements	Graded Constraints
Board games	14	9	14	Supination, wrist extension, precision grasp, maintaining grasp through changes in spatial orientation	Active wrist extension: position deck of cards to elicit wrist extension and grade difficulty by changing position of deck.
Card games	6	6	6	Supination, precision grasp	Precision grasp: less difficult when cards are beveled on deck for easier grasp. Increase difficulty by not beveling the cards.
Functional tasks	11	4	8	Wrist extension, supination, and pronation	Supination and pronation: for turning key in lock, vary starting position of key to grade from using only supination to using both supination and pronation.
Gross motor	7	4	7	Shoulder flexion, shoulder abduction, shoulder external rotation, wrist extension	Shoulder flexion: elicit shoulder flexion by moving child from easier position stabilized against a wall, to free-standing position that requires more control.
Manipulative games	21	14	21	Finger individuation, precision grasp, wrist extension, modifying grasp to accommodate various objects	Precision grasp: to increase difficulty provide child with increasingly smaller or more complex objects to manipulate.
Puzzles	2	0	2	In-hand manipulation, precision grasp, release accuracy	Release accuracy: once competency in releasing puzzle pieces is attained, increase difficulty by introducing a puzzle with smaller pieces.
Arts and crafts	2	0	2	Supination, precision grasp, maintaining grasp through changes in spatial orientation	Maintaining grasp: begin child at an easier level with a built-up brush, and increase difficulty by removing assist. Smaller brushes can be introduced.

In a previous attempt to use the TagTile for the Piratengroep this effect of circumventing to be trained movements was also mentioned as compensating behaviour. Children resist the corrections and thus it slows down therapy. It is one of the problems of the therapy according to the therapists in an interview back then (Li et al. 2008). Preventing such compensation by automatically triggering the right movements or giving well timed corrections could be an opportunity for games on the TagTile.

2.2.2 Other revalidation and therapy for children with CP

Besides mCIMT there are also other forms of therapy used for children with CP. In revalidation centres in the Netherlands therapy is also given in the traditional way. Individual training is given twice a week for 30 to 60 minutes each time. Activities are targeted to stretch the arm, improve weight-bearing and bimanual cooperation. Parents are given instructions and activities to let the children train 7,5 hours a week at home and to record this in a log. (Aarts et al. 2010)

An alternative therapy for children with CP uses elastic cords. It attempts to counter balance gravity and thereby making it easier to train movements resulting in better coordination. Combined with power training some remarkable results were achieved, although success is not yet verified in properly done clinical trials.

(Lewis Mehl-Madrona 2001; Papavasiliou 2009; Adeli Medical Center 2010) Some mechanical devices for training stroke patients that are created in a more scientific setting also use the principle of countering gravity forces for (re)learning movements. (Stienen 2009)

For some people with CP surgery can be beneficial. Mentioned are cutting through over-active or over-responsive nerves from the spinal cord. Another surgery is the shortening of muscles to even out the tension of muscles. (BOSK 2009)

Figure 2.3 Child showing palmair flexion.

2.2.3 Cognitive problems

The cognitive difficulties accompanying CP are broad (and thus almost unpredictable) similar to that of cerebrovascular diseases or traumatic brain injury (TBI). The most important is occurrence of concentration problems but also slight forms of visual impairment, having a temper and reduced smell have been witnessed. However the children in the Piratengroep in general can be communicated with and seen as normal children with similar interests. Although some children are slightly behind in average cognitive development and participate in special education for children with reduced cognitive abilities (Verhaegh et al. personal communication, 2010).

2.2.4 Movements

The muscle tension in the affected arm and hand is above normal, especially when they are set in action. This result in the children inclining slightly to palmair flexion when muscles are set in action, see Figure 2.3 [i] [2]. The movements that should be trained: dorsal flexion (not palmair flexion), training different grips, extending the elbow, turning the forearm (pronation and supination) and in hand manipulation and pincher grasp. It would be nice to also train coordination. The games should be a 'power training' consisting of several repetitions of movements in a short time (Verhaegh personal communication, 2010).

The movement "extension of the elbow" is self-evident, its counterpart is called flexion of the elbow/arm. In-hand manipulation is the ability to move an object through the palm of the hand. "For example, picking up a pen and moving it into position with your fingers for writing."(Department of Occupational Therapy 2005, p. 1). The other movements are described using figures: Figure 2.4 (Boumans & van Ooy 1999) and Figure 2.5.

2.2.5 Tests and inclusion

There are several tests to indicate the abilities of the upper extremities of a patient. Not all tests are designed for children with unilateral impairments. Most tests focus on unimanual activities and not on activities done with affected and non-affected arm working together. But activities of Daily Life (ADLs) such as dressing, which are done bimanual are very important. (Gordon et al. 2005)

The description of several tests can be found in Appendix A.

[2] This roman numbering is used for referencing media used in the research not coming from papers.

Inclusion criteria

The tests can be used as inclusion criteria for therapy, to be in the targeted group the children may not score too high or too low. Another part for inclusion can be a criterion for cognitive competence to follow instructions. For example in the experience of Deakin, Hill and Pomeroy(2003) about 30% of the population with unilateral CP was suitable for their kind of therapy.

At the Piratengroep about 80% of the screened children fulfilled the following Inclusion criteria:
"(a) CP with a unilateral or severely asymmetric, bilateral spastic movement impairment;
(b) age 2.5 to 8 years; and
(c) Manual Ability Classification System (MACS)19 scores I, II, or III.

Exclusion criteria were
(a) intellectual disability such that simple tasks could not be understood or executed (ie, developmental age less than 2 years),
(b) inability to combine the study protocol with the regular school program, and
(c) inability to walk independently without a walking aid." (Aarts et al. 2010, p. 2)
The Manual Ability Classification System mentioned, is a rating system for children with CP. It is a categorisation process of the quality and quantity of the bimanual handling of objects needed in daily use with whatever strategy needed. (Eliasson, Krumlinde-Sundholm, Rösblad, Beckung, Arner, Öhrvall and Rosenbaum 2006)

Figure 2.4 (Boumans & van Ooy 1999) Hand &under arm movements from left to right: (L) wrist extension, also known as dorsalflexion its counterpart is palmairflexion. (M) Pincher Grasp (R) supination its counterpart towards medial (centre of body) is pronation.

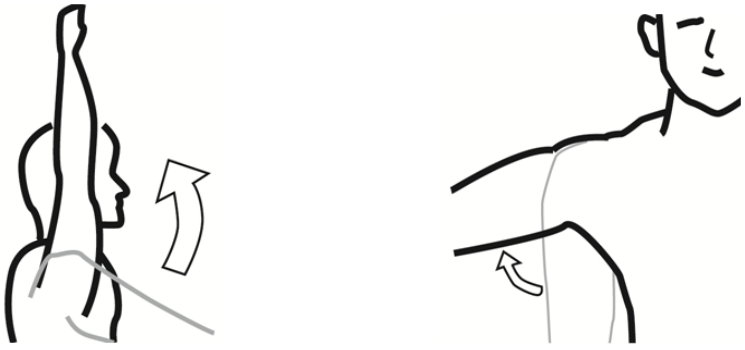

Figure 2.5 Shoulder movements & upper arm movements from left to right: (L) shoulder flexion such a rotation of a limb is also called circumduction (R) shoulder abduction its counterpart is adduction

2.2.6 Study results, the success of mCIMT

Gordon et al. (2005) minimised the risks by careful monitoring and making their therapy child friendly in several ways, such as the reduced intensity, the early positive feedback on effort and added fun of using toys and games. The risks mentioned include the loss of self-confidence by focusing on their impairment and injuries. They did not have substantial evidence for the efficacy of the costly method at that time. The test included 38 children fitting inclusion criteria, 37 successfully ended the program,

> *"1 child with high levels of frustration discontinued the program at the staff's request." (Gordon et al. 2005, p. 838)*

Naylor and Bowler (2005) used a single case A-B-A experimental design with nine children. In which 'A' stands for 4-week rest period from normal therapy. During B periods children did the modified Constrained Induced Movement Therapy (mCIMT), as mentioned earlier with manually holding the arm that functioned as a fixed restraint and using playful therapy. This was done with an intensity of 1 hour a day for a period of 4-weeks. The QUEST test was used at four times, once every 4 weeks: 'pre-test', pre-therapy, post-therapy and 'post-test'. The scores on the QUEST test were compared between before the therapy, after the therapy and the improvement during rest. Using the non-parametric Wilcoxon signed rank test on the means of pre- and post therapy scores they found a significant positive result ($p<0.01$).

A recent study of Sint Maartenskliniek used several tests to verify the effectiveness of their therapy method. After reviewing several results from therapy with cIMT and forced use of the affected arm they concluded that earlier results from other research were positive but the effectiveness has yet to be proven with stronger evidence. From the initial 76 screened children 8 did not fulfil the cognitive inclusion criteria another 7 could not combine it with their daily school activities. Their test consisted finally of 50 participants, allocated to one of two groups, another 12 suitable children were thus not included in the tests. The two groups were traditional care (n=22) and the mCMIT-BiT(n=28), by throwing a dice. The mCIMT-BiT group shows more improvement compared to the UC group.

2.3 Ethnographic study

In order to know the true nature of the revalidation sessions and the users a limited ethnographic study approach is used. Only two afternoon sessions were visited. Ethnography is explained in more detail in section 5.2 and is for now described good enough by Ireland:

> *"a research approach that produces a detailed, in-depth observation of people's behavior, beliefs and preferences by observing and interacting with them in a natural environment." (Ireland 2003, p. 26)*

These observations are accompanied with conversations and recording the actions and expressions of the people with text, pictures or video (Fetterman 2009). Druin on the other hand advised not to use video. Not using video is also chosen for the ethnographic study as will be explained in the next session.

2.3.1 Applied method

Two of the Piratengroep sessions from one group are visited. In both sessions a different child is observed during the individual stage of therapy. These two children are selected by the therapists in order to get a proper overview. The first observed boy is three years old and the second boy is three and half years old. Such a non-

random selection of for instance more extravert people can be useful in order to get to know thoughts about a system (Fetterman 2009).

During the observations the ethnographer participates in activities as similar to other people present making himself part of the group. This is done by assisting the therapist when possible fetching objects and helping the children, observing the child in a similar way as the therapist and participating in some exercises like the other therapists.

During the introduction and ending phase of the therapy all the children of the Piratengroep are together. During these phases the other children are also observed. Short handwritten notes are made during breaks and a more complete description is written directly after the sessions. No photographs or video are made by the ethnographer, this is done in order to minimise an awkwardness of the idea of being under observation for the children and therapist. However the normal video recordings performed by the therapists that show the progression and ability of certain tasks of the children to the parents are continued[3]. Questions were asked to the therapists about the games and toys used for therapy and about the behaviour of the children. Some questions were asked to the children about their interests during free play at the end.

2.3.2 Results

A detailed description of a Piratengroep session can be found in Appendix B. Only the used relevant findings are described here. These findings are used for the requirements, inspiration for games and getting a better picture of the target group.

An exercise for a young boy was to sort simple small plastic animals. Some of the animals were picked from a box. The therapist instructed the child for instance to put all the black spiders back in one box and all the pigs into another. During this process the child was distracted by another child sitting at the opposite side of the table.

After about an hour of individual play, the attention of the first observed child was noticeably less. This could be seen by the child turning away, more frequently looking at other children. His name had to be called to get his attention back to the game. One of the therapists stated shortly after this that it would be a plus if the attention was drawn automatically by the to be developed TagTile game.

The children enjoyed to make animal sounds and listen to other children making these sounds. This making of animal sound was done spontaneously without a therapist asking for it. A child chose to play with a pirate boat. The therapist asked the child to pick objects from the boat and place others in the boat in a playful way. A young boy took a small object in his mouth and the therapist had to order the child to take the object out of his mouth.

2.4 Conclusion

Cerbral Paresis (CP) is a disorder resulting in a deficiency in motor function that is caused by brain damage in the first year of life. The disorder is incurable but with therapy the abilities can be improved. The children in the Piratengroep have unilateral CP and must not be in a wheelchair. This means that they have one lesser

[3] Using these recordings alone without direct observations or short ethnographic study would have given a non-realistic image of abilities of the children as the video mainly shows the abilities and not the disabilities of the children.

functioning hand and arm because of increased muscle tone, but are able to walk; although they sometimes need a splint for their hand and or leg. The Piratengroep consists of children ranging between two and half up to eight years old. The cognitive abilities of the children are between the higher end of special education and normal education. Concentration problems are seen frequently. They undergo six weeks of therapy in which the non-affected hand is restrained using a sling. This is followed by two weeks of bi-manual therapy to train cooperation of the non-affected arm with the affected arm. The therapy method that is based on using this restraint is called modified Constraint Induced Movement Therapy. Several studies showed better results than traditional care. The type of therapy is used in other countries as well. The Sint Maartenskliniek is unique in using the metaphor of a wounded pirate and ending with a two week bi-manual period. The therapy focuses on certain movements that the children should make repetitively. Movements that have to be trained are mainly the hand-eye coordination, dorsal flexion (wrist extension), supination and pronation (turning the underarm), extension of the elbow, in hand manipulation and pincher grasp. Training movements is done by doing many repetitions with the affected arm. The games should accomplish the same. Different types of games and toys are used to make the therapy more fun while still training these movements.

The interests can be seen as that of other non-affected children of that age. Certain specific interests from the children were seen in a short ethnographic study. An object such as a pirate boat was preferred by a young boy also the liking of animal sounds was witnessed.

In the games these interest can be used. An earlier attempt in another research of using the TagTile for therapy showed that compensation should be prevented as much as possible.

3. The TagTile

It is important to also know the system that will be used in this research. To give a proper overview in this chapter first some of the development and grounding research of the TagTile is summarised. The games created for the TagTile are mentioned in the last section of the chapter. The history of the system is used in predicting what next steps can be taken, in knowing what will and won't work. It also helped in doing something new, in building on top of and being inspired by previous work and in getting to know the strengths and weaknesses of the system.

Tangibles and Tangible User Interfaces are a term for objects/interfaces where objects are used for interaction with interactive devices. In this context traditional objects for interaction with a device such as buttons, keyboard, mouse, trackball, pen-input devices and joystick etc. are excluded.

The TagTile is the English term for the tangible objects board designed by the company Serious Toys, a spin-off of Philips Research; in the Netherlands this device is called the TikTegel. A tangible objects board is a system which can determine the location or state of a physical object on a table or board. With the TagTile SeriousToys primarily targets primary schools.

The TagTile localises with RFID antennas and (passive) RFID tags; therewith it can identify and localise the position of multiple objects 'simultaneously', it also has audio and visual feedback (Fontijn and Van Rossem 2010). This visual feedback is a 12x12 or 16x16 full colour led grid arranged in rectangles of 20mm x 20mm. Over time several versions are created:

- A board consisting of three parts 2 sensor boards and one LCD screen in the middle.
- A prototype consisting of one part. It has a grid of 16x16 fullcolour LEDs for feedback and a detection grid using RFID antenna. It has to be connected to a computer using 2 serial (to USB) cables and to a power source. This version available at the Sint Maartenskliniek during the entire research, is known as the BlackBoard as it is black.
- The first consumer version(s) is similar to the blackboard but with a 12x12 grid, see Figure 3.1. It can also load and run its programs from a SD card, thus no longer need to be connected to a computer but still needs to be connected to a power source. The board is slightly raised using four legs; on top of the board it has space for storing some basic objects and placing identification cards. An overlay can be placed on top of the board (such as the road shown in Figure 3.1). This overlay has a tag as well and can be used to automatically load the correct game. This version, being blue, is known as the BlueBoard.

During this research the BlackBoard is primarily used as it was available for usage at the Sint Maartenskliniek. This section will proceed with a history of the TagTile's development and research done with it, the TagTile originally was a Philips Research product. This and closely related research, on the use of tangibles for education in primary school instead of mouse-driven interfaces, will also show why tangibles could be beneficial in therapy as well.

3.1 Mouse-based interaction or tangibles for children

An advantage from tangible interaction over mouse-based interaction is found in research on traditional mouse-based interaction. The performance of these mouse movements of a ten year old does not reach that of

an adult (Lambert and Bard 2005) . Hourcade, Bederson, Druin and Guimbretière (2004) also showed the inability of young children to handle a mouse with accuracy and recommended the following:

> *"In considering solutions, designers should particularly make certain that user interfaces are appropriate for the youngest children they intend to support and should consider designing alternative interfaces for different age groups. " (Hourcade, Bederson, Druin and Guimbretière 2004, p. 384)*

Simple physical learning aids have been used in education for years. The use of physical objects is beneficial for the development of a child because it is less abstract than alternatives and helps them create a mental representation. An interactive tangible platform can provide more engagement with the children and be automatically tailored to the level of the child while at the same time providing this advantage of having physical objects. (Verhaegh, Fontijn and Hoonhout 2007)

Verhaegh, Fontijn and Jacobs (2008) analysed this difference with a block pattern puzzle game: a virtual version played with the mouse and a tangible version of the same game. The test consisted of 26 children ranging from 5-7 years playing both versions. Half of the group was assigned to first use the tangible version and the other half first played with the virtual version of the game. The virtual version required longer time to complete. Besides observed drag and drop problems, the children also had problems using the interface's rotating block system and depiction of empty space. In play with the tangible interface a more trial and error or exploratory approach was seen.

Besides the cognitive advantages of using tangibles, using tangibles can also trigger a wider number of movements making it usable in therapy. Playing games with a touchscreen was used in therapy of children with CP by Naylor and Bower (2005), this can triggers other movements than a mouse but is still limited compared to the number of movements that could be triggered with tangible games.

3.2 Predecessors

Before the actual TagTile was developed a tangible storytelling game called StoryToy was created consisting of stuffed animals with simple sensors and audio feedback. The goal was to create a high-tech toy wanted by children that would be useable without instruction. (Fontijn and Hoonhout 2007)

The first natural reaction of a child when confronted with StoryToy is to pick up the animals, and that already starts the interaction. Out of curiosity or by listening to the directions given by the animals the children try out the various combinations of animals and locations in the farm and are thus drawn into the stories. Based on the experiences and results of this project, development proceeded with location based object interaction. The output was until then limited to audio and they intended to implement LEDs embedded in the animals and ambient lighting.

Figure 3.1 The BlueBoard TagTile with some standard tagged objects and a semi transparent overlay showing a road.

Mendels and Fontijn (2005) mentioned that the concept of using high tech solutions for storytelling with children is not totally new. For example Allison Druin, a researcher with emphasis on designing with children, worked on physical programming of physical interactive

environments to enhance children's storytelling experiences and a storytelling robot for pediatric rehabilitation (PETS). (Plaisant, Druin, Lathan, Dakhane, Edwards, Vice and Montemayor 2000; Druin 2002).

In their scenarios PETS was also suggested to make the repetitive therapy of children with CP less dull (Plaisant et al. 2000).

Several toys and games were developed for research on the relation between fun, motivation and learning. This includes an improved version of the StoryToy which makes use of environmental lighting to enhance the feeling of daylight or a storm. Another platform with several games was Splashball. This is a game using a wall projection which can be interacted with by throwing a ball as a point and click interface. The recognition was based on advanced image processing. The conclusion of this research was that tangible interfaces can easily combine sources of fun and address all three aspects of development (physical, cognitive, social). (Hoonhout, Isbister and Schaffer 2008).

Figure 3.2 The first version of the TagTile consisting of three parts: in the middle there is a plasma screen and at both ends a 8 by 8 sensor grid.

3.2.1 Early TagTile

Verhaegh, Fontijn and Hoonhout (2007) had thirty-eight participants ranging from 10-12 years old participating in an evaluation of the first design and game of the tangible table called TagTiles, see Figure 3.2. The social interaction between the players was not too much because they mainly focused on their own playing boards.

> *"It was designed to be suitable for investigating the balance between challenge and control by providing fine-grained and wide ranged difficulty levels. TagTiles can address a range of skills including fine motor skills, cognitive and social skills. Evaluation of the game showed that the children appreciated the game and that most of them were offered a challenge that was appropriate for their skill level." (J. Verhaegh et al. 2007, p. 1)*

3.3 Tangible games on the TagTile

Dozens of games have already been created for the TagTile. Amongst others a prototype for a game for therapy of CP in the Sint Maartenskliniek was already developed. A description of some of the more relevant games is given here.

3.3.1 Recreating figures

Recreating figures is played on the early TagTile and uses a Tagtile version with three parts, seen in Figure 3.2. The screen shows a pattern of 8 by 8 some filled with colours which has to be recreated by both users on the end. This is done by tagging an area with the proper coloured object which is recognised by the sensor grid. When a mistake is made a specific sound is played which is different for both players. The first one to complete the pattern wins; it uses two different types; sequences and merely the patterns itself. There is total of 15 different levels available. (J. Verhaegh et al. 2007)

Based on the results of the evaluation a handicap was suggested to make the game more interesting when participants were much stronger than their opponent (13 out of 19 sessions).

> *"An interesting observation, and supported by the log file data, is that some children were better at copying patterns, whereas others were better at copying sequences, which suggests that both versions of the game address different skills." (J. Verhaegh et al. 2007, p. 190)*

In later versions of the TagTile this logging and in-game data recording is used as an adaptive feature to alter the level to the child and for testing of users and to record progress. (van der Wouw 2009; Fontijn 2010; SeriousToys 2011)

3.3.2 Games for primary schools

SeriousToys has developed several standard games provided with the board. Other games have to be bought as an extra. They also develop games that are proposed for the TagTile by Dutch publishers of educational games, books and magazines (amongst others Zwijssen, Blink Uitgevers (Bobo) and Jegro) and sell these (additional) games to be used on the TagTile platform (van der Wouw 2009; SeriousToys 2011; Fontijn and Meijles personal communication, 2010). Only the more interesting games will be described here, for a short description of all games one can visit the *TikTegel*-website (SeriousToys 2011).

"Je Lijf" is a set of games in which Bobo, a cartoon figure for primary school, can be dressed. This is done by putting a Bobo figure on the clothes, depicted on the left of the overlay. It also has games in which parts of the body, the functions and senses have to be recognised and a game of rhyming with body parts. The games can be chosen by selecting the number 1-5 by putting the puppet on top of it. Possibly interesting from the game are the awards for right answers. Shown on the right are stars and above are five different cups. This game can be seen in Figure 3.3.

Most other games also have to do with simply putting an object somewhere on an overlay. Sometimes game also make use of the computational powers such as multiplying or keeping track of progress. Most of the games resemble conventional exercises, "the TikTegel could be employed better" (van der Wouw 2009, p. 107). Van der Wouw(2009) proposed two games to incorporate the direct tangible feedback and feedback through LEDs. One of the games had the goal of learning to read by constructing words. The tangible object consists of three parts which can be rotated independently. Every part has six sides; every side has a letter or letter combination representing a sound. By turning the wheel words could be made, pronounced and the correct picture on an overlay could be selected. Different levels were suggested. In the most advanced level an object would be lit from the overlay and the child had to form exactly the same word. In an easier level children could just make random words and this was followed by a lit object and verbal praise.

3.3.3 TagTile games for therapy

An earlier research is done on making games for the Sint Maartenskliniek on the TagTile to improve therapy at the Piratengroep. (Li et al. 2008) The resulting games were not satisfying enough to incorporate into the therapy. The games and lessons learned can however be used in this research.

Figure 3.3 A game with the cartoon figure Bobo (SeriousToys 2011)

A participatory design method was used with two therapy centres (the second being Blixembosch Revalidatie Centrum Eindhoven). The research started with contextual interviews and observations. This gave insight in the movements and current training procedures. This was followed with an iterative design approach using video prototyping to get feedback of the therapists on the

design concepts. Flaws were found on overestimating the physical abilities of the children and a lack of withstanding possible compensations of the children to circumvent the to be trained movements. These compensating movements are ways in which the children circumvent the movements they have problems with such as using their non-affected arm.

A brainstorm session was done with a therapist to improve the games. To see if children would enjoy the games, these were made tangible but not yet digitalised. This was evaluated on both children with and without CP, to find out how children with CP perform and compensate. Again in these games compensation was seen by the therapists as a point for improvement. Based on the earlier made games, three games were developed on a TagTile. These are described later on. On site testing and observations with video recordings were used for evaluation. This was combined with interviewing the therapists on quality of movements triggered and fun and motivation of the games for the children. Tests were done individually with a therapist present.

> *"All participants said they enjoyed playing the game, though their preferences ... varied with age ... Therapists were happy to observe children engage in the desired movements spontaneously" (Li et al. 2008, p. 190)*

Some movements like extension of the wrist and supination were not triggered enough. Another point of improvement was the unwanted wrist flexion by the children during the games and not enough prevention of compensating movements. Still the response of the therapists was described as "promising as a therapy aid". But the proposed longer evaluation of the games was not proceeded with until the current research.

The games

A coloured hammer game was designed to trigger supination and elbow extension. The tangible object was a `hammer' made of polystyrene foam with eight different square faces each with its own colour. The game principle is turning off a light emitted by the board in one of the colours of the hammer, the child has to turn the hammer to the right square and hit the light to turn it off.

A coloured block game had a wooden cube of 10cm with six different colours as a tangible object. No triggered movements are mentioned. The game principle is to turn off all the emitted lights on the board with the block. Every square of four adjacent lights was shown in a colour also present on the cube. The cube had to be put on the board with that coloured site down to turn off that square of lights.

A rotating coloured block game is an extension of the previous game. The cube exists of two parts that can be rotated. Instead of a one-coloured square, two rows of two lights with two different colours are used. The cube had to be rotated to resemble the pattern to be able to put off the lights.

One game was ultimately developed after the work of Li et al. (2008) was done, designed by a student hired by the Sint Maartenskliniek. A block with a pirate puppet had to be used to turn off lights on the board. The difficulty increased by making the target lights smaller after successful completion. Unfortunately the game was not programmed well and freezes frequently due to wrongfully written saving commands. It also triggered unwanted movements.

Positive feedback and no games in use

In a short informal interview with employees of SeriousToys, the company behind the TagTile several other reasons were given why development for therapy on the TagTile stopped. The triggered movements were very difficult for the children to perform, thus only training those who already have a reasonable performance. The

cube was too big and thus also hard to handle. For SeriousToys the effort to create new games for therapy was of lesser importance compared to developing the board and games for the primary school. The market of primary schools is much bigger compared to the market for therapy purposes. Projects for therapy would only be taken on in context of a larger setting. They did provide a TagTile to the Sint Maartenskliniek and were willing to assist in development by the therapists. However, there was not enough knowledge and time needed to develop games by the therapists themselves. (Fontijn and Meijles personal communication, 2010)

3.4 Conclusion

The TagTile is a tangible board on which objects can be identified and located. Several versions have been created over the years. During the research focus is on the Blackboard as this was available during the entire research. A newer version is called the BlueBoard. The main difference of the BlueBoard compared to the BlackBoard is that it can run alone, without being connected to a laptop and has 12^2 fields instead of 16^2. Every field has full colour LED underneath which can give feedback. Another option of feedback is using sounds. Tangibles are easy and natural to use for children. Several games have been developed for the TagTile but these focus on usage for primary schools. There has been a previous research which attempted to create games for therapy of CP on the TagTile by a post-master student. The results were promising as therapists were positive of its possibilities in triggering movements of the affected arm and providing fun. However due to using badly chosen dimensions, not handing over the games and triggering too much compensating movements it was not used in therapy. The Sint Maartenskliniek also let another student create a simple game. This game however crashed every time as it contained programming errors in saving and loading games, this should be prevented in the new TagTile games. There is an opportunity in creating these new games on the TagTile for therapy for children with CP, the games can and should be enjoyed by the children. An important strength of the board that can be used in the research is the ability to log progress and to change the difficulty according to the user.

4. Games: fun and motivation

Games on the TagTile can make use of some of the parts that make computer games interesting for children. This chapter will give more insight in what makes computer games fun. Knowledge of what makes games fun inspired the tests done in this research and helped in explaining the outcome. Some of the features are implemented in all of the created games to make it more fun.

4.1 A taxonomy of Malone and Lepper(1987) to make games fun

Research into computer games has been done for decades. Malone (1981,1982) and Malone & Lepper(1987) already advocated the usage of games to make learning more fun. This research is still been summarised, completed and cited in more recent research of others (Barendregt 2006; Dickey 2006; Fontijn and Hoonhout 2007; J. Verhaegh et al. 2007; Kannetis and Potamianos 2009; Moon and Baek 2009).

The research of Malone focused on variables that could make games fun to play. Something that is applicable in this research as well, although no focus on learning is intended. His research consisted of a survey and analysis of most popular games (top 25) at that time. This was tested with 65 children in the elementary school that had to rate these games on a 3-scale level. Malone looked at the preferred games by the children and the features present in the games. Another research was done by letting children play with different versions of darts computer game. Each version a possibly motivating feature was removed. These features included scorekeeping, kinds of feedback, fantasy and music. The children were free to play their version of the game or hangman. Afterwards the duration of play was analysed between features.

Based on their work they proposed a taxonomy on criteria to make a game intrinsically motivating (Malone and Lepper 1987) . This consists of

- Four individual criteria:
  - Challenge - Curiosity – Fantasy – Control*
- Three interpersonal criteria:*
  - Cooperation - Competition - Recognition (as in appreciation)
- Two application principles of this criteria for individual differences :*
  - Student treatment interactions (differences between children's interest) - Instigation vs maintenance of interest (attractive first use with gimmicks often fails in remaining interesting over time)

The ones marked with * are added in 1987 to their earlier existing taxonomy. Individual preference difference for these features are present for instance between sex (boys/girls) (Malone and Lepper 1987), but also in age(Li et al. 2008). Instead of explaining and summarising all the features further, only some of the most important results for this research are explained. A short description of the criterion of fantasy can be found in Appendix C. This description is omitted in this chapter as their findings on fantasy are not investigated in my research.

4.1.1 Challenge, goal, and performance feedback

In the survey the two least popular games lack a goal while popular games had an explicit goal such as "getting a high score, shooting the opponent's snake, or knocking all the bricks out of the wall" (Malone and Lepper 1987, p. 224).

According to Malone & Lepper (1987) this goal is one way to create challenge but an important factor is uncertain outcome amongst other of reaching the goal. In their research they point to some models according to which a success ratio of 50% would be optimal (McClelland, Atkinson, Clark and Lowell 1953) in (Malone and Lepper 1987). Having levels, multiple goals, hidden elements and random elements present in a game can also help for the increase of uncertain outcome, challenge and fun. Other mentioned components for challenge are the engagement of self-esteem and a performance feedback that is frequent, clear, constructive and encouraging. These two components can be put together creating at the same creating a tension between clear feedback and raising self-competence. To engage self-esteem with performance feedback it should be made personal relevant. To this end amongst other social relevance is mentioned. (Malone and Lepper 1987)

A term used in combination with challenge and experience is flow. This is "a condition of high challenges and skills" and this influences the experience of an activity such as the satisfaction (Csikszentmihalyi and LeFevre 1989, abstract). Another description is "strong involvement in a task occurs when the skill of an individual meets the challenges of the task." (Kannetis and Potamianos 2009, p. 40). It is thus important to provide the right difficulty level as it influences the experience of playing a game.

4.1.2 Scorekeeping

One way to create social relevance could be using scorekeeping. Malone's survey showed that games with points were preferred. Surprisingly, no significant effects were seen in duration of play when adding this scorekeeping (Malone 1981; Malone 1982).

4.1.3 Sound/music

It was found by Malone that a darts game which played music in the beginning and a sound played after each round was played significantly longer ($p < 0.05$) by the participating fifth grade girls (approximately ten years old) than another group of girls playing a game without this feature(Malone 1982). On boys however this effect showed a non-significant trend ($p>0.05$) but towards a negative/decreasing duration effect.

A similar effects was found in his survey where there was a strong correlation in game preferences and having audio effects (Malone 1982).

4.1.4 Research on using the fun factors

The framework of Malone could be used to do tests on preferences of children of today. Such tests can help to improve concepts and in making design choices. One such example on comparison on the factors from Malone's research was found from Kannetis &Potamianos (2009), although others can exist. Five games consisted of the following tasks: animal recognition, shape recognition, number recognition, a quantity comparison and addition. They tested three of the features identified by Malone(1980): fantasy, curiosity and challenge (by difficulty). They tested the preference for fantasy with a story and fantasy trigger. The fantasy was amongst others a "crab" running around and a story of returning an alien to his home planet. Curiosity according to Malone (1980) could amongst others be stimulated by having audio and visual effects as reward and by giving surprising feedback. This surprising feedback should be kept constructive in order to remain educational, which was one of the goals of Malone. This is why Kannetis and Potamianos for testing curiosity used a progress bar, an object coming to possession of the player, randomness of position in the form of where an animated character appears, randomness of the proposed next task and randomness of a selected item in the answer bar. The challenge was in the number of items, for example for the number recognition task divided into numbers 1-5, 1-9 and 1-9.

The test was done with nine children ranging from age 4-6, was tested in different ways needing to play 3*3*5=45 different implementations of tasks per child. This was done in three sessions. With the youngest children one or two of the tasks were not done.

Fantasy and curiosity levels had a significant effect on entertainment measured by the preferred version, while difficulty had not. A remarkable result was that girls had a significant longer inactive response time, measured as time until either verbal input or measured mouse activity (p=0 [sic]). Girls scored significantly better on task completion (97.62% vs 90.32%). Age differences were also seen. Four year olds had significant worse task completions (90%) than five and six year olds (97%). A trend can also be seen in average response time, younger children taking longer on three of the four tasks but not on the more/less task. The adding task could not be done by the younger children.

One might question if only changing the range of items/numbers (and in two cases change from item help to no item help) really represents enough change in challenge. It was also suggested by the authors themselves that difficulty might be better defined on the capabilities of the individual.

4.2 Motivation

Malone and Lepper(1987) make a distinction between two types of motivation: extrinsic and intrinsic. Extrinsic motivation is a type of motivation coming from outside the activity itself while intrinsic motivation is coming from doing the activity itself. For instance intrinsic motivation is the motivation to continue to play a game coming from playing a game. Extrinsic motivation is for instance making homework to prevent punishment from the teacher. Malone and Lepper (1987) use fun, enjoyable and intrinsically motivating as somewhat interchangeable terms.

4.3 Conclusion

There are many features that can make computer games fun. Some of the most interesting features that could make a game fun are having a goal, sound, (intra- and interpersonal) challenge, scorekeeping, fantasy and rewards. The research from Malone(1981,1982) explaining these features was done several decades ago. This could have influenced its findings and it was done with children from a different target group. A test on using these features of fun is done recently (Kannetis and Potamianos 2009). The tested games in that research were not tangible but focused on the usage of speech in combination with mouse input. Such a test on the fun factors in the context of tangible games could lead to new findings which could help to improve games for therapy.

Malone&Lepper(1987) proposed to use games in education as they can provide intrinsic motivation. This is a type of motivation coming from doing the activity itself. This type of motivation can also be beneficial for therapy as it can increase the number of proper movements made.

5. Design and research techniques

There is a very broad range of techniques and tools that can be used in this research. Some interesting techniques that seemed appropriate based on the target group and games to be designed are mentioned here. Not all of the techniques described in this section are used, for several reasons. Some have been used partly, some slightly altered. But even the methods not used entirely in the research still inspired and might be applicable for future related research or designs.

The chapter starts with explaining participatory design and a method for designing with children. The next part gives an introduction to an enhanced observational technique known as ethnographic research. This is followed by a brainstorm technique of acting out movements. The section ends with two evaluation methods to include end-users.

5.1 Participatory design

The focus of participatory design is in giving the end user a say during the entire design process to come to a design that closer fits the needs of the user. A new system will only be used if it is acceptable for the users. Therefore participatory design has three characteristics (Dix, Finlay, Abowd and Beale 2004) :

- It aims to improve the work place and task.
- Collaboration with the user in the design and the user is able to contribute in every stage.
- Iterative approach, evaluation and revision at every stage.

One might emphasise in the first point that it is aiming their work environment. Thus in proper user participation the active participants are directly affected (Bødker, Kensing and Simonsen 2004, p. 58). The second point does not mean that the users have to take part at all times (Bødker et al. 2004, p. 58,59).

Several techniques can be used in this process to narrow the gap of understanding between user and designer (Dix et al. 2004). In the following sections some techniques are described more thoroughly. The first described techniques focus on designing with children. The next described method using observations is also especially applicable for children as interviewing or surveying children is difficult. Design techniques are explained that focus on the interaction which are especially applicable as movements have to be trained. Evaluating with children and getting input of the end-users can benefit from the techniques that are described at the end of this chapter. The use of video prototyping was already mentioned in the work of Li et al. (2008) which might also be usable in participatory design especially when co-located meetings are cumbersome.

5.1.1 Designing with children

Once being an adult it is hard to think as a child again. All kinds of learned concepts are used as soon as one is making sense of something resulting in a different way of thinking or for example drawing. Designing with children could have benefits to bridge this gap of knowing what a child likes again and to make something interesting in the world of a child. Druin is one of the researchers who have been deeply involved in designing with children. Druin (2010) believes it is critical to give a child a voice in the design of new technologies. Designing without this child's perspective,

> *"…it's like making clothes for someone you don't know the size of…"*
> *an unnamed 9-year boy (Druin 2010, p. 4)*

Cooperative inquiry, a method to design in cooperation with children

The co-design method with children used by Druin is based on cooperative design methods, low-tech prototyping and contextual inquiry (Druin 1999). This latter resembles ethnographic research. Like contextual inquiry, ethnographic research is also focused on field experiences to comprehend the user, activities and cultural relationships (Druin 1999; Fetterman 2009). The child with its specific knowledge could be seen as the "native informant" (Scaife and Rogers 1998). The traditional ethnographic study is explained in more detail in the next session. It is of specific use because Druin found that children of three to five years old are lacking in some self-reflective capabilities. Thus making it harder to understand what their needs would be. Children older than ten have difficulty letting go how things "are supposed to be". This makes children from seven till ten years old better partners. (Druin, Bederson, Boltman, Miura, Knotts-Callahan and Platt 1998).

Over time several of these and other techniques are tested and used in the co-design method with children. This method is now widely known as cooperative Inquiry (Druin 1999; Druin 2010). It focuses on children being part of the entire process (Druin 1999; Montemayor, Druin, Farber, Simms, Churaman and D'Amour 2002).

Some of the techniques and guidelines that are used in the cooperative inquire method are:

- Low-tech prototyping, with sticky notes and basic art supplies (crayons clay etc.). A technique that is equally suitable for adults as the youngest children. (Druin 1999)
- Analysis and observations of in context activities or usage of developed prototype. Possibly with the children from the design team observing and questioning participants in these tests. (Druin 1999; Montemayor et al. 2002). But environments such as a school, with its schedule and rules dictated to the children, might also influence researchers in a biased way in what they find as the needs of children. (Druin et al. 1998)
- Trying to minimise steering as an interactor. An interactor is more than just an observer, he questions participants about what they are doing but tries to keep the natural flow of interaction and prevent steering. This is done amongst others by not asking directive questions, let a child be an interactor and circumventing power structures something that helps is not wearing formal clothing. (Druin 1999)
- Non-uniform note taking/drawing, children and adults have different techniques in which they feel comfortable. Adults were afraid to lose detail in drawing while children have difficulty writing in detail. Note taking should also not be done by an interactor because it makes the children feel being tested. (Druin 1999)

In their method they circumvented usage of video. According to their beliefs it tends to freeze children or let them perform. Unobtrusive cameras on the other hand tend to lose quality in the recordings, they are hard to place in the right spot and sound is likely to be inaudible. (Druin 1999)

The other side of the medal

On the downside the effort required to do proper design in cooperation with children can be enormous as Druin's research with children on developing KidPad, PETS, StoryRooms and physical programming shows (Druin, Stewart, Proft, Bederson and Hollan 1997; Druin, Montemayor, Hendler, McAlister, Boltman, Fiterman, Plaisant, Kruskal, Olsen, Revett, Schwenn, Sumida and Wagner 1999; Alborzi, Druin, Montemayor, Platner, Porteous, Sherman, Boltman, Tax\, \#233, Best, Hammer, Kruskal, Lal, Schwenn, Sumida, Wagner and Hendler 2000; Montemayor et al. 2002). This effort ranges from a group of eleven children having an hour-long session twice a week for a month(Guha, Druin, Chipman, Fails, Simms and Farber 2004) to a small group of six children who come together two afternoons a week for one/two years working on several projects (Druin 1999).

And even a group of 48 children working more individually having a classroom session three times a week for six months (Druin et al. 1997).

Another problem is the young age of the children.

> *"[...] with our youngest design partners (ages 4-6) one challenge that stands out is the ability for children of this age to truly collaborate by elaborating on one another's ideas. The concept of building upon each other's ideas in an elaborative brainstorming process appears difficult for children of this age to understand and accomplish. They can have a difficult time "letting go" of their own personal idea to combine it with another person's generate a completely new idea." (Guha et al. 2004, p. 2,3)*

A way to circumvent this problem is mentioned, a method called mixing ideas with techniques such as more facilitating by adults and working in smaller groups. But the problem in essence remains and results shown are based on children from 5 years old. Keeping in mind a possible retardation in cognitive development of the children with CP of approximately a year, this problem will be essential in this research.

On the other side of the spectrum is the tendency of children to start copying each other. By Desjardins and Wakkary (2011) this was seen by children from age 9 to 13, and viewed as an exchange of ideas and a positive effect of working together. It seems however more likely that it will ultimately lead to only a reduced set of concepts instead of the preferred building on each other's work. One of the children participating in their research also concluded this during a design exercise

> *"We are all copying each other!" (Desjardins and Wakkary 2011, p. 8).*

The goal of contextual inquiry

What is attempted with contextual inquiry is to give children a chance to let us know what they want and to give them a voice in design with all its benefits. This does not mean they can tell us everything needed in a design. But when the stakeholders have something to say, including children and in this case therapists,

> *"a complete range of experiences can be taken into account during the research process"* (Druin et al. 1998, p. 2)

5.2 Ethnographic research

Ethnographic research originates from anthropology. It is used to better understand a culture and individuals in this culture. This is done by doing observations from within a community also interacting with this community. This interaction, in-context observation and making yourself part of the community being observed distinguishes it from other observational techniques. The observations can also be recorded using video, photo or text. Ethnography can be used to get to know the users or a usage situation.

The work of the ethnographer Fettermann(2009) contains several guiding concepts which can be used to explore new directions and to get proper data. For instance an ethnographer should accept multiple realities (emic perpective), try to minimize but keeping in mind his biases towards a different culture (non-judgemental orientation), take into account the differences inside a culture (inter- and intracultural diversity) and try to describe observations accurately leaving a reachable minimum up to interpretation (operationalism). (Fetterman 2009)

The method has several advantages over paper-based approaches such as surveys. In these paper-based methods users have to recall and describe their own behaviour on paper which can lead to several discrepancies (Dishman 2003; Alburo, Komlodi, Preece, Druin, Elkiss and Resnik 2005).

The ethnographic approach attempts to get more in-depth information of a smaller target group and can be very time consuming; up to several years in its original anthropologic context (Plowman 2003).

5.3 Acting out movements and interaction relabeling

Several design techniques make use of acting out physical interactions with an imaginary product or doing other physical movements to come up with new ideas. Three are mentioned below: informances, hands-only scenarios and interaction relabeling. All are normally performed with several persons.

The main part of informances is acting out an envisioned future usage scenario using a prototype as a prop in front of a group of designers. Informances are used after a first brainstorm as a communicative tool, an alternative to storyboards and scenarios. Thus being more of an evaluative tool instead of inspirational tool (Burns, Dishman, Verplank and Lassiter 1994).

Hands-only scenarios, on the other hand, are a more concrete design technique. It is meant for moving towards the tangible interaction instead of the current focus on cognitive interaction for plants and household appliances. Simply using hands an action can be designed before the actual shape and design is known. This method doesn't make use of props because it doesn't yet consider the physical form of an envisioned product and focuses on designing the action. It can make use of props in a later stadium as a simple mock-up tool (Buur, Jensen and Djajadiningrat 2004).

In interaction relabeling a prop is used to tell and act out the usage of an envisioned product. It uses interactions of the prop transformed to that of the product, for instance emptying the bullets of a toy gun was mapped to cancelling the appointments in an appointment management system. It is claimed that it works better in a group than as an individual technique. Their hypothesis is that inhibitions towards a silly technique tend to get lost by group pressure(Djajadiningrat, Gaver and Fres 2000).

5.4 Systematic Inventive Thinking

Systematic Inventive Thinking (SIT) is a way to alter a product, or to overcome a problem, by using one of five thinking patrons. These thinking patrons are simplifications by Horowitz and Goldenberg of TRIZ which is based on an empirical study by Genrich Altshuller mid 20-th century on about 200.000 patents and inventions. (Horowitz and Maimon 1997; SIT-Ltd 2005)

SIT unlike TRIZ is not so much usable to solve problems but more for finding new solutions (Bonnema 2011). SIT consists of the following steps: identifying the components of the idea/product, applying a thinking patron, visualising this solution and then foreseeing whether it will fulfil (new) needs.

Five thinking patrons are applied on the components (SIT-Ltd 2005):

- Division
- Multiplication
- Subtraction
- (Task) Unification
- (Change of) Attribute Dependency

An example of the product television is shown in Figure 5.1, using the thinking patron subtraction of the component screen resulting in a TV without a screen which could be a cost effective solution for blind to buy a TV (SIT-Ltd 2005).

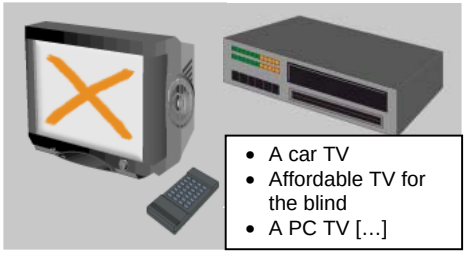

Figure 5.1 Example of using SIT on a TV subtracting the screen and possible resulting product ideas (SIT-Ltd, 2005b)

5.5 Evaluation techniques

When a concept is generated and developed in an iterative process it should be tested and refined based on this test at least once, hence iterative process. During these evaluations the interaction with participants is sometimes limited to prevent interaction interfering with the quantitative results. But verbal feedback during a test might be helpful in indicating problems. A technique used often (without keeping to the strict rules) is called think out loud. Another technique that could be used during the evaluation is called development panel. Herein a group gives feedback for improvement after evaluating a product.

5.5.1 Altered think out loud

Ericsson and Simon created guidelines for an evaluation method called "Thinking out loud" for cognitive psychology, according to them constant prompting should be done to gather quantifiable verbal data during testing. Abandoning this constant prompting is used often in the field of HCI (Boren and Ramey 2000). Barendregt found in his research, that constant prompting could also result in non-problems when testing children (Barendregt 2006). For this target group, with known concentration problems, a use of constant prompting could be too distracting from a current task. It is expected that verbal feedback during tests by the participants indicating problems, could however be helpful even when constant prompting is not used.

Using "acknowledgement tokens" in non-intrusive backchannel techniques (e.g. "hmm hmm", "oh I see", "ok") can also help to create a normal usage situation and user-facilitator interaction. This will actually diminish the effect of the present facilitator, when compared to the stricter guidelines of Ericsson and Simon(Boren and Ramey 2000).

5.5.2 Development panel

In a development panel a group evaluates and gives feedback on a product. This can be described as being a participatory method, using input of end-users without falling into temptation of turning them into actual designers (Ireland 2003). Previous to such methods the development could benefit from testing with non-end users. Zimmerman (2003) describes several cases using the development panel: creation of the games SiSSYFiGHT, LOOP and LEGO Junkbot. In these cases testing games moved outward from game creators to friends, invited beta-testers and finally a created playtesting "club". Such testing can directly influence the design of a game (Zimmerman 2003). It can also be beneficial as certain bugs can be already fixed during more informal tests which would have worsened test results otherwise.

5.6 Conclusion

Designing for and/or with children can lead to several challenges for doing interviews, observations, brainstorm sessions and evaluations. Several techniques used in the contextual inquiry method to include children in the entire process have been proven to be fruitful. It however takes a lot of effort and time to properly design in cooperation with children.

Doing an ethnographic study helps in creating a good image of the target group and can be especially useful as young children have problems with self-reflective capabilities. Wearing informal clothing, having conversations but preventing steering and not filming the children could help in observing a natural flow of interaction during such a study.

In the context of designing games to trigger physical movements using design techniques that require acting out the movements seems suitable. The three techniques, informances, hands-only scenarios and interaction relabeling, are normally used in a group setting. Looking at the techniques in the context of this research they might also be beneficial for individual usage.

SIT is a simple yet powerful technique that can be used to generate ideas or improve products. Altered think out loud could be useful for testing with children from this target group. The children have known concentration problems but with this technique could still give important feedback during play. The development panel can be beneficial in this research as there is limited time with the end-users available.

6. Requirements

This section contains a set of requirements following from the literature review, interviews and ethnographic study. The first designs have to be kept simple in order to test them with a variety of children as soon as possible. At the same time the designs should give insight into the possibilities and usage of tangible games for therapy and the TagTile's SDK. This SDK makes use of its own programming language called ESPranto.

Some of the requirements are only created for a first test others are for the Tagtile games in therapy in general. When a requirement is only created for the test version this requirement is indicated with (T). Wishes or preferences that can/could be implemented are also included in this set.

This set of requirements is divided in functional (*ID:F*) and non-functional (*ID:NF*) requirements and numbered and identified accordingly. Each requirement also has a priority assigned to it.

Train motor skills		**ID: F_01**	**Priority: 1**
.1	The games must train different grips	Rationale: the purpose of the system is to train the motor skills of children by repetition and make this more fun.(Verhaegh personal communication, 2010; Verhaegh et al. personal communication, 2010) The set of trained motor skills were seen during ethnographic study and completed and confirmed by a therapist (Verhaegh personal communication, 2010).	
.2	The games must train dorsal flexion		
.3	The games must train extension of the elbow		
.4	The games must train supination		
.5	The games must address multiple repetitions of the movements		
.6	The games could train coordination of the movements		

Prevent compensational movements		**ID: F_02**	**Priority: 1**
.1	The system must be used with their affected hand	Rationale: the system is made to train certain motor skills of children but should inhibit other (compensating) movements. Children are inclined to palmair flexion which makes a grasp weaker (Wielders personal communication, 2010), inclined to use their good hand which doesn't need training (Li et al. 2008) and inclined to move their torso instead of hands or arm (observations).	
.2	The system must prevent movements only using a finger or torso		
.3	The grasps should be trained without use of palmair flexion		

Provide entertainment		**ID: F_03**	**Priority: 2**
.1	The games must be intrinsically motivating	Rationale: intrinsically motivating should be possible as suggested for educational software (Malone and Lepper 1987) and gives opportunities to improve intensity for example training at home and thus improving results of the therapy sessions. The games will be tested and this should give insight on how to improve (new) games.	
.2	The games should be fun to play		
.3	(T) The games should be able to give insight in entertaining aspects of tangible games for therapy		
.4	The games could make use of the Pirates theme		

Play alone		**ID: F_04**	**Priority: 3**
.1	The games should draw attention in such a way that a child is never distracted longer than 20 seconds	Rationale: most of the times there are more children than therapists and children have concentration difficulties. Games should be kept simple enough in order to be played alone	
.2	The games must be simple enough to let the children train on their own (after explanation is given)		

(T) Is quickly designed		**ID: NF_01**	**Priority: 2**
.1	The system must be ready to use during the first return sessions.	Rationale: the system should be tested with a number of children. A normal session only has 5-6 children in a period of 8 weeks. The return sessions give opportunity to see more children interacting with the system. It would be efficient if the system can be made ready in the morning before the sessions.	
.2	The system should be transportable in the train and bus.		
.3	The system should be based on the already existing and available black TagTile		
.4	The system can be put together in less than three hours		

Effectively programmed		**ID: NF_02**	**Priority: 3**
.1	(T) The set of games should give an insight into possibilities and usage of the ESPranto SDK.	Rationale: the programming language used for the board is ESPranto, it has to be learned and future games should benefit from the insight in possibilities. The games should start quickly enough without problems. During iteration features will be added.	
.2	The games should make use of the same version of ESPranto.		
.3	The games should be easily changeable		
.4	(T) The games should be logged to improve quality of results of the evaluation		

Be safe		**ID: NF_03**	**Priority: 1**
.1	The tangible objects must be larger than an open mouth of the target group	Rationale: safety comes first. NEN-EN 71-1:2010 Ontw.en requires toys to prevent fingers getting stuck and requires toys to be large enough to not be swallowed. (The board itself is already certified)	
.2	The system must not have small areas in which children's fingers could get stuck		
.3	The system must not have sharp edges by which a child can wound himself/herself		

Start fast		**ID: NF_04**	**Priority: 3**
.1	The system should be able to be prepared within 5 minutes for use	Rationale: only a small amount of time is available for the individual therapy part already. Time should be used efficiently to train movements: about a tenth of an individual session (6min) will be maximum time spent as is 2min for a session.	
.2	The system should be able to be quitted/put into standby within a minute.		
.3	The system when prepared should be able to launch a particular game within 2 minutes.		

7. Design of tangible games for CP therapy

This chapter describes the used design method and first versions of three simple games developed for the TagTile in therapy. It starts with a description of all the design steps in this research followed by a more extensive description of some of the used techniques to develop the first three games. These first three games can be found in the following section of this chapter.

7.1 Methodology

Designing for and/or with children can lead to several challenges for doing interviews, observations, brainstorm sessions and evaluations. To gather input of children and therapists an iterative design approach is used. After each iteration/(set of) test(s) more knowledge is gathered and feedback of therapists is triggered. As this research requires expert knowledge and analysis such an approach seems beneficial. The therapists are involved actively during the entire research, in some steps more than others. This combination of active collaboration with the end user at every stage, iterative process and aiming improvement of work place and task make it a participatory design method.

The chosen method starts with the performed ethnographic study of two therapy sessions. Some of the methods and target group is already known which makes such an observational study more efficient. The interests, movements and exercises found in the literature survey, observations and interaction with the children and therapists, combined with old low resolution games form a basis for inspiration. By acting out movements and using props when necessary this inspiration is transformed into ideas for games, this will be described more thoroughly later on.

The first ideas are presented to the therapists using video prototyping. The further developed ideas are tested first on friends and family and finally with children and with therapists present. A longer term evaluation is performed to analyse actual usage of the games followed by an interview with therapists. In the last iteration, which will be described in chapter 10, the first step in creation of new ideas is done with therapists. For this co-design session with therapists SIT and interaction relabeling are used.

Arguably more co-design techniques can be used for the generation of the first games. However the limited amount of time until the first test and the amount of work that has to be done before a co-design session can be done led to abandoning this option for the first games. Also the feeling was gained that the therapists were already having a very full schedule at that time and it would thus be hard to fit into both schedules during the period just before summer holidays in the first stage of the project. This was also found in a 64-item survey amongst 52 therapists of Adelante and Sint Maartenskliniek, which mainly used Likert scales:

> *"Although therapists consider themselves personally creative, the result of the survey shows that they lack the initiative and minimum commitment to develop new treatments alone or in collaboration with others. Regarding our own interests for the feasibility of EUD[End User Development], we can argue that they are not likely to engage in creating novel technology supported therapy out of working hours [...] Since participants have regular work to do, any extra activities such as developing new therapy tools would have to be in their free time." (Kierkegaard and Markopoulos 2011, p. 8,9)*

7.1.1 Children's input by ethnography

The input from children was limited. This is mainly due to the limited amount of time available from the children for non-therapeutic ends as stated by the therapists. Another limitation was the age of the children. "Young children, particularly from ages 3-7 have a difficult time abstractly describing what their technology needs and wants may be." (Druin 1999, p. 2) and have trouble building upon each other's work and therefore letting go own ideas (Guha et al. 2004). This combined with a busy period at the Sint Maartenskliniek with the holiday period coming up; led to the conclusion to use the ethnographic study, described in section 2.3 of this report, as inspiration on interests of children.

For generating ideas the interests and exercises seen in the ethnography are the most valuable. These include like making animal sounds and listening to those sounds from others, picking marbles, selecting animals and placing puppets in and outside a pirate boat.

7.1.2 Existing games for inspiration

Another source of inspiration besides the ethnographic study are existing games for consumers, both board and computer games. To this end games from a "Brick game 118 in 1"- portable device and games from www.quickflashgames.com/games were played. The 118 games actually could be divided into five really different games: shoot other "space ships" without being shot, race 2 or 3 lanes "passing" other cars, shoot blocks that come near, let a ball bounce which breaks blocks away and jumping across a river. The flash games contained some interesting games such as treasure finding game through a maze and some simple puzzle games. A board game called "don't break the ice" also seemed interesting. This game is similar to Jenga or Timber. Instead of building a tower the 36 cubes of the game are placed in a horizontal plane. Players have to remove one of the cubes hold together by friction in a square border slightly above the surface using a tiny hammer. On top of the cubes a polar bear stands. The first to let the polar bear "drown", by letting it tumble onto the surface while trying to remove one of the cubes, looses.

7.1.3 Acting out movements as a generative technique

A new method is created and used for designing the therapy games. This is a technique for individual use in which movements are acted out. This method is based on *informances*, *hands-only scenarios* and *interaction relabeling* (see section 5.3).

The adapted method makes use of hands acting out certain to be trained movements. Acting out the to be trained movements is done repeatedly; triggering ideas which are tried to combine with the other inspiration sources. When something interesting is found this is sketched and or written down.

Sometimes, when stuck, a prop such as a pen, a stick or a CD-spindle can be taken for inspiration for movements. Here the form and its limitations are seen as less of a concern. The exercises are done on several locations but mostly with no other persons in the room to minimise personal inhibitions by being connected to a somewhat silly looking technique. This latter is in contrast with the beliefs of the creators of interaction relabeling who expected that group pressure is a more important factor in performing such an activity. The method seems very natural and suitable in this case. Because the system itself is also designed for training movements using props thus lowering the barrier to implementation.

7.1.4 Implementation

The mentioned techniques in combination with the recorded criteria result in several ideas. These can then be grouped according to the movement which they should activate. After which from every group one game is selected. After the selection of games is made the games are implemented for the TagTile using the Lonely Bert

v0.40 ESPranto software platform. This is chosen based on the interview done at Serious Toys in which it was explained that Lonely Bert was an easy to learn version and this version number was the last properly tested version(Fontijn and Meijles personal communication, 2010).

Simple tangible objects are created after the game principles are designed and programmed. For two of the three games already existing objects were searched, bought and slightly changed to be used as tangible input objects. The object for the third game is made out of polystyrene foam.

7.1.5 Evaluations

To see if the chosen games are promising enough, a recording is made explaining the games while playing them on the board. This recording is then sent to a therapist to see if the anticipated movements would be activated.

The next step in iterative design consists of doing several types of evaluative tests and improvements. A design technique similar to *Development panel* that was described in section 5.5 is used, a technique in which a group evaluates and gives feedback on a product, in this case ultimately both therapists and children. In this process stepwise inclusion of test participants from non-users towards end-users is done. So first an informative test with friends, roommates and family is used to find bugs and certain points which needed to be improved. Secondly, a pilot test is done at location to both test the test set-up and the games with the actual user group. A third set of tests is then done to improve the games and to get more insight into what elements make games fun for these users and their interaction with possibilities of the device. During this set of tests with children acknowledgement tokens are used when necessary to maintain natural flow of interaction and reduce influence of the facilitator being present. These tests at location also give an opportunity for the therapists to get active in the design. They can further specify their needs and propose improvements directly after the tests as they have seen children interacting with the games.

7.2 The games

Using the techniques from the previous section combined with requirements resulted in several ideas for three types of games:

- Training different grips and extension of the elbow
- Training dorsal flexion and extension of the elbow
- Training supination and pronation.

From each type a game is chosen, the description of the chosen games is given in this section. The choice is made by the designer individually based on the found interests, requirements and needs.

7.2.1 Different grips: the animal game

The first game is mainly triggering different grips. The game is based on an observed exercise in which small animal shaped toys have to be sorted according to commands given by the therapist. This exercise is chosen to use as inspiration because it is anticipated that different grips can be trained properly when using both lying and standing and both small and large animals. When objects are made somewhat instable it requires supination to get a good grip and when tumbled over put them back up again. Furthermore the liking of animals can motivate and bring joy.

Figure 7.1 Five animals, a grey elephant, a brown dog, a white cow, a pink pig and a bright green crocodile

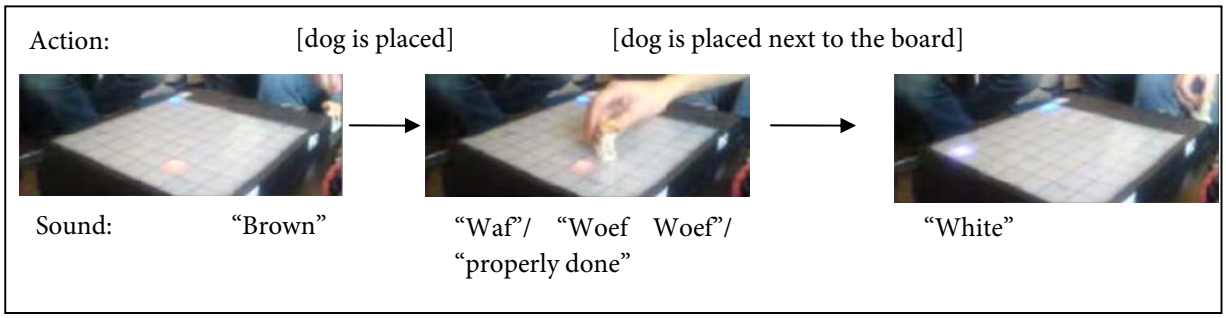

Figure 7.2 Explanation of animal game with actions and response sounds

The principle of the game is depicted in Figure 7.2. The game consists of five animals, shown in Figure 7.1, each has a unique colour. One of these colours is shown on the board on a certain position. The animal with the same colour has to be placed on this position. The colour is also pronounced to make it easier to identify it with the proper animal. The placement is rewarded by one of three sounds: the sound the animal makes, an imitation of the animal sound or a spoken reinforcing message in Dutch, for instance "Properly done, a cow!".

The animal then has to be placed next to the board, the light is dimmed and the next target illuminated. This is repeated until all five the animals are placed. It is then stated in Dutch that the child is doing good "Properly done, we are going to do that again". When a child places a wrong animal this is stated "That is not the right animal".

When the child takes long to place the right animal a first hint is given for example for a brown animal "Hum, which animal is brown?" followed after some seconds by "The doggy is brown". The animals are chosen such that it requires different grips. A small pig requires a different grip than a crocodile and to grasp a larger elephant again another grip is needed.

On the right side of the board the gathered points are tracked. For every correct animal a point is added per round. This also gives an indication when the round will be finished as the number of animals that has to be placed is known.

This animal game was chosen because it was clearly enjoyed by children to make animal sounds and hear another child making it. Also the broad variety of animal shapes could train the needed different grips in a quite natural way.

7.2.2 Dorsal flexion: the hitting game

The second mainly targets dorsal flexion. This game is inspired by the games "don't break the ice", whack the mole and the coloured hammer game developed in the previous research. These games were chosen to use as inspiration as compensation can easily be prevented by "forcing" the arm on the board and using the palm of the hand instead of a hammer to hit a target. The game is made more fun by playing simple sounds when a target is hit.

The game consists of a target, an illuminated square, which would jump to a new random place after some time. The process of the game is shown in Figure 7.3. The target has to be hit by the child to score a point and after hitting 16 targets the games is won. A glove is used to prevent compensation such as hitting by moving the entire arm up and down. This glove has two tags attached: one on the wrist and one on the palm of the hand.

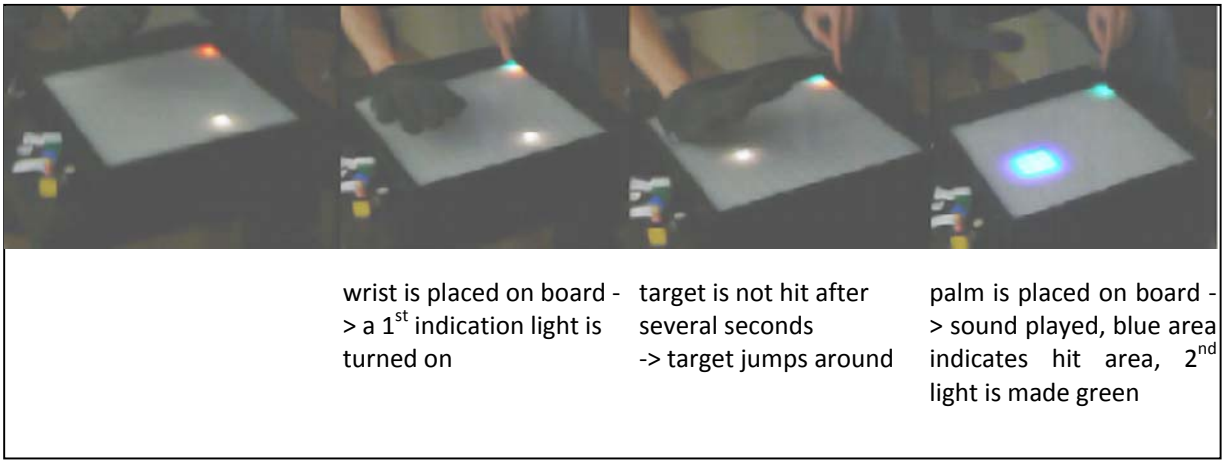

Figure 7.3 Explanation of game using screenshots of the hitting/glove game in practice

To make sure dorsal flexion is trained they have to keep their wrist on the board and then have to hit the square by putting down the palm of the hand. If the wrist is not on the board slightly before hitting the target feedback is given, "uh uh, keep your wrist on the board".

At the position where the palm of the hand is put down a blue square of 3x2 lights is drawn. It can be seen whether the target is hit in this way. When the target is hit this is followed by a sound and the target disappears and moments later it shows up somewhere else.

Two gloves can be used a small and a big one to make it suitable for the whole range of ages. On the side the score is tracked with a column of green lights. It can also be used to see when all the needed 16 targets/points are gathered. On the other side two lights show whether the wrist is on the board and if the target is hit.

This game was chosen because it seemed very likely to prevent any compensation and training the exactly wanted movement.

7.2.3 Supination & pronation: the pirate boat game

The third game mainly targets supination and pronation. This game is inspired by the exercise of putting puppets in and outside a pirate boat and by several games of shooting incoming targets. This is chosen as inspiration as it fits the metaphor of the pirates and playing with a boat was already seen to be liked by one of the children. When a big object is chosen that requires some extension of the fingers and has to be turned around it seems that compensating movements will be prevented.

The game consists of a pirate that has to be turned towards the targets. The process of the game is shown in Figure 7.4. These targets, called boats, are visualised by three lights moving towards the player. Only five targets are shown at a time each in a different colour, only one at a time at the same horizontal position. The targets slowly come towards the player and after two steps towards the player a new target is created on another place (in column of 3 LEDs) with another colour. When the boat is grasped from above and has to be turned supination and pronation are triggered. By making the pirate boat as wide as the grasp of the child and placing the board quite low some compensating movements can be prevented. The boat is equipped with two tags underneath, one in the front and one in the rear to detect where the player is pointing at. To visualise where the player is aiming at and what target(s) it hits, a red line in the longitudinal direction of the boat is illuminated on the board.

targets appear at the top and move down slowly

the boat is turned towards the targets → exploding sound plays, the targets disappear

Figure 7.4 Explanation of pirateboat/shooting game using screenshots with a spindle instead of the boat itself

The dimensions for the boat are based on the DINED (1-D data) anthropometry database from TU Delft (Steenbekkers, Molenbroek, Dirken and van Oekelen 1993). Based on personal anthropometry it is assumed that the dimension of the needed grasp is approximately 69% of the width from the extended finger dimension (145mm/210mm, dimension of extended fingers as seen in Figure 7.5). The idea is to create two boats one for the smaller and one for the larger older children.

7.3 Conclusion

Using the entire cooperative inquiry method seemed unsuitable. Some of the techniques and hints are used in combination with other techniques. The input of children is mainly given during an ethnographic study. Such a study seemed very useful with these children since it lead to direct validation and input for the design concepts in this case. A new method *acting out movements as a generative technique* that is a combination of informances, interaction relabeling and hands-only scenarios is successfully used as a brainstorm tool to come up with concepts for games. This version makes use of props laying around and making movements over and over again to inspire games making use of these movements. Being inspired by other games and currently available products in the sessions including a pirate-boat game, small toy animals, wooden puzzles and a marbles glide, old-brick computer games and more recent flash games was also found useful. Three concepts were generated. Special attention was given to preventing compensational movements. The liking of children hearing animal sounds was used for the first game. In this game a plastic toy animal has to be picked up and placed on an indicated spot after which the child gets to hear either an animal sound or a verbal reinforcement. The second game was inspired by the hammer game in which amongst others targets had to be hit. It uses a glove; the child has to hit a target on the board but has to keep his wrist on the board while doing this. The third game was inspired by an old low resolution computer games in which incoming targets had to be hit and a child liking a pirate boat. The game requires aiming a pirate boat into the direction of incoming ships blowing them away. These respectively aim to train: different grasps, dorsal flexion and supination.

Figure 7.5 Dimension for extended fingers

8. Evaluation of three tangible games for therapy

This chapter describes the set-up of the evaluation, the results and the changes made to the three games based on these results. It also describes the newly given insight into the fun of games.

8.1 Feedback on video by therapist

To get feedback from the therapist video prototyping was used, as is explained earlier in this report. The animal game was looking good and using the hint for the animal that has to be placed seemed nice according to the therapist. A suggestion was made by this therapist to create two types: one for children with good motor skills and one with easier shapes for the children with more severe damaged motor skills. The feedback on the game with the glove was that it had a nice control whether the wrist stays on the board. Whether the children are able to play the game or not had to be seen in the live tests. For the video a CD-spindle was used for the game with the boat. That object was regarded as improper. The child had to open his entire hand with all fingers extended (instead of only a grasp). The CD-spindle did not yet resemble the boat which had to be made at that time. The position of the board would be of importance whether the right movement is imposed.

8.2 Informal tests

The feedback from the therapist was quite positive. Now knowing that the games had some potential the games were developed and tested further. To find bugs and features which had to be improved; friends and family were asked regularly in the process to play the games. In total six students, two middle-aged and two elderly were asked for their opinion while playing the games. During these informal tests several things were found that could be improved. These were discussed afterwards resulting in possible suggestions. Some of the suggestions were put forward by the participants other by the evaluator. These points for improvement and or suggestions for the games are mentioned per game.

In general:

- The feedback should be slower and louder, maybe use a female voice.
- When winning a game nothing special happens, flickering lights on the border of the board could be nice to see.

In the animal game:

- The hint was given too early leading to frustration for some, the time span should be longer
- The hints were sometimes played at the same time as another sound, making it incomprehensible. One of the sounds should be stopped.
- The lights of the animal game would keep on after an animal was placed and removed, this made it harder to find the proper light to place the animal on. Instead the light could be turned off when the next one is turned on.

In the hitting game:

- It should be for both left and right handed persons, thus the tags should be easy to switch
- A suggestion was made to use new sounds after hitting a target in the game with the glove
- When using the glove the target was hard to see, when the only covering the target is enough this is easier. Thus the size of the blue area should be increased.

In the boat game:

- Hitting the targets in the boat game requested too precise aiming. Upon inspection this was found to be an error in the programming because anti-aliasing was used automatically for drawing a line on the board.

Thus giving different colour values than expected drawing an aliased line. Instead of checking if part of a target contains red, check if the colour of part of the target is changed.

All these problems were addressed using the mentioned suggestion, with exception of the use of a female voice instead of the voice of the designer itself. This was not incorporated because it would cost quite some time to get all the new voice recordings and the person stating the problem had a known hearing problem. To fix the accuracy problem for hitting a target with the glove a more tolerant area of 3x3 squares was used instead of 3x2. To let the users understand what was said during a hint a simple solution was implemented: play the hint again after a certain amount of seconds and when another sound is played, stop playing the hint.

8.3 Game design variables

To gain better insight in what makes games fun for this target group some parts of the games were changed. The anticipated test consists of comparing two types of three games. Once the original version of the games is played and once an altered version to test the effects of a certain part/mechanism of a game. These altered parts are following from questions that arose during reading literature about games with children; these were reduced to three variables that could help in improving the games. The three variables and resulting differences in the game can be seen in Table 3 and will be explained in this section.

8.3.1 Sound

The first variable that is looked into is sound. Malone(1982) found a positive effect of sound on preference and when only looking at the girls a positive effect of elongating duration of playing. However this was found during a time, the early 80s, in which games with sound were something new and with children from a different age group, children from the fifth grade thus about ten/eleven years old. Such a novelty, for example nowadays using the WiiBoard as a pointing device or use of simple animations back then, is suggested as an addition on the perceived fun factor on its own (Malone and Lepper 1987; Fikkert, Hoeijmakers, van der Vet and Nijholt 2010).

One game was used to test if merely this novelty factor of sound and or the age group had influenced the positive outcome of sound in Malone's research. The game with the glove had a version with sound effect upon hitting a target and a version without sound.

8.3.2 Challenge by difficulty and possibility of loosing

In all the three games one could not loose, this was done to give a feeling of success without the chance of failing. This group of children might be more devastated by a negative outcome than other target groups, because of a possible lower self-esteem. But this might result in a lack of challenge. This tension was already stressed by Malone&Lepper(1987), stating that a growth in self-esteem should be encouraged by giving the idea of competence while at the same time keeping clear feedback.

From a cognitive evaluation theory perspective, intrinsic motivation can be affected by feelings of competence, where decreasing perception of competence would lead to diminished intrinsic motivation(Eisenberger and Cameron 1996). Some researchers also link the fun or urge to play games to a feeling of successively mastering parts and the use of save features which minimise the cognitive regret incurred by losing (Malone 1982; King, Delfabbro and Griffiths 2009). Flow, which occurs in a state of high challenge and skill, can also influence the experience of an activity such as the satisfaction(Csikszentmihalyi and LeFevre 1989). In short overcoming a difficult task with a chance of failure can be more fun or motivating to play.

It was thus not known what would work better:

- A game that becomes more and more difficult in which one could lose but upon winning has a bigger gain in feeling of competence or
- A game in which one is less challenged with a lower growth of competence but where one is easier to find success.

When children would react strongly on loosing this should be circumvented but when children are eager to play again or react neutral it is possible to incorporate this kind of challenge in new generation of games.

Table 3 The difference in the altered version of games

Variable			Game	Description	
				Normal version	Altered version
.1	Sounds played		Hitting with glove	After a target is hit one of ten random sounds is played	After a target is hit no sound is played
.2	Challenge	Difficulty	Pirate boat game	Targets follow each other up every x seconds when the targets have moved two blocks down	Every time a target is hit the targets will follow each other in increasing speed . The blocks thus move down faster at the end of the game.
		Ending		When blocks approach the bottom they disappear and their colour and position can be used for a new target	Once a target reaches the bottom it is *Game Over*, the border would flash red for some time. In a later version a message is also added in Dutch stating "Too bad, you have lost"
.3	Inter-personal competition	Competitive objective	Animals game	At the start of the game it is explained that the animal has to be placed on the lightened square	Besides the normal explanation it is also stated that the player should try to do this as fast as possible, try not to make any mistakes and afterwards you will see if you were the best
		Feedback on high scores		When finished setting all the five animals on the board it is stated in Dutch "well done, let's do that again"	When a round is finished the results are compared to earlier results from the other players and in the second round the results of the first round. Depending on the speed, number of errors and points, feedback is given. For example: "Good, you gained the most points and were the fastest and now try to make even less mistakes."

To test this variable the boat game was created with a version in which the targets would follow up quite slow in the beginning but more rapid in the end of the game. This is done in such a way that the total amount of game play remains about the same, as can be seen in Figure 8.1. Another addition in this version is when a boat reached the bottom of the board the player had lost and the game would stop. The fastest time was expected to be still in reach of the children, but should lead to a big enough difficulty difference.

8.3.3 Competition by feedback on high scores as a performance-dependent verbal reward

In the beginning of the project the analyses of competition and collaboration in games was seen as possible research topic. Unfortunately the board was quite small and is perceived as unsuitable in this context for playing games with multiple players at a time. Some games that cannot be played by multiple players at once still have competitive elements.

For instance it was found by Malone's survey that games with points were preferred but no significant effects were seen in duration of play when adding score-keeping (Malone 1981; Malone 1982). Many games keep track of a high score to generate a type of competition without another player playing at the same time.

The use of verbal reinforcement in the animal game "Properly done, we are going to do that again" & "Properly done, a cow!", can be seen as a verbal reward. Although results of studies on these kinds of rewards are not univocal, some studies indicate that such rewards might already lead to higher effort on the rewarded performance dimension(Eisenberger and Cameron 1996). In the normal version of the game the reward was completion-dependent. To test the usage of competition by feedback, a performance-dependent verbal reward is given in another version of the game. A version of the animal game is created in which the time, errors and points of one round are recorded. When the child has finished placing and removing the five animals he/she will hear that he/she was the fastest, scored the most points or made the least mistakes. This was done again after finishing the second round.
A point is given for every animal that is placed unless it was stated which animal should be placed and the child still put on the wrong animal. An error-point is given whenever a wrong animal is placed. To make the child

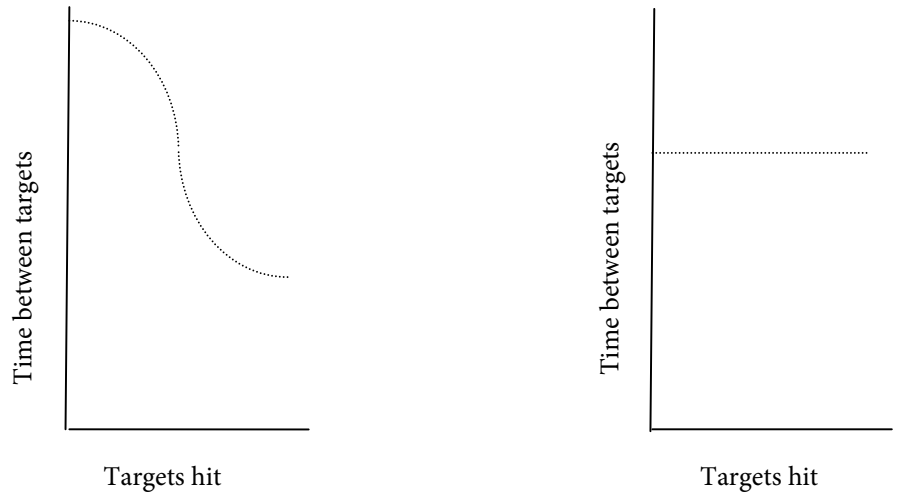

Figure 8.1 The tempo of targets appearing is kept constant for normal version but s-shaped for the other version

aware of these features this is added to the instruction: "Try to do this as fast as possible, try not to make any mistakes and afterwards you will see if you were the best." When a child did not succeed in one of those objectives, for example when he/she isn't the fastest, the child will hear: "Well done, you scored the most points and made the least mistakes and now try to do it even faster this time". This is thus a type of performance-dependent verbal reward, which hypothetically could result in improved performance times.

8.4 Experiment design

8.4.1 Test set up

A pilot is done to test the test and if needed improve the set-up as well as the game. The test set up is therefore slightly different for the pilot as it is for the first more formal test with children. The improvements for the set-up based on the results of this pilot are already included within this section.

The designer being the facilitator during the tests is also present at the start of the therapy session. In this way the children would get somewhat acquainted already and it could make the test less frightening later on. During this start of the therapy session the facilitator is introduced by a therapist. After which the facilitator shortly explained the purpose of the test "we are going to play some games to see if we can make it better and more fun to play for other children".

The tests are done in a separate room outside the normal session environment. This keeps the extraneous variables more constant and distraction of other children to a minimum. The individual guiding therapist is also present during the test to make it more comfortable for the children. This was not yet the case for the pilot. The test with the first child in the pilot was done in the same room where the rest of the children were at that time. As a casual environment could be beneficial for the given amount of input by the child (Alborzi et al. 2000). However, the sound played through speakers distracted the other children in the room.

The board is placed with the cables away from the child. In the pilot the board was first placed with the cables towards the child to make the amount of extension of the elbow as big as possible. However the cables of the game were accidently unplugged by a child in the pilot. During another game in the pilot a child had a hard time to reach the end of the board.

The order in which the games are played is either the altered versions first (animal game with feedback or pirate boat game with high score) or the normal versions first. Kids in the test will play either:

A. The hitting game, the animal game without feedback followed by the pirate boat game without the possibility of losing or
B. The hitting game, the animal game with feedback on high scores followed by the pirate boat game with more challenge by difficulty.

The pilot was done with six children, the tests were done with nine children in total from whom four children played different versions of a game twice. In total three test sessions and the pilot are done.

After the pilot the sound variable is omitted to look into. The pilot results already strongly indicated sound was essential for the fun in the games and that the novelty factor was not essential herein. This choice also had to with a non-performed but planned switch from within user to between user testing after the pilot. As between user testing would make it impossible to ask for which version was liked more. Sound was instead only investigated by looking if smiling or grinning occurred when a sound was played.

The first group in the test has three children playing the normal version first and one child playing the B-version first. In the second group three children thus played the B-version first and only one the normal version.

The explanation of the game is included in the game this is automatically played when the game is started. This is done as it is hard to give the exact same explanation and otherwise felt awkward to read out loud the introduction about the games.

Before a test is started the child is encouraged to give feedback "When you find something fun, stupid or you don't understand what you have to do or find it frightening or hard try to say this. Then I will know what has to be changed and make it more fun game for other children." During the test itself the children are not constantly prompted to talk out loud. Non-intrusive backchannel techniques are used (e.g. "*hmm hmm*", *"oh I see"*, *"ok"*) when expected by the children. Explanations or answers during the tests are only given when a question about the game or test is asked directly and needs to be answered to continue the game.

In-between tests notes are taken of observations. Notes are not taken during the test as it seemed to be too distracting during the pilot.

All the sessions in the second and third test are recorded with video. In this way response to certain parts of the games can better be analysed. The camera is placed in such a way that it is not directly visible for the children. Turning it on is done while starting the game on a laptop close to that position thus children are less likely to be influenced by the recordings. During the pilot only some video recordings were made by a therapist when he was present.

After all the games are played a short conversation is done with one of the therapists to give feedback on whether the movements were appropriate and what could have been improved. Directly after all games are tested the participating child is also asked several questions:

- his/her age,
- which game he/she would like to play again if,
- which game he/she would not like to play anymore
- what was liked and disliked about these games
- if there was time left what computer games he/she liked to play at home and what board games.

8.4.2 Expectations and measurements

The expectations for the pilot are similar to that of the actual test. Instead of analysing the results of the pilot on the expectations; focus was put on finding problems in the test set-up and the design.

No expectations existed for which game will be liked. To know which game is liked the question "What game would you like to play again?" is asked. For disliking the question is "What game would you not like to play again?".

The variable sound is investigated in another way as only one version with sound remained. However it is expected that a majority of the children will like the game and thus smile upon hearing a sound in the hitting game. This will be analysed by looking if grinning or smiling occurs upon hearing a sound in the hitting game. Another way this is tested is by asking the children which parts of the game were fun. It is expected that sound will be named by the children as a fun part.

Figure 8.2 Example of proud stance, similar to body language witnessed during the test

The animal game is used to test the variable of individual competition using high scores. The expectation is that children will be more motivated to improve their performance upon hearing how they performed in time and score. Thus a reduction of time needed to complete a round and errors made will be expected for the second round. This difference is expected to be the effect of hearing the feedback. It is expected that there is a difference between the two versions of the game in increase between the two rounds of speed and correctness. The difference 2nd round – 1st round in the A-version is expected to be smaller than this difference in the B-version. This might also be big enough to generate a difference in average time over the two rounds between the two versions. This difference is indeed expected to be still significantly faster, a one-tailed paired sample t-test will be used for testing both expectations.

An order effect could be present as children would learn how to play a game. However this order difference is not expected here as there is a two week period between the two tests. To test this an independent t-test is done on the difference in time. The time difference is taken between playing the first round at the first time and playing the first round during the second time. It is thus expected that there will be no decrease in time between first and third played round. A paired sample t-test will be done on whether the first round from the first time is significantly slower than the first round from the second time it is played.

It is expected that the children will like the high score feature. To this end children are asked which parts of the game are liked. It is expected that children will mention the high score as liked part. A second measure is observing the children's reaction upon hearing their score and resulting behaviour. A response is expected from the children upon hearing their score.

The pirate boat game is used to analyse response on challenge by difficulty and possibility of losing during the game. It is expected that children will like the increasing difficulty of the pirate boat game. Also for this end the children are asked what parts of the games they liked. It is expected that this will be mentioned several times. Also the opportunity was given to state what was disliked. To see if loosing is unsuitable for this group; their response upon loosing will be observed. It is expected that no crying, screaming or aggressiveness towards the game or therapist will be observed. A base-line (the A-version) is used to exclude that the game itself instead of the loosing/challenge could be the reason for this kind of behaviour.

It is expected that the games can be played by all ages. None or only a slight but non-significant ($p<0.05$) trend in time needed to complete the games per age is expected. This is tested using an independent two sample t-test on the time needed to complete the hitting game over the different age groups. The first time that the hitting game is played is not yet influenced by the version. Due to the interaction of both age and version played first it is tricky to do a test on age for the animal game. The first attempt is used to analyse this possible effect. As the time needed for the first attempt is expected to be less influenced by the version. It is also tested with an independent two sample t-test on the time needed to complete the round between the different age groups.

It is expected that the games will train the proper movements with exception of supination. This will be asked to the therapist(s) in a short conversation after the sessions. Supination is no longer trained due to needed changes to the boat game upon the pilot.

The pirate boat game is changed after the first session because it was too hard to handle. It was expected before the second test that this change would increase the amount of measured movements per participant significantly. This is tested using a paired sample t-test. It is assumed herein that the difference between A-version and B-version did not play a role. Because in both games the same amount of targets has to be hit.

The time needed to finish (a round of) a game, the made errors and the number of movements for the boat game were automatically logged.

8.4.3 Pilot

Results pilot

In total six children, ranging from 4 years to 6 years, 3 boys and 3 girls, played the games on the board. Only the first two children played all the versions. Because the test took much longer than expected; which also resulted in a reduced interview for most of the children.

The game with the boat was not working properly because the children could not grasp around the boat. The fifth percentile of a five year old was taken of the dimension of extended fingers and it was therefore assumed that a 4 year old child would also be able to grasp this. However the children were not able to make the extension of the fingers and even when some extension could be made the boat was still too big. Therefore no supination could be trained with these games. To test the game play the children were allowed to grab the boat at the end with both hands to turn it. Although the instruction was given that they had to keep the boat somewhat beneath the middle of the board, some children moved the boat towards the targets instead of turning it. The children losing a game were not really reacting to this. It seemed as if they did not notice it as losing the game.

The game with the glove was not working in it is current form. The small glove was too small for some children wearing a splint around their wrist. The big glove was too big. Another problem was that only one of the children could make the needed extent of dorsal flexion. Others could not raise their palm high enough to get the tag outside the detection field. The game was changed on advice of a therapist to using a tape of Velcro with the tag fastened on it. The wrist tag was put on the board all the time when a child could not make the extent of dorsal flexion needed. In this way the last three children could play the game as the game with glove did not work. The game now still trained extension of the elbow but less of dorsal flexion. The game itself was understood and enjoyed by all the children with smiling upon hearing a sound. The version without sound seemed to be enjoyed much less and the feedback whether a target was hit or not was sometimes unclear without the sound. Some children were hitting the score instead of the target at first, no one tried to hit the two indication lights.

The animals game did succeed in requiring different grasps. The sounds of the animals were often followed by a smile. The rules of the game were understood. The response on the given feedback was not recognisable by most participants, but by one it was clearly seen. Upon hearing that he received the most points he raised his shoulders and pressed his chest forward, similar to Figure 8.2[ii]. As was the case in the hitting game one child misunderstood the score lights. She thought that the blue score lights was where she should put down the animal, the elephant in this case.

Some children while placing the animal next to the board touched the board with the animal. This resulted in a response of the system playing the statement “that is not the correct animal”. This resulted in some confusion in these sessions. It was also unclear in the first place that animals had to be put next to the board to continue

the game. The actual number of made mistakes is low but some of mistakes were logged wrongfully as the animal touched the board on its way off the board as stated before. In the observations only once it was clear that a child really made a mistake by placing the wrong animal.

During the last three games four different therapists were shortly present to look at the games. They gave positive feedback stating that the games seemed promising.

In a short conversation with a therapist after the tests some issues were clarified and some positive points of the games were highlighted. In the animals game sometimes it took longer when a child had to find a crocodile from the hint green opposed for instance after the hint pink for the pig. The therapist was present during the session in which the mistake was made and observed the child taking the wrong animal. According to the therapist the linking of colour to an animal was quite cognitively challenging. Especially when an animal was greenish, see Figure 8.5, instead of the typical bright green or when the lights would not be the exact same colour it could be hard. According to the therapist sounds that were quite extreme seem to lead to more positive reactions and enjoyment. He suggested that the sounds should be made more like the extremer sounds for instance that of the crocodile.

The therapist did not see the pirateboat game during play but given the description a change of width could indeed lead to the training of supination. The game with the glove was simple but still amusing and trained some wanted movements. The hitting game in its full extend was expected to be playable only by a few, approximately the best 5-10%, as the extension needed was quite big.

Discussion pilot

Following from the results some changes were made to the set-up as has been discussed. Also some changes had to be made to the games. These will be discussed here.

To prevent the movement instead of turning of the boat a rectangle is drawn on the board with a whiteboard marker. When the boat is outside this area the red line will disappear. In this way children are prevented from moving the boat all over the board. To make the boat graspable and rotatable the width for the smaller boat is reduced by 25mm. This makes the boat smaller than the 69% (fracture of grasp dimension/ extended finger dimension) of the 5th percentile of hand length from 2-3y Dutch children, which is 93mm: *93mm*0.69= 64mm*. The first boat measured 80mm; the width of the new boat is 55mm in width. This is even similar to the 5th percentile of the circumference grasp from 2-3y olds which is 58mm; see Figure 8.3 (Steenbekkers et al. 1993). To have a usable back-up, a mast was placed on the big boat with a width of 25mm which should make circumference grasp possible. The game could then be used to train dorsal flexion instead of supination.

To prevent the problem with the colour recognition the crocodile was replaced with another one having a brighter green colour, as was already depicted in Figure 7.1.

During the hitting game a girl made the remark that a target was orange instead of yellow at a particular place. The instruction was given at the start of the game to hit the yellow lights. An additional test is done to see how every square on the board emitted all of the possible colours. This test was done based on the RGB-value controlled colours of the board. Using 16 squares to represent the values 0-255 from green horizontally and blue vertically. Every 2 seconds the red values increased in 16 steps towards a red value of 255. This showed that the colours are slightly off between squares especially when using mixed colours the colours were not as uniform as they should be. It also showed that one square had a broken red

Figure 8.3 Circumference grasp

LED. This could lead to possible problems when a pure red light would show on it. This would however not occur in the current games. The targets in the hitting game were depicted as yellow and only changed colour slightly so no extra precautions were taken.

The score was kept with blue/green squares lighten at the side. To prevent children from thinking the lights are targets, 16 inverted black stars were drawn on the board with a whiteboard marker, see Figure 8.4. This is similar to the score used by the Bobo game described in section 3.3.2. Black squares were used, as black would block light better, from which the star-shaped middle was not inked. To make it harder to wipe away, but still removable, see-through tape was placed on top of it.

Figure 8.4 A new way of showing gathered points using stars

All the games had to be mirrored as the board is turned around for the next test.

The tests took too long and therefore should be significantly shortened. Concluding from this pilot test, although not enough data is available for proper analyses, it can be assumed that sound in games is still contributing to fun in large amounts. As it was seen that all the participants enjoyed the sound, this variable is no longer tested with two versions instead simply observing reaction on sounds could lead to enough qualitative evidence. The starting of the games took some time; it was tested later on if this could be changed. Using a shortcut on the desktop to the already compiled games sped things up significantly compared to using the terminal for compiling and running.

The time needed per child per session should be shortened by more than 50%. When an animal is not placed next to the board an instruction is given which also reduces the time needed. It seemed to be appropriate to reduce the amount of games played per session from five/six to three, thus either change from within-user to between-user testing or divide the tests over two sessions. After the first test it is however stated that the group is available for another test thus within-user test is chosen again as results were expected to be depending heavily on individual users. For the second test group the second part of the in-between user test was unfortunately ultimately omitted as there were two too young children and only one representative participant in that group. Losing in the game with the boat is made more extreme because children did not always made notice of it. In this version they would see a red flashing border and hear a Dutch translation of “Too bad you have lost.”. Because this might possibly lead to unwanted extreme emotions this game is played last. This would prevent losing data of playing the other games and give room to directly comfort the child if needed. The game hitting targets can be seen as the easiest and could gain some familiarity with the board making the animals game easier to play. Thus the new order would be the hitting game, the animal game and then the pirate boat game either with normal versions or with the altered versions of the animal game and pirate boat game. The introduction of the game was awkward to give thus this was now recorded and played automatically when starting the game.

Figure 8.5 Greenish crocodile used in the pilot

The results of these tests were presented for the consortium of WikiTherapist. WikiTherapist is a consortium performing research which aims to improve end-user development in a health care setting, amongst other using the TagTile for children with CP and adults who had a stroke or a Traumatic Brain Injury. These adults can show similar physical difficulties. During the discussion it was questioned whether wrong movements could be trained with these games. The practitioner questioning this, worked with TBI patients which undergo similar therapy. The general conclusion was that movements can only be tracked up to a certain level, how higher this level how harder to design and implement such a game but the easier it is for the therapists. For instance the grasping of the animal was sometimes combined with palmair flexion while this leads to weaker grip and thus should be inhibited for training. This possibility of training compensating movements also makes it less suitable for individual play, as there would be no therapist to correct the child from compensating.

Changes in the games based on the pilot

The differences in the games based on the pilot are:

- A more bright green and slightly squeezable crocodile is used.
- The instruction that the animal has to be put next to the board is made more clear in the introduction and a hint is included in the game when an animal is not put away fast enough.
- Stars are drawn at the border to clarify the points opposed to targets.
- The red line is removed when the boat is placed outside the drawn border.
- Another pirate boat is made almost twice as small in width 55mm, see Figure 8.6.
- On the original boat (80mm) a mast is attached (25mm) to function as a back-up, see Figure 8.6.
- A rectangle is drawn on the board to show where the pirateboat may be used.
- When a child looses this game not only the border of the board flickers red but also a voice would state the Dutch translation of "Too bad you have lost.".
- The glove is no longer used, instead a small Velcro band with a tag only on the palm is used.
- The board is turned around with cables away from the children (and thus all the games are mirrored).
- Included is a spoken explanation in the games which is started when a 'starting block' is placed.
- The pirate boat game still wasn't good enough for proper testing in the first test. To make it better playable but without influencing the set of games and game self too much a plate is glued to the bottom to make it more stable. In this way it is harder to tumble sideways. The mast has also been placed towards the middle in this way the wrist is put on the boat itself. This also makes it harder to accidently tumble the boat backwards.

Conclusion pilot

Performing the pilot test had serious benefits in finding problems in the experiment design and game design. The games should be tested in an altered set-up, mainly because it would take more than the available time free in one afternoon to do all these tests with all the children. The current use of the glove itself was not

Figure 8.6 3D-model of new version of boat, realisation of boat and the photo of changed boat (the one used in the tests)

satisfactory. Dorsal flexion would be trained in a less extend with the new alternative in which it is no longer needed to keep the wrist on the board. With a working version of the boat game, all the games combined would train all the proper to be trained movements in some extend. The children seemed to enjoy the games. Sound still seems to be essential in the fun factor of the games. What kind of ending is most suitable and if a high score is extra motivating has to be concluded from the tests.

8.4.4 Results of testing TagTile games for therapy and features of fun in these games

Participants Three test sessions were done, twice with the same group. In total 9 children participated in these tests (another 6 in the pilot). Four children participated in both the first and second test session; three girls from which two were 9 years old the third 8 years old and one 8 year old boy. Three of those participants played the standard (A) version first. This asymmetric division was due to one shy child which unexpectedly refused to participate in the first test. In the second test the girl (8y) that refused to play the first time did participate. In the third test this asymmetric division was mirrored three playing the B version, one playing the A-version. The children from the third session, three girls and one boy, were younger; in the range of 2.5 years to 5 years old (5y,m; 2,5y,f; 3y,f; 5y,f in participant order). One child present in the therapy at the start of the third session was unsuitable for participating in the test. He was crying constantly and seemed to be very homesick. This combination made it unadvisable to do a test with him. According to the therapists present such an extreme case had not been seen before. The first participant of the third test session (participant 12) did not have brain damage but a severe shoulder injury. He shared many of the symptoms in motor skill with CP patients.

The start of the games was significantly sped up improving the timing of the entire session, an entire session including interviews took about 20 minutes.

The first two participants were used to test to grasp around the new pirateboat before playing the game. They could not perform this grasp thus the back-up original boat with mast was used for all children in all sessions. This was still a hard training because of the limited capability of dorsal flexion. To make it playable the board was rotated in plane in a range of 0-45 degrees according to the maximum dorsal flexion the child could make.

Preferred games The most preferred games were the hitting game and animal game (both 4x). The youngest participant preferred the boat game. According to the interview (when hinted by the present therapist) this was because of the attractive tangible object. The boat game was disliked four times, two times the animal game was disliked and once the hitting game was disliked.

Positive& Negative points The younger children of the third session did not give much feedback in the interview (avg. 1,25 positive &negative answers) compared to the older children (avg. 2,8). For positive elements besides the mentioned boat, once the placing of animals and once the easiness of the animal and hitting game was mentioned. Hitting the board itself was mentioned by four of the older participants as a fun thing to do from the hitting game. The (funny) sounds were also mentioned by them as a positive element in the hitting game (2x) and the animal game(2x). Lights itself were also mentioned twice as positive for the hitting game.

Negative points were that it was too difficult to aim and turn the boat (3x, twice after the B-version once after A-version, all unique participants). A boy (8y) from the older group disliked the animal game because it was too easy. Once the crocodile was mentioned as scary (this was hinted by the therapist that was present).

Losing the pirate boat game Two older girls both smiled upon losing the B-version pirate boat game after seeing the red light and hearing that they had lost. In the interview they both stated they disliked the game, they

disliked that it was so difficult to aim in the good direction. The other children also had significant problems properly aiming. Also the youngest child that participated showed no visible or audible cues upon loosing the game. Another girl (p9) looked at the facilitator upon loosing and smiled shortly after when asked by the present therapist if she also saw the "boats".

Winning the pirate boat game One girl (p7) laughed out loud upon winning the pirate boat game A-version after having lost the B-version in her first session.

Therapist conversations After a session a short conversation with a therapist was held. The latter was present during two sessions. One of the therapists stated that the hitting game still trained dorsal flexion in some extent and elbow extension, the animal game properly trained several grasps. The games could be played in quite a tempo and that this tempo was faster when the child was succeeding was nice to see. The animal game could be improved by using different size and weight of animals which were present at the clinic. The pirate boat game was not functioning to train supination which was thus missing from the set of movements that were trained. A suggestion was made to enlarge the amount of dorsal flexion by playing the hitting game with the board in an upright position. To actually get the board used at the clinic a proper manual should be written with a few simple to-do steps. This manual can be found in Appendix D.

In the conversation with a therapist after the first session was stated that the instability of the boat is problematic. The movement of palmair flexion is slightly coupled to pronation which sometimes makes the boat tumble; thus non-recognisable for the system. In one session a participant was helped by the therapist during the game to feel if the proper movements and muscles were trained. It did trigger this according to the therapist. A suggestion was given by this therapist to improve the game, making the boat heavier and more stable could give enough resistance to the pronation and palmair flexion and still train dorsal flexion. He liked the idea of the pirate boat game. It is less childish than the most games that were played.

Improved pirate boat This improved stability was implemented with a plate glued underneath the boat. During the pirate boat game less mistakes and tumbling were indeed made in the second session compared to the first session. A one-tailed paired sample t-test indeed showed significant higher number of identified movements $p<0.05$ ($n=4$, $\mu_{diff}=28$ more movement, $\sigma_{diff}= 15.23$ movements). The girl that played the alternative version first is also included herein, all four participants that played the game with both versions showed more movements.

Order effect A one-tailed paired sample t-test failed to show ($p>0.05$) an order effect in the animals game, thus no significant effect between the first and third round in the animals game was seen.

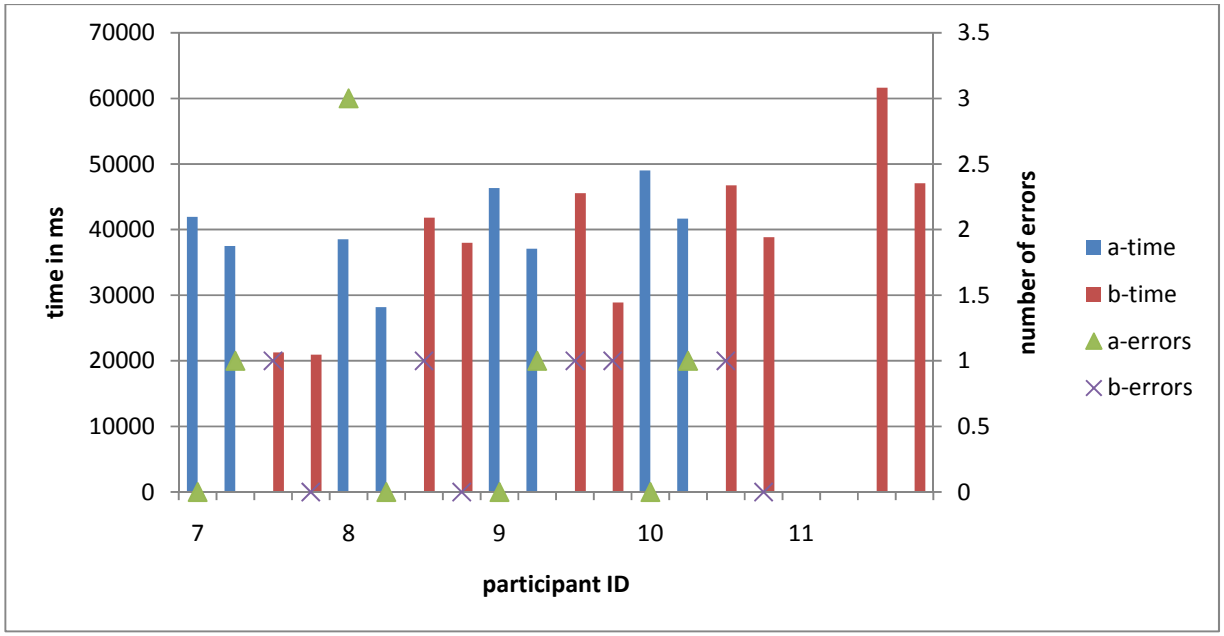

Figure 8.7 Bar chart showing time and error results for the animal game in the first and second session. It contains the data for in-user comparison from the 8/9 year olds

Increase of decrease in time and errors Assuming there is indeed no difference in this order all results of the four participants that played with both versions are used to analyse the difference between the A and the B version. These results can be seen in Figure 8.7. The difference from A-version and B-version(pairs) over the increase in time between the two rounds is taken as measurement. A one-tailed paired sample t-test failed to show a significant effect ($p>0.05$) in time improvement in the animals game between the versions. A one-tailed t-test also fails to show ($p>0.05$) a difference (A vs B) in the average over the rounds. A similar test also shows no significant effect on the number of errors. The difference in age (next in this section) seems to make a full between-user comparison on the two versions unjustified. In Figure 8.9 it can be seen that two very young (P13&P14) children have a similar time needed to complete the game. This is much longer than the nine year olds. When only including the five year olds as there was no effect found between those groups (8/9y – 5y), it does not show a significant difference ($p>0.05$) in increase of decrease in time or in the average time needed to complete the animal game.

Age and time This is compared using the first attempt for the animal game. An independent two sample t-test showed a significant effect ($p<0.001$) of time needed to finish the animal game in their first attempt between the groups of eight/nine year olds (n=5) and two/three years olds (n=2) and ($p<0.001$) for the group >4 years old (n=7) compared to two/three year olds. No difference ($p>0.05$) was found between nine and five year olds or between eight/nine years old and <6 year old. The results can be seen in Figure 8.9

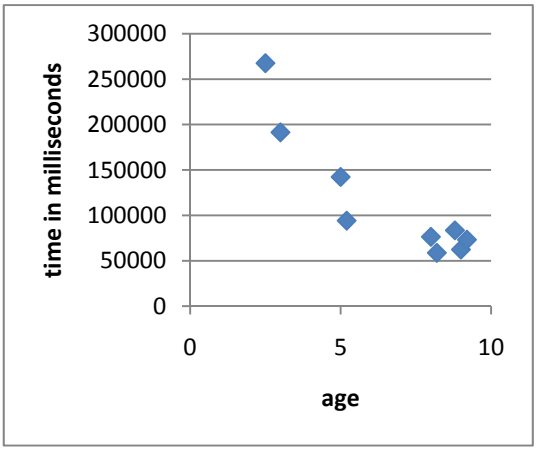

Figure 8.8 Time needed to complete the first played hitting game. Small age differences are used to show all data clearly

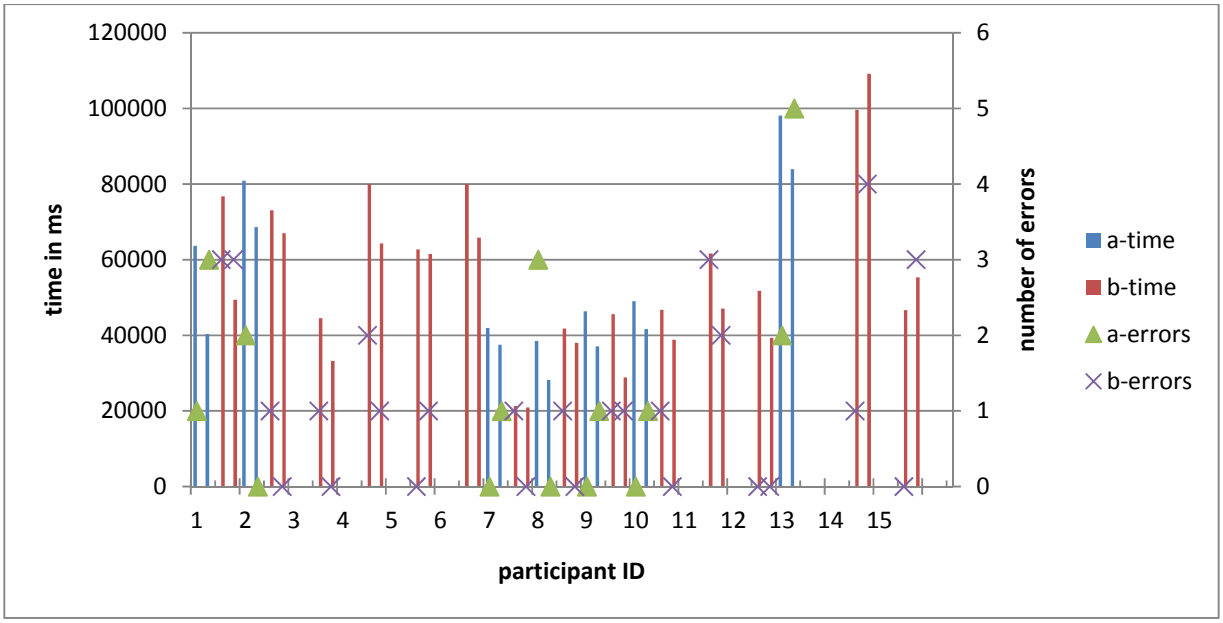

Figure 8.9 Bar chart of the time players in the first test needed to finish the two types of animal game and the number of errors they made. Results of both rounds and versions (when available) are shown per person. Participant 8 and 11 played the b-version first. Participant 1-6 played the game in the pilot. P7-11 are 8/9 years old P12 and P15 are 5 years old, P13 is 3years and P14 is 2.5 years.

For the hitting game an independent two sample t-test between ages 8/9 and <6 showed a significant effect ($p<0.05$). As well as a significant ($p<0.001$) difference between >4 and <4, a significant difference ($p<0.05$) between age 8/9 and 5 and a significant difference ($p<0.001$) between 8/9 and 2/3 was found. The test failed to show a significant difference between 5 and 2/3 years old. The time needed to play the hitting game can be seen in Figure 8.8.

Age and playability The second youngest child needed assistance for hitting the first target in the hitting game and needed her arm to be put away from the board between appearing targets. In the animal game the right animal had to be put in her hand or a hint about the right animal had to be given.

She let the animal loose and hit the light as if she was still playing the hitting game. The pirate game was played together with the therapist but even in this way she could not understand and play the game. Similar problems occurred with the youngest child. She had to be pointed often where the target was in order to keep her attention and continuing the game. She was easily distracted by sounds outside the room on the corridor. During the animal game the animals either had to be pointed out or handed to her. She did smile on several occasions, which didn't happen at the hitting game. Twice she smiled when it was stated that it was not the correct animal. This happened when the previous animal was put off the board and accidently touched the board again. This was a problem that occurred by other participants as well. Several times she had a difficult time placing the animal upright on its pedestal. During the pirate boat game she was moving over the entire board instead of turning thus losing the game quite fast.

During the second session the second youngest child showed clear use of palmair flexion when placing some of the animals. The youngest however did perform a proper grasp and placement on by herself, see Figure 8.10.

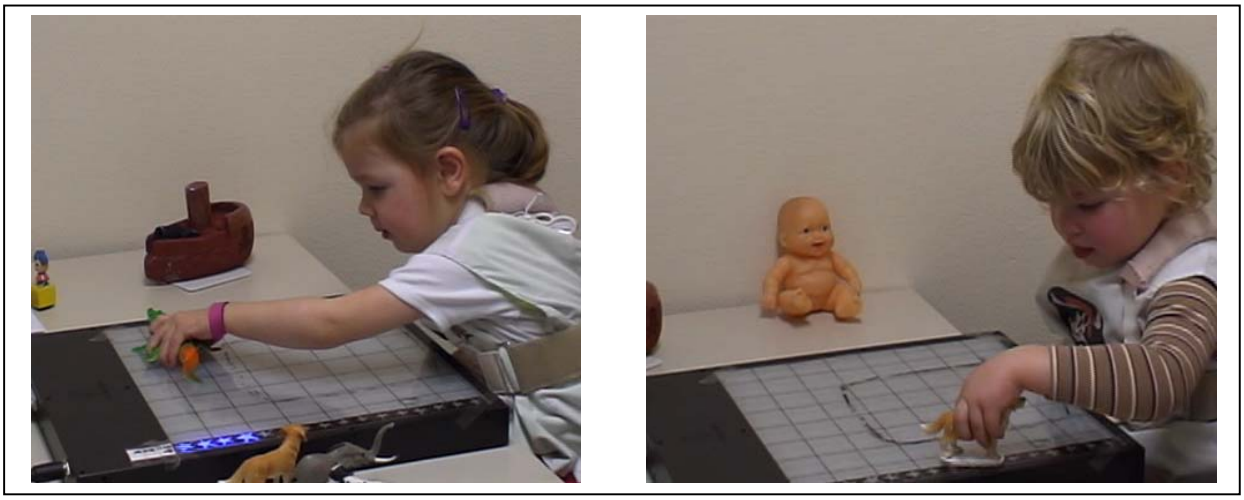

Figure 8.10 Movements of participants in the animal game. Wanted extension of elbow and fingers (L) and unwanted grasp using palmair flexion and no extension of the fingers or elbow (R)

Smiles and sounds Video analysis showed that 6 out of 9 smiled or grinned upon hearing a sound for the first or second time in the hitting game, see Figure 8.11. Some animal sounds such as the snoring pig also resulted in smiling (e.g. P12).

Hearing introduction twice During one test the pirate boat game stopped responding. The game was restart and the participant smiled somewhat sarcastically when hearing the introduction of the game again.

Reaction upon hearing the high score Most of the participants did not show any response upon hearing the feedback. P7 sighed deeply and turned with her chair from left to right. P9 stated afterwards he found the animal game too simplistic. P11 did not show a direct response but after being tapped on the shoulder by the therapist she grinned. P12 grinned both after the first and second round after hearing he was the fastest, made the least mistakes, scored most points and was doing good. P8 playing the B-version was not captured on video. After completing the A-version she did smile when seeing the blinking lights. Several other participants playing the B-version also gazed at the blinking green lights upon finishing the game. P13 did not show any reaction finishing the A-version game.

8.5 Discussion of the three tests

Participants and age In the third test the games were played with two very young children, 2 ½ and 3 years old. This made that those two participants were unable to play the animal game and pirate boat game entirely on their own. The validity of recorded times used is thus somewhat doubtful (participant 13&14) as the facilitator or therapist had to influence the test directly. The children in the first and second group were slightly older (8y/9y) than in a normal Piratengroep. Thus the cognitive skills were more developed making it easier for the children to play the games.

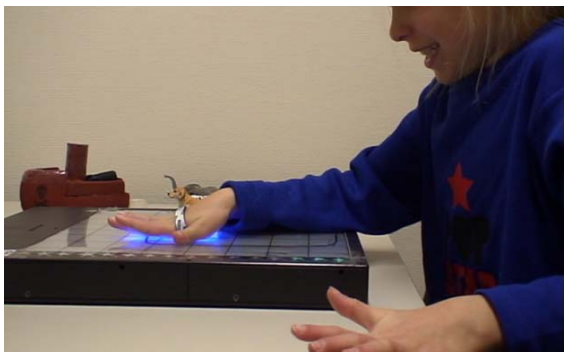

Figure 8.11 Participant smiling during the hitting game

Changes in set-up After the first test it became clear that the original planning of return sessions was altered. The group had not participated in a previous Piratengroep, made use of a new metaphor called Popstars instead of Piratengroep and would also be replacing the next return

group. A change in the test set-up was already made based on between-user testing as this would have been more suitable in the expected return session. The two most important changes were no longer asking preferences for version of a game and only testing one type of hitting game. This seems to be a disadvantage of making choices and changes based upon a pilot in a short time span.

A possibility for a second in-subject test with the group from the third session has been omitted directly after the test. The only results that seemed to be usable for analysing the animal game and pirate boat game at that time were of the two older participants. But one of these two participants was not having CP reducing the good useable data to the last participant. However this girl was slower in her second attempt in the B-version animal game thus already undermining the hypothesis. An extra test with this group was thus omitted.

It should be stated that especially the in-user test are based on only a very small population. Results that seem insignificant might be significant when larger uniform populations would have been analysed, using different age groups with more participants per age. The current in-subject test did not result in many conclusions with proper statistical basis on the research questions. The effectiveness of the plate was the only expectation that was confirmed in a quantitative way.

It was expected that a participant would be faster when getting feedback on his performance. Seen in retrospect it might have been impossible to test when there would have been a difference between the first and third attempt. It would then be unknown whether such an effect would be due to the altered version or due to the learning curve. If other researchers would like to repeat a similar research on a larger scale they should keep this in mind.

Feedback testing Not everyone heard the feedback of try to be faster as they also could have been the fastest. The speed might even decrease if a participant only hears to make less mistakes. Earlier research has indeed shown such effects(Eisenberger, Mitchell, McDermitt and Masterson 1984). Eisenberger et al. (1984) did a test in which preadolescent students were rewarded on their reading abilities either on their accuracy or speed. This resulted in subsequent quicker generation of stories when tangible rewards (toys) were given upon improvement of speed; more accurate drawings and stories were created when this reward was given based on their accuracy. When extrapolated to this research this would mean that the difference in time and errors could thus indeed depend on whether the given verbal reward after the first round was on the fact they had made the least mistakes or that they were the fastest. A two sample t-test still did not show a significant effect. In this test the B-version of P7, P8, P12(as they received a different type of feedback) and(P14 because of age) were excluded from the results , the remaining B-version timings (n=4) were compared to the remaining A-version timings(n=2, excluding P13 because of age).

Both the 14th and 15th participant were slower in their second attempt than in their first. This is opposite of the other logged results. The 14th participant was very young and needed help. When analysing the video it seems she was distracted by something on the floor for several seconds. The child seemed somewhat exhausted, the session was at the end of the afternoon, which could be the reason she was more distracted during her second attempt than her first. The 15th participant had serious trouble grasping the dog and setting it upward on the board in the second round which took several seconds longer; this is probably the main reason why the second attempt took longer.

Playability The added plate resulted in better playability. It also resulted in significant more measured movements. It has to be stated that the inclusion of the girl that played in the reverse order implicitly assumes that the added plate is of more impact than the different versions on the number of movements.

The repetition of the introduction about the pirate boat game was noticeable irritating to the girl that underwent this. When the games will be used more often the therapist should be able to select whether or not to play the introduction or explanation of the game. This will make more time free for the necessary exercises which is the main purpose of the games. This number of iterations of the exercise is an important factor in therapy.

The children from two and half and three years old were unable to perform the games in an independent way. It seems that the lower bound of the suitable age of children is somewhere between three and five years. The games can be played with some help of the therapists. To know if these games are appropriate it should also be compared to the alternatives. In the ethnographic when such a young kid was observed playing the therapist also had to regain attention to the task frequently.

Interviewing children The interviews were hard to do with young children; often the questions were changed into closed questions to get a response. But using closed question for the young children seems to give a bias. It is more likely that a child would answer such a question with for instance "Yes, I liked that one" than responding in another way. Thus the answers given, especially by younger children who only responded on such type of questioning, should be taken with care.

Responding on questions It seems to be necessary and expected to react on questions, remarks or gaze of the participant during testing, especially with children. It seemed that the flow would be disrupted more if the participant was not answered than if short answer or simple acknowledgment or non-intrusive backchannel techniques were used. This is a general point that makes evaluation of products hard.

Number of tests The number of tests done during the return sessions was less than anticipated because of several reasons. Still the chosen approach to have multiple tests and having the therapists present seemed to lead to useful input from the therapists. However the reduced number of tests and the change of session into a pop-star group, is likely to have affected the test results. Such miscommunications and time-dependent alterations in testing could be a direct result of the non-co-located work-environment and scarce communication.

Diversity in target group The observed children during the ethnographic study seemed to be in the top segment of the children that participate in the therapy sessions. This seems to be a risk of ethnography in which properties of the observed are assigned to a too large group. Outliers of a small group can be a significant part of the total user group, as was warned for by the *inter- and intracultural diversity* principle of Fettermann (2009). This seems to have led to the wrong dimensions of the pirate boat game and the non-appropriateness of the glove game. However such diverse properties of participants also mean that these games are likely still suitable for some of the children of the Piratengroep. It is regretful that even though being warned for this overestimation by earlier research results from Li et al (2008) this occurred again.

Destructive factors An interesting point observed during the research is tendency to like a destructive factor by both girls and boys. This could for instance be seen during the hitting game and the pirate game. Such a destructive fantasy was also present in Malone's research, although he did not recognise it as such. A type of fantasy which was less related to the task (extrinsic fantasy) was the popping of a balloon in the top of the screen, something that resulted in significantly longer playtime of boys.

> *"In summary, the primary result of this experiment was that boys liked the fantasy of arrows popping balloons, and girls appeared to dislike this fantasy."*
> *(Malone 1982, p. 64)*

Although several reviews, summaries and proposed enhancements of Malone's work were submitted as papers (Fontijn & Hoonhout, 2007; Moon & Baek, 2009), this destructiveness or destructive fantasy was not argued as an essential point for the liking of a game. From personal experience the liking in games of hitting and scaring away virtual fish, destroying projected shapes by stepping on them, driving a Formula one car in opposite direction to let it crash into another and lots of violent games incorporating driving over objects and subjects has been seen to enjoy many children as well as adults.

During the evaluations several improvements were made and some possible improvements were found. Also the research resulted in better insight in what makes games and therapy fun for the children. This can be applied in a next generation game.

8.6 Conclusion from the three tests

Some of the working principles of game elements (sound, challenge by difficulty and clear feedback using high scores) from Malone & Lepper(1987) were questioned for this particular group because of a generation difference, difference of devices, the difficulties of children and sometimes resulting lack of self-esteem. The games were enjoyed by the children with the different sounds as the main cause for smiles during the games.

Most children smiled when hearing sounds during the hitting game. Several also smiled upon hearing the animal game sounds. The sounds were mentioned as liked parts of the games. This both gives an indication that sounds is still a feature to make games more fun. The crazier the sound how funnier it seemed to be.

The experienced difficulty seems to be coupled to the abilities (and age) of the child. None of the children mentioned the increasing difficulty as positive part. One child after losing in her first attempt seemed to be very glad to win; a challenge effect might be present. However the difficulty was not yet tailored good enough as it was mentioned as being too difficult by several children. The increasing difficulty of the pirate boat game did not lead to observable emotional problems. The results give no reason to believe that these children could not handle loosing. Thus both a game over and a simple ending game could be suitable. Difficulty should be tailored to the children because competency differs strongly between the children.

The use of a high score and reward did not led to significant effects in this setup. In these tests no effect was found of high scores improving the number of made mistakes or the speed (and effort) of play of the children. The feature was not mentioned as being a liked part nor did more smiles than during normal play occur upon being mentioned the high score. The extent in which interpersonal recognition leads to extra motivation and use seems to depend strongly on the personality. Some children seem to enjoy a feature others don't even notice it.

Especially the younger children seemed to lose interest during the games and were distracted easier. Distractions or loss of interest could not be tracked back to certain parts of the games.

A strong age dependency was found in the time needed to finish a game. For both inspected games, the animal game and hitting game, a two sample t-test showed a significant difference ($p<0.001$) between children aged eight/nine and two/three. Only in the hitting game a two sample t-test also showed ($p< 0.05$) a difference between eight/nine and five year olds.

The animal game and hitting game are mentioned an equal amount of times to play again. The pirate boat game was the least favourite. The difficulty of the game was disliked by several participants.

The youngest children had a hard time in playing the games. They had to be explained again by the therapists or facilitator what they had to do. The children also needed to be focused to the games and most of the times helped at least once during the game by the therapist or facilitator. Pointing at the targets or actual guidance of the arm was used. Thus these games could not be played individual by these youngest children.

The games train several sets of the motor skills. This includes the grasps, dorsal flexion and extension of the elbow but no supination. The pirate boat game did not succeed in training supination. The game had to be altered; a mast was added around which a hand could grasp and that needed dorsal flexion for rotating the boat. Even in this altered form it was not working properly enough this time not good enough in training dorsal flexion. The children tumbled the boat and some did not understand it had to be turned instead of being moved. Adding a plate underneath the boat improved this. Further improvement by making it fixed to the board might help. During games some of the non-preferred movements were still observed, for example grasping while having the hand in palmair flexion. This kind of compensational movements should be inhibited even more in future versions to make it more suitable for individual play. Between the different versions of the same games no difference in the amount of these compensational movements was observed. Between the games some differences could be seen in the amount of compensated movements. The pirate boat game was not only requesting dorsal flexion but also the less preferred palmair flexion. Pronation seemed to be coupled to this palmair flexion in this movement. During the hitting game dorsal flexion seemed to be triggered better but in a limited extent. Not all the children were able to lift the hand high enough to play the hitting game with the wrist on the board. During the animal game sometimes palmair flexion was witnessed also reducing the strength of the grasp. The game with a glove intended for dorsal flexion was altered into a more simple hitting game. In which it was no longer necessary to keep the wrist on the board.

Based on the results the games are altered in several ways. Most of these improvements are needed because of a general over estimation in cognitive and physical abilities of the children. It might have been the result of an overrepresentation of good performing children during the ethnographic study. Some by the designer unforeseen limitations were anticipated by a therapist, for instance the questioning of appropriateness of the pirate boat game following the video. This was however not considered enough during the design process. One of the reasons was that it was targeted at the prop instead of the actual boat and assumed to be fixed with that implementation.

Two games are already usable in the therapy sessions; namely the hit game and the animal game. To make it better a broader range of animals can be used and an upright-board version of the hitting game can be made. The pirate boat game could be used to train dorsal flexion in some extend when some changes are made. All the targeted movements are trained in some extent with exception of supination.

The unwanted palmair flexion was also seen during the tests. Improvements in the pirate boat game made after the first test indeed led to significant more detected movements. To tailor the difficulty and make the games suitable for a wider age range; changing timings might be necessary. The automatic logging built into the ESPranto development platform was very useful for analysis of timings errors and detected movements.

9. Fourth and longer evaluation

The end goal of the games is to make the therapy more entertaining. To test this it seems to be good practice to not only test first or second use but to actually follow real usage for some time. The kinds of problems that are found in first usage testing are different from those after some practice (Barendregt, Bekker, Bouwhuis and Baauw 2006). Longer term usage is also important for predicting usage during actual implementation and thus in making conclusions about the suitability of the games. This chapter describes this performed longer evaluation

The test should lead to qualitative and quantitative results for assessing the applicability, entertainment value and possibly for improvements of the games and additional input for the last designed game. The results most importantly give an indication whether the goal is reached of delivering an entertaining alternative for the currently used therapy, if it is training the wanted movements and if it satisfies the other functional requirement that it can be played alone [F_04] and the non-functional requirement of "being started fast"[NF_04].

9.1 Improvements made before the test

For the pirate boat game a fixed rotatable heavier wooden object instead is made of the one of foam. This prevents it from tumbling and makes it an appropriate revalidation game for dorsal flexion. A bolt can be tightened to make it harder to turn; this makes it adaptable to the different strengths of the children. The base can be hooked onto the board and taken off without using a screwdriver or other tools but with its connection it is not moved during the game. The version can be seen in Figure 9.1. The target group's reduced extension of the fingers led to abandon this game as part of training supination earlier in the research.

As it was suggested by a therapist an upright version of the system is made. This is done with a "sleeve" made from MDF that can be hanged on the wall. Instead of hanging it on the wall it can also be used standing on the end of the table against the wall. The cables run through a small opening between wall and table. This upright version can trigger better movements. The hitting game can make use of this. It can be seen with the TagTile in it in Figure 9.2.

Figure 9.1 Pirateboat game connected to the board

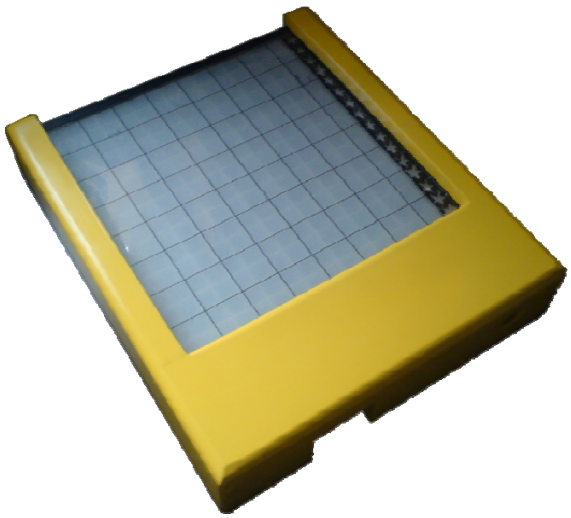

Figure 9.2 Wooden sleeve for upright version

Therapists suggested using more animals during the previous evaluations. The animal game makes use of six additional animals and some new sounds; the sound made by the bear was exaggerated as was hinted by a therapist and also based on the observations. Such sounds can make the children smile more often. Some of the added animals are the same type of animals but different in weight and form making it harder or easier. This makes it adaptable to the needs of the individual child. Added are: a black bear, a lobster, a sheep, a bigger flexible pig, a bigger flexible elephant, a bigger flexible cow and the first used crocodile. The added animals can be seen in Figure 9.3.

Figure 9.3 The added set of animals to the animal game

In the performed evaluations large differences in abilities was seen between the children. A small program is added to make it further adaptable to wishes of the therapists and children. It also simplifies starting the games. Instead of using a command line interface it can now be started only using mouse movements. The program can be used to include a subset of the animals and choose which of two objects from the same type of animal will be used. With this program it becomes easier to include different subsets of children to play the games. This program can change the following features: time for refreshing targets, the number of targets which have to be hit, whether or not the child can lose, playing the explanation of the game, choosing different animals, choosing whether the colour or the name of an animal is given, resetting and saving high score. A screenshot of this program can be seen in Figure 9.4.

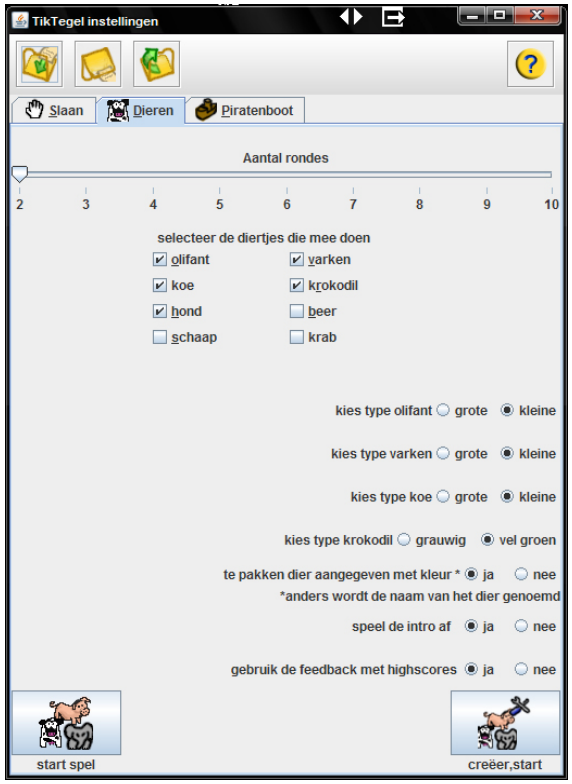

Figure 9.4 Created GUI for starting and setting the games

This program is also used to generate more statistics about actual usage, such as timing, differences in age and choice for using introduction of the game on a longer term.

A manual is created which further facilitates a deployment in the everyday sessions.

9.2 Test set up

The goal of this test is mainly to see during longer usage if the games will fulfil the requirements and reach the goal.

The requirement that it is safe [NF_03] is briefly tested with a therapist by examination of the form of the product: checking on small objects [NF_03.1], small holes [NF_03.2] and for sharp edges [NF_03.3].

For the evaluation the board is released with a manual (see Appendix D) and an explanation to one of the therapists. The cables are taped together and connected. Two USB

cables need to be connected for communication between the board and the laptop. Besides connecting the USB cables, both the laptop adapter and adapter for the board need to be plugged into the socket for power.

During the deployment, the usage is automatically logged. To compare usage per child, every child has an assigned tag with his/her name on it. This has to be used to start the game, which makes it possible to track individual usage, settings and improvement. The therapist is not told to use the game a certain amount of times. Nor is the therapist told about the logging. In this way, without pressuring usage, actual usage is tried to be mimicked more closely. A journal is used for additional feedback of the therapists. The small (approximately A6 format) journal has five tabs. Each tab represents one of these categories: ideas for new games, errors (bugs), wanted settings, points for improvement and interesting stories. For each category an example from the previous evaluations is written in the journal to stimulate to write something. The board is placed in a small room for individual therapy where the earlier evaluations were also done.

After a seven week period the therapists perform a 5-point Likert scale survey followed by a semi-structured open interview taking about an hour. The questions and transcript of the interview, the used survey and the used set of hypotheses and expectations can be found in Appendix E.

It is expected that the games are an entertaining alternative for training the movements (with exception of training supination and pronation) and that the adaptability of the game is wanted added function.

9.3 Results

Several sources are used to gather results on the longer evaluation. The results are shown per source in this section

9.3.1 Journal

The section of the journal with ideas for games was left empty besides the examples from earlier evaluations already written in the journal (being a hairdresser game and a race game). Also the wanted settings section was kept empty with exception of the given examples.

The lag of the boat game was seen as an error. Its response was too slow. The hitting game had three points of improvements. The wrist bands consisting of Velcro are not fitting comfortable: “it was too sensitive”. The aiming has to be done too exactly; the lit squares should be bigger. The last point for improvement is that too much dorsal flexion is required.

9.3.2 Interview

Usage There were 18 one-handed sessions in which the board could have been used. The children that used the board played about four games with it on average. In the sessions it was used twice in the second week and twice in the fifth/six week.[4] Only four children played with the game, the group normally consists of six. This time only four really started the Piratengroep program. One of the children did not play with the game later on, as his grasp was not good enough. The remaining three children were: three years old, almost four years old and almost five years old.

The mentioned reason to use the board is that it provides something new for the children. The children also indicated that they would like to play with it more often. The main reasons not to use it are “the technology”

[4] The logs clarified that it were in total eight completed attempts in two afternoon sessions

and preparing the board for usage (fetching the laptop and connecting it with the board). Changing from one game to another was found problematic. One had to look away from the child at the laptop. Also the location at another room might have led to less usage as it is not in sight and usage is thus not triggered in that way. The advantage of this location is that the children focus more on the game.

Preparation took about ten minutes according to the therapists.[5] They suggested that the games should already be running and ready for usage.

Improvements The Velcro used for the hitting game was not comfortable and took time to get it on. It was also unclear for the children how to hit the target at the right spot. It was not attractive enough for the children. The hitting game was not tried with the setting "without keeping the wrist on the board". According to the therapists this would be too much simply pounding the board. It would also not require the correct movement unless they used another starting position (e.g. standing) or had to really push for some time. This latter was not possible with this game as it would go to the next target upon hitting the target.

The boat game did not respond fast enough, sometimes children aimed properly and then the target did not disappear. The idea of the game was very good, the movement was triggered.

Somehow during the deployment the shortcut to start the program to set and launch the games was deleted twice (it disappeared with no apparent reason).

Preferred games The children were willing to play the animal game again but not the hitting game. The animal game was liked best by the therapists and seemingly also by the children. The boat game also led to high expectations but because of the reaction time it was not good enough to use. When this would be changed it could also be used.

Movements When movements would have been triggered better the games might have been used more often. The animal game was already ok. Compared to the earlier pirate puppet game the movements triggered with the pirate puppet were not right, it was better in the animal game. Wrong movements were still seen sometimes in the animal game but not often. The boat game also triggered the right movements.

Settings It was good that the timing of the games could be altered and that a subset of animals could be used appropriate for the child. There was also a child that was colour blind. The animals were then selected accordingly with lesser variation. This prevents a lower reaction time to influence the efficiency of training. The game was not set to use the other hints, indicating the correct animal by its name instead of the colour. The therapist accompanying the colour blind child did not know this was possible. A number of standard settings, e.g. use only the big animals, might have also worked. At the moment one had to pay more attention in making the changes.

[5] The time needed by the researcher was also timed: fetched the laptop, connected it, placed the pieces and started a game. Time needed was about 6 minutes including fetching and making and restoring a mistake which needed a restart of the game. When only starting the laptop, placing the board, connecting it, placing the pieces and starting a game it took about 3 min. This might indicate a difference in perceived and actual time, a difference in user background or a strong improvement in learning to set the game ready.

An adaptive system might improve the quality of the game in some cases. In other, such as a child having concentration problems, it might be disadvantageous. Making settings on the board instead of the laptop could also improve the system; for instance just placing the animals on the board to use these during the game. This combined with an adaptive speed change might be optimal. Although at the moment it is hard to say because it hasn't been used often enough yet.

Logging Tracking development of the children is of less importance when compared to therapy for adults. It is not needed for this therapy; therapy material is more interesting in our case especially letting the child play on its own behind the TagTile (and laptop) might be an improvement.

Compared to USI games The games are compared to games developed by a group of USI students (post-master education at Stan Ackerman Institute/TUE). These games were completed and tested half way of this research. They were also informed about this research and the developed games. Their games were started by launching a menu application, choosing one of five icons on the board and then making two settings: the number of repetitions (ranging from 20 to 70) and difficulty by setting the time or by choosing the objects. They created five games in total:

- Hungry Monster, targeting grasp. A small object has to be pushed on an illuminated square.
- Playing the piano, targeting finger extension. The index finger and thumb are equipped with a thimble and have to be placed on two illuminated squares while being extended triggering a piano key sound.
- Dance dance revolution, targeting supination. Either the palm or back of the hand has to be placed on an illuminated square depending on the emitted colour.
- Catch the flies, targeting dorsal flexion. The wrist or end of the palm of the hand has to be placed followed by the fingers to catch a fly depicted by four illuminated squares.
- Catch the raindrops, targeting shoulder extension. A mug has to be placed underneath an illuminated square falling down, having the BlackBoard standing on its side with cables pointing up.

The games developed by them looked more professional/ready[iii]. Their games were on the other hand less appropriate for the target group as unrealistic movements such as extreme thumb and finger extension were required. Also their incorporated interests seemed to be less fitting the target group.

Future Looking at all the developed game there are still possibilities in having more games on the TagTile for therapy.

9.3.3 Survey

The survey was filled in by four therapists. Two did this pre-going the interview, one did not use the board during the longer evaluation but only saw others using it and also filled in most of the survey. The survey consisted of answering statements on a 5 point Liker-scale, ranging from the Dutch "1. helemaal mee oneens" (totally disagree) to "5. helemaal mee eens" (totally agree).

All the exact answers can be found in Appendix E. Only the most important results and in which there is coherence will be explained in this section. Slightly negative results (2-3) are stated while not all slightly positive statements (3-3.5) are described as people are inclined to answer slightly positive on a survey.

The children wanted to play the animal game again according to the therapists (avg 4). A mixed answer is seen from the therapists on playing the hitting game again (2,3,4,5). The game with the boat scored neutral (avg 3). All movements (dorsal flexion, stretching the elbow, pinch grip, coordination) can be trained (rated 4 by all on

all movements). Also the unwanted palmair flexion was used in at least one of the games (all answered 4). To time to get the device and games ready was not seen as quick enough (avg 2.5). It was seen as positive that the games were placed outside the room (avg 4). The program was not used to change settings of the games every time (avg. 2.7, n=3). The games could be used in the therapy of the Piratengroep (avg. 3.8). The black TagTile can be used in therapy (avg. 4) and new to be developed games can be used in therapy (avg. 4.3).

Figure 9.5 The animals that were not used in the longer evaluation.

9.3.4 Logs

The game was launched sixteen times in two afternoon sessions. From this at least three times can be assigned to a therapist trying the game (interview and time of log). Another three times can be assigned to launching the game without starting it. Another two times the game was started but not finished. From this once the hit game seemed to be misunderstood, seven times the wrist was not on the board while hitting the target, with not one successful attempt. This game was "killed" (stopped directly) after these erroneous attempts. The other stopped game was the boat game that was stopped after hitting one target. Looking at the results of the interview it was probably reacting too slow.

From the remaining eight games that were actually played with completion, six times the animal games was played. Two times the hitting game. The pirate boat game was only attempted once with a child and once by a therapist self. For this attempt of the therapist the time between targets, set at 1400ms, was not adjusted (as one might have expected when the game reacts too slow).

The hitting game was not used without the prerequisite of holding the wrist on the board while hitting. The animal game was not played with keeping track of the high score.

The individual tags had not been used to identify a child. Thus thorough comparison between settings for and play of different children cannot be done. Once the animals were selected differently and two times the timing of the hitting game was altered. The hitting game was played with two settings, target switching place in 2000ms or in 4000ms. The first time the animal game was played with the five animals also used in the previous tests. The second time the crab and bear were added. No changes in one type of animal were made, thus the bigger and flexible animals seem not to have been used. Both times the version without high scores was used.

9.4 Discussion fourth test

The usage was far under expected thus also leading to missing data to draw conclusions from. It seems that there is a resistance to using the board because of technical difficulties and time needed to set it up. The coming into availability of the BlueBoard for the Sint Maartenskliniek might have played a role herein. Expectations could have increased seeing the BlueBoard functioning at SeriousToys as it doesn't need a laptop.

The field of difficulty or challenge and success rate will not be further investigated in next design steps. It seems to be that personal preferences are an important factor herein and an optimum would be hard to find in such a diverse group.

The hitting game was now regarded as not giving enough fun in contrast to earlier evaluations. In these earlier evaluations a smile was observed quite often and the game was found to be equally preferred as the animal game (both 4 times). This can be due to forcing the arm on the board again requiring a hard to reach dorsal flexion. The fun might be improved by incorporating a fantasy, storyline and more complex rewarding structures. However seeing that also the tangible object and the movement were not good enough it seems better to abandon development of the game totally.

A quicker response for the boat game was already tried to be reached by reducing the two tags to one tag, a fixed point of rotation and some code optimisation. Unfortunately the game was still not responding fast enough in the field. The way it was programmed might not be the most efficient in the ESPranto language. The game might be too high fetched for this platform. It is also designed for the dimensions of the black TagTile and it could be hard to make it suitable for the BlueBoard.

The therapists still see possibilities in using this or a newer version from the TagTile in therapy. However looking at the very small amount of usage due to "the technology and preparation" (usage of the laptop and getting the board to work), switching to the BlueBoard, although smaller, seems to be appropriate. The improvements made thus far have not reached the goal while most requirements seem to be met. One set of requirements [NF_04: start fast] was stated wrongfully. NF_04.1 should have been "The preparation of the game/system should be perceived as been done within two or five minutes by the target group". There was a large difference between those two. One requirement [F_04.2: played alone, ...train on their own] was only partly met. The games seem to be unplayable by the youngest children on their own. It is however questionable (safety wise) if such young children should train without being observed.

New types of rewards besides verbal praise, points, sounds and emitting lights might be needed to bring more fun into the games and keep interest. For instance incorporating more fantasy and triggering more curiosity. The usage of a destructive element might also be beneficial as was shown during the hitting and boat games.

9.5 Conclusion fourth test

Only the animal game seems to be an entertaining alternative for training the movements according to the therapists. The boat game and hitting game are not played as often, six times the animal game and two times the hitting game. The boat game was not responding properly mainly too slow. The hitting game was not appealing enough; it did not capture the imagination of the children and therapists. The animal game was fitting the target group. The opinion which game was liked by the children differed slightly between the therapists.

It is unclear if the novelty factor plays an important role in the experienced fun by the children during the games. The gathered data are hard to be analysed as usage was very limited. This on its own might indicate a lack in a novelty factor of the board with these games.

The games train the wanted movements with exception of supination. The unwanted palmair flexion is also triggered during at least one of the games. It can't be said if the training is as effective as other used therapy techniques. The used design methods seem to have worked well in triggering the right movements and ok in fitting the interests of the children. The animal game did a good job in targeting the appropriate grasps limiting palmair flexion according to two of the therapists in the interview.

The games can't be prepared quick enough for usage by the therapists. This was indicated in the survey, interview and the usage as the games were played only a few times. The requirement should have been altered to fit the target group and tested in that way before implementation.

The therapists liked the ability to change settings to tailor a game for the needs of the children. However this option was used only used three times. The program might have been unsuitable as it was only understood by two of the three therapists and requires focus away from the child.

The hitting game and boat game still have room for improvement. It is however questionable if effort should be attended to making these changes to the games. One could conclude that the black TagTile is simply unsuitable for this therapy as the games are still perceived as not started fast enough. Therapists are however still positive towards incorporating new games and games on the black TagTile in the therapy.

The journal worked ok as an additional way of gathering information. As some written phrases were not clear it seems good to combine it with an interview of some kind. The journal was not used to propose new ideas, but did contain points for improvement and positive feedback.

The longer evaluation did show other results than the earlier tests. It seems to be less biased or biased in another way. In the previous evaluations the feedback and results were mainly positive, in this evaluation other shortcomings where made clear. The needed preparation was cumbersome and became a more important factor as it focuses on actual implementation in the longer evaluation.

The main reason for not using the board regularly, only in two sessions, is the time and effort needed to start playing with a game. Another reason might have been the use of the program to launch the games, as one had to focus on the screen of the laptop and away from the child when starting a game.

For the hitting game several things should be improved: the bands, its attractiveness, making the settings changeable within the game and making it playable on the BlueBoard. It is questionable if effort should be taken to improve this; instead creating a new game targeting dorsal flexion might be more efficient.

The animal game should be made playable on the blue TagTile as it should be started faster.

The improvement of the pirate boat by making it fixed to the board did not help enough. The game was not successfully played during the longer evaluation because the system did not respond quickly enough; sometimes targets were not deleted even when the boat was properly aimed at them. A next improvement could be to make the game playable in a shorter amount of time. This will however be hard as it is made for dimensions of the black TagTile and this requires the laptop which takes time to get, start and connect.

Further development of the current three games is stopped, for the reasons mentioned earlier; instead creating a new game will be tried. In this new game supination should also be trained properly. This design could benefit from co-design with therapists instead of the participatory design techniques that were used until now.

10. The "Ik hou van Holland" TagTile game for therapy

The results from the previous evaluations are used to draw lessons for the next generation of games. The first and most important reason is the shown lack of use in the long time evaluation for several reasons. It seems some of the pitfalls (compensation, problems in used dimensions) indicated in the first phase of the research are not circumvented. These reasons together with the aversion of using the Black TagTile because of "that technology" with its longer start-up/installation time seem to be the main reasons for not using the TagTile more frequently.

One more game is created to also train pronation and supination with the tangible games. The last group that is incorporated in the test for the last game, being slightly older 8/9 years, didn't make use of the Piratengroep metaphor. Instead they participated in a one week lasting therapy with an "Ik hou van Holland" context, a popular Dutch TV-quiz show. In this week of therapy in the morning they had one hand training (mCIMT) and in the afternoon they had two handed training.

For the last game the therapists are incorporated more directly at the beginning, at the concept generation and a switch to a provided BlueBoard is made.

The inclusion in the idea generation could help to motivate the therapists more to use the system and could help in circumventing compensation better. To have an efficient concept generation of games; a new participatory design technique, amongst others using interaction labelling, is used. The technique used, the resulting game and the short evaluation of the game is described in this chapter.

10.1 Design session

To let therapists participate in the concept generation an idea generating session combining two techniques is used. The goal of the session is to get ideas that already have some detail. To reach this goal first interaction relabeling is used, which should lead to multiple concept ideas based on movement. This acting out movements to generate concepts to train movements showed positive results earlier in the research. This is followed by a technique to quickly change a product into something different and more detailed. The technique called Systematic Inventive Thinking (SIT) is used for this. This was chosen based on personal experience; as it is one of the most efficient techniques to generate creative new product/altered products. The results will be described shortly in this section, a more extensive description of the design session with the therapists can be found in Appendix F and the used presentation on interaction relabeling and SIT can be found in Appendix G.

The session consists of four parts:

- Presentation about the session and introduction to interaction relabeling.
- Interaction relabeling session.
- Introduction to Systematic Inventive Thinking (SIT).
- SIT session proceeding on results of the interaction relabeling.

Interaction relabeling (Djajadiningrat et al. 2000) uses the interactions of an object (often called prop) to translate this into new interaction methods for another product, see section 5.3. Systematic inventive thinking is a technique to create a new product by using one of five thinking patrons.

10.1.1 Pilot design session

A pilot of the set-up was done. This is used to see if the method would work, what kind of props work better for the interaction relabeling and to better plan the time available. There is only one hour available for the actual session thus this is also used for this pilot.

One research using props to act out future usage advocated "simple abstract generic forms". (Brandt and Grunnet 2000) On the other hand mechanical objects were advocated for use in interaction relabeling.(Djajadiningrat et al. 2000). From both kinds of objects several are tried out.

Set-up

The pilot is done in a living room environment. The four parts are assigned 4 minutes, 21 minutes, 4 minutes and 21 minutes. The following props are available and presented on a table:

- Rope
- Coloured papers
- Cup
- Dices
- Cards
- Pieces
- Clay
- Lead
- Torch
- Headphones
- Calculator with lid
- Towel
- A box with magnetic closing
- Rabobank RandomReader
- A big round glass lamp

After the presentation is held, the participants are told to start designing. The ideas are written down on an A3 paper by the facilitator, sometimes asking for further information when ideas are not explained clear enough. These descriptions are later on used to retrieve the ideas to be used for the SIT part.

Results and conclusions pilot

Three male participants participated with the ages 23, 26 and 27. The pilot resulted in 16 ideas and one idea that was directly found unsuitable for the target group. Four drawbacks were seen in the interaction relabeling session. Participants hesitated to grab a prop from the table. During the session most ideas were not forming a complete game idea. It was hard to keep in mind the target group, the movements and creating fun games at the same time. The props with only a few interactions (e.g. cup) seemed less appropriate than the more mechanical props (e.g. calculator with lid and buttons). The more mechanical props are thus used for the actual session.

One of the participants (aged 26) could not make it to the second part of the session. In total twelve new ideas were generated during the SIT session. The SIT session did result in more detail but not on a too detailed level. Four points were improved based on the pilot. When the pattern dividing was targeted the participants actually used multiplying. These two thinking patterns are now taken together. There was not enough time to try out every thinking patron. Thus more time was assigned to the SIT session and not all thinking patrons are used at every product. Some products ideas did not profit from the SIT session. Thus the most promising ideas according to the therapists will be used for the SIT session. After the session one participant seemed to wonder what the use of the session was. To prevent this with the therapists it is shortly explained that therapist will have a better knowledge of the children's interest and the movements to be trained.

10.1.2 Therapist design session

Session set-up

The session introduction is held on a laptop using a PowerPoint presentation with a wide screen laptop. The explanation of interaction labelling is planned to take approximately 5 minutes, the relabeling session 15 minutes, explaining SIIT 5 minutes and performing SIT 20 minutes another 5 minutes are accounted for setting everything ready.

Again an A3 paper is used to write down the ideas during the interaction relabeling session. The participants are directly ordered to take the first prop and explain how one would use this. After explaining they have to try to alter this into a game setting training the wanted movements. When running out of ideas the next prop is introduced by the facilitator.

The interaction relabeling now makes use of more mechanical type of props:

- A stapler
- A multi head screwdriver, rotatable by pressing
- A Rubik's cube
- A small box (size of USB-stick) with magnetic closing

Results

Only two therapists could make it, a third could not make it. Nine ideas were generated during the interaction relabeling. Four of these were seen as promising and used for the SIT session: a cube game similar to that of Li et al. (2008), a racing game with motor cycle type gas throttle, a jar game (something has to be shaken out like a needle out of its container) and a pinball game. From this latter an attempt was made by a polytechnic student earlier but the student failed with both consumed budget and applicability according to one of the therapist.

The session was done in a slightly shorter time span than an hour due to interruptions and a lag in starting up.

Several ideas were linked to already existing games. The interaction labelling was started with some difficulty in the first minutes. Not all thinking patterns could be used in the short amount of time. Instead a pattern was randomly chosen.

During the SIT refinement session two new to be trained movements being part of the hand coordination were explained: thumb abduction and opposition. This was done while explaining how incorporating a button might trigger these movements. In the beginning of SIT session it was unclear to the therapists how SIT should be applied. During the SIT sessions after a short time of warming up and more strictly proposing the patterns, the ideas were successfully further refined. In total ten alterations were found. From these the three most promising when looking at the requirements and triggered movements are described next.

The cube game

A cube with six different faces, for example colours or patterns, should have the correct side facing down. Using a small target underneath on a side could provide in triggering automatic repetition and hand-eye coordination. A button could be added that has to be pressed just before or when hitting the target. This requires the thumb abduction, by choosing the sides smart and providing some barriers palmair flexion could be prevented while supination or dorsal flexion would be required.

The game with the spring

A barrel or a long closed "runway" has a ball in it. This ball can be shot away similar to launching a ball into a pinball machine. Instead of retracting the spring directly a rotatable arm is used. The ball has to be shot with a certain speed to score an amount of points. This arm should be designed in such a way that dorsal flexion, coordination of the dorsal flexion and grip is trained.

The jar game

The object is a jar with on both sides a rotatable lid. Both lids contain several shaped holes. These holes make a pair with objects that can be put into the jar. A goal of the game is to let the items meet in the middle. To let two

items meet each other one lid has to be rotated in the right way. Using the board hidden combinations have to be searched. This could lead to competition and collaboration when children see other performing on the game or secretly whisper combinations to each other. This could require two handed coordination, supination, and in hand manipulation.

10.1.3 Conclusion design session

The SIT session did lead to some more refinements, but the explanation and warming up might have made it too inefficient for the short time span. A normal brainstorm in combination with triggering ideas by combing themes might have been more efficient and effective.

For the interaction relabeling the more mechanical props outperformed the simple more abstract props. It seems the combination of interaction relabeling used as a participatory design method is an efficient method in this context. Most ideas in the therapist session were still based on previously existing games; in the pilot more original ideas were seen.

A conclusion on a possible increased affinity because of the co-design session and therewith increased usage of the system can't be concluded, since a long run evaluation would be needed for this. This couldn't be done in the time span of this current research.

The ideas seem promising enough to combine and or further develop into one more game that could satisfy the requirements and could be used in therapy.

10.2 Concept development

The last session in which games are tested and played takes place in another context with slightly older children (aged eight and nine). The requirement of swallowing objects is not needed for this group [NF_03.1] and thus no longer holds. It also means that somewhat more cognitive challenging games can be created. The overall metaphor of pirates [F_03.4] is dropped for this group's therapy method and instead the overall theme is a popular Dutch TV-quiz called "Ik hou van Holland".

The game must be ready in the week the therapy is held thus the requirement now holds for this week instead of the previous return session [NF_01.1]. In this stage of the research, gathering insight in the SDK [NF_02.1] and automatically logging the results [NF_02.4] are no longer needed and these requirements can thus be dropped. The version will be running on the BlueBoard because of the reduced needed preparation time for therapists and it coming into availability, the requirement for using the BlackBoard [NF_03.3] is thus dropped.

The designed game made use of the ideas and movements generated during the participatory design sessions. The ideas that are implemented are the block turning idea, the shaking from the jar game and the making of combinations. As the theme switched to a quiz-show; correctly answering multiple choice questions is used as game goal instead of making shape or colour combinations. The movements to select a question and to answer a question trigger several to be trained movements using the block turning idea and shaking from a jar.

10.2.1 Combination of movements: the "Ik hou van Holland" game

The game The game consists of picking a category, getting a random question, hearing the answers, choosing an answer, loading this answer and hearing if it is correct or false. A more detailed description of these steps is given next.

The game starts with the intro tune of "Ik houd van Holland" and showing a tulip symbol. A category of questions has to be selected using a wooden cube, this can be seen in Figure 10.1. These are with the board provided coloured (yellow, red, blue and green) wooden cubes of 2 cm with a felt and a pre-programmed tag underneath. A printed logo of the category is placed on top. The four categories are based on the "Ik hou van Holland" TV-show and the board game of the TV-show: sports, Dutch habits, songs (and Dutch TV-shows) and well known Dutch people (BN-ers).

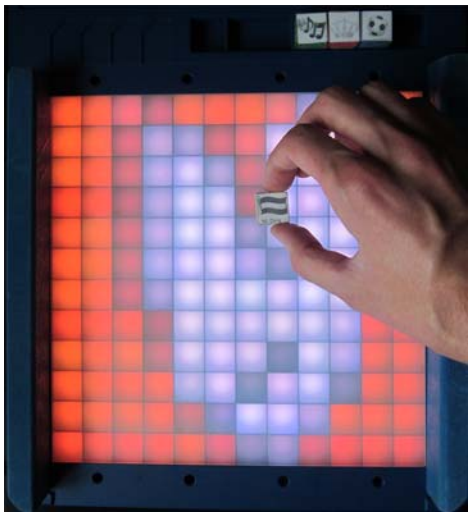

Figure 10.1 Choosing a category

When the cube is placed the category is selected, the category is spoken out loud and the according icon is shown on the board. An instruction is played to throw a question on the board from the question box. A question has to be shaken out of a question container. The tangible version of "the question" is a tag inside a small piece (18x18x8mm) made of a foam block. The container is a (with foam block fortified) carton rice box(40x100x160mm) which has a hole to pore the rice, in this case question, out of one side (38x20mm). The other end has a foam block inside to prevent it from being squeezed. The set of tangibles can be seen in Figure 10.2. When one or more questions are thrown on the board a phrase from the game show is played: "and here comes the question". This is followed by "a question for 2/4/8 points", the number of points for the question is depending on its assumed difficulty for the children. At the same time a question mark is shown on the board with emitting green LEDs moving by underneath.

The four multiple choice answers can be heard by rotating a block over the board resulting in hearing the four answers to the question. This "answer block" has four colours (yellow, blue, purple and green) every answer is depicted by (one or) two rows of LEDs lighting up in the according colour. The answers can only be heard in the order of yellow, blue, purple and then green. An instruction is given to choose the right answer by placing an answer ball. The answers can be heard again by rotating the block in whatever order.

The answer ball (actually a blue disc of 18mm and 10mm in height in the tube in Figure 10.2) has to be placed on one of the rows to choose that answer. This answer is repeated: "you chose ....", switching the choice made upon hearing it is not yet included. The user is instructed to load the answer. The answer has to be put into a tube (160mm high 25mm in diameter) with a small pedestal underneath outside the board. When the answer ball is raised from the board three green loading lights are emitted with a small pause between each one getting lit and a loading sound is played. The tube with answer has to be placed on the board. Another three loading lights are lit next to the previous three with the rest of the loading sound playing. The user is instructed to throw the answer on the board. When it is correct the phrase "the answer that you gave is ..... correct" with all the LEDS on the board flickering white and just before the word "correct" flickering in green. When the answer is wrong a phrase recorded from the show is played "Almost

Figure 10.2 The set of tangibles used for the *"Ik hou van Holland"* game

correct. The answer was almost correct, but almost is not good enough". The user is instructed that he/she gets another chance to answer the question but for half of the points. The game proceeds again from hearing the question. When a question has been answered incorrectly for the second time or the correct answer is given then the game starts from the start again with selecting the category.

When a correct answer is given the question is removed from the listed set of questions. When this question was thrown from the question box on the board it is stated that another question has to be chosen. When all questions from a category are answered and this category is chosen, the user is instructed to choose another category as all questions have been answered and then the score is shown. The phrase from the TV-show is played: "Let's go to the interim score that seems to be a good idea". The score is shown with LEDs in red showing the number of points (in the Hindu-Arabic style). Underneath and above the number green LEDS "are moving" from left to right. At the start of the game the therapist or user can select the number of questions that have to be answered ranging from 5-12. When all answers from one category and the number of questions are answered the user hears he/she did very well answering all these questions correctly followed by 20 seconds of the song "We are the champions" from Queen.

The used set of questions can be found in Appendix H. A short guide (in Dutch) for using the BlueBoard and playing this game can be found in Appendix I.

Movements Almost all the movements are triggered in this game. The questions that are thrown on the board also have to be put back into the box, the answer ball has to be picked up and put in the tube these actions both require the pincher grasp. The tube and answer box have to be turned to throw the objects out, both actions require pronation. Placing objects back on the board or table triggers some supination (up to normal position of the hand). Placing the answer ball on the right spot requires coordination. The rotation of the answer block trains a passive dorsal flexion, see Figure 10.3. This is also the reason why the block can only be turned in one direction which prevents using palmair flexion instead.

Some of the lessons incorporated The game makes sounds as they were clearly enjoyed in the previously designed games, for instance playing a Windows' "tada.wav" upon hearing the score and the two loading sounds in the answering process. Sounds (and speech) are also used in the audio fragments used for the questions such as a Dutch song "There is a horse in the corridor, yes yes a horse in the corridor". A point system is implemented as at least one of the children in the pilot was clearly seen to be positively influenced by hearing the score and as giving score feedback is one of the features assumed to add fun. A reward for winning is incorporated by playing part of the song "We are the champions" of Queen. The objects that needed to be grasped have smaller dimensions (max 38cm) as earlier grasping the boat was impossible for many children. In the overall design compensations are tried to be minimised by choosing the right shape and size of the tangibles. For some of the tangibles back-ups were made. It was seen during test that things can get broken (a pedestal of an animal) thus a second tube and additional foam for the tags were present. The boat made clear that even smaller dimensions might be necessary, thus a second foam bar could be used. Multiple alternatives for the question box were also present. None of these were actually implemented. The BlueBoard is used

Figure 10.3 Tumbling the answer block to hear the answers, targeting a passive form of dorsal flexion

with the build-in function of automatic launching the game when it is powered on. This might overcome the problem with the technology mentioned after the tests with the BlackBoard.

10.3 Evaluation of second generation game

The game differs in several ways from the three previously designed games. Instead of focusing on one movement it triggers several movements in one game. Instead of just lighting one, two or line of LEDs it now also shows simple bitmaps to indicate the categories, score and state of the game. The game is making use of the BlueBoard instead of the BlackBoard.

10.3.1 Experiment set-up

A short evaluation is used to see if these new choices are improvements or not. For this test a therapist is present while three children play with the game. This therapist was not part of the co-design session and had only seen the other three games during the pilot test done earlier in this research. The therapist is asked afterwards which of the two is better: "Targeting multiple movements in one game or a game focusing on one movement?" and "will games on the BlueBoard be used more frequently" (as the technology will be less cumbersome). To find out if the sounds and lights indeed have a positive effect the children are asked what parts they like to see. But also what part they dislike to indicate needed changes. To this end the play is also observed by the designer to identify possible improvements. To know if the game is good enough in triggering motivation the child is asked whether he/she wants to play again.

The games might be quite difficult for the children. First use is therefore explained by the facilitator also showing them the necessary actions (and thus movements). The game is started by the facilitator indicating at least 5 questions have to be answered. The board is placed on an in height adjustable table with a chair placed in the middle. The accessories were placed beside the board.

10.3.2 Results

Participants

Three children played the game. The two boys with the best functioning hand and arm motion of the affected arm of the group and one girl with the worst functioning hand and arm motion. All were eight year old and had little or at least no observable problems in cognition. The first two children, being the boys, played with their non-affected arm in a sling. The third child played with her non-affected arm freely moveable.[6]

Observations

Understanding and movements The children were able to understand the game principle and the needed movements after shown how to do this in the first round. The only action that was not well understood was the turning of the block. Two of the three participants (the girl and one boy) sometimes didn't place it with the yellow side down at the start. They all at least once rotated the block properly towards them but as the block was turned around in a second axis, the turn around its proper axis was not detected. The first participant had to be reminded in his first attempt but after that didn't make the mistake again the other two did it several times. The picking of the answers and questions triggered the pincher grasp well. The required forming of an "O" with thumb and index finger could be seen. Even the participant with the worst coordination performed

[6] This was due to the fact that this test found place in the afternoon instead of the morning. The afternoon was planned for bi-manual therapy and the morning for one-handed therapy. The child was cooking at the moment she was asked to participate which she liked doing and might have influenced the results.

this action although needing more attempts and being much slower. The pronation was triggered with throwing the questions and answer on the board. Both boys showed an unnatural looking compensating attempt using palmair flexion and some pronation to make this movement but as this didn't work they automatically switched to the proper grasp. This was witnessed twice with one boy and once with the other.

More affected girl showing other movements The girl automatically turned to using her non-affected arm for throwing the answers out the box. This however trained the more wanted supination by chance, as she threw the answers in her hand (needing supination to have it with the palm facing up) and then placed it with her affected arm on to the board. This action was already suggested by a therapist to improve the game before the tests. No instruction was given during the game and she was in another room when this remark was made. Throwing the answer ball out of the tube and on the board was done with the non-affected arm several times. A therapist that was present reminded to do this with her affected arm. The answer block was not rotated using dorsal flexion but with hitting the block in palmair flexion instead. Even though this was hard to coordinate and several times resulted in skipping a colour thus requiring turning it around again. When placing the answer ball on the board she accidently let it loose indicating a wrong answer. She was a little bit disappointed by that "oww too bad that is not going to be the correct answer". She also needed several attempts to put the answer in a tube as she accidently pushed over the tube while inserting the answer.

Motivation Two of the three participants were clearly motivated to play the games. Even when the facilitator and therapist were in discussion; the children continued playing the game (this occurred for both boys). The girl questioned whether she had missed any cooking action while playing the game.

Shaking the tube ad-hoc solution Sometimes on placement of the objects no response was given. The tags were not detected immediately or maybe placed or displaced too early (detection of tags in the game was in some occasions not programmed to be done in parallel but sequential, as this is an easy way to be sure the instruction was played entirely). To solve this problem the children were then instructed to move the question a little bit over the board or to shake the answer tube on the board and place it again. One child started shaking the answer tube before placing it on the board. The movement of shaking also requires limited supination, pronation and coordination.

Both boys sighed heavily at a moment in the game. It did not occur at a special moment in the game. It might be an indication of lack of entertainment but also of simple exertion by the exercise as it occurred only after several minutes of play.

Playing same phrase again One boy knowing his answer was likely to be wrong, as he stated he made a wild guess, sarcastically started lip syncing the phrase that the answer was not good. On the other hand the children could sometimes not hear the question. The therapist knowing this started asking whether they knew what the question was several times a part or the whole question was not understood, remembered or not heard. At one time a boy also questioned if his answer was right or wrong as he didn't hear this.

Therapist(s)

Multiple movements in one game were preferred by the therapist. It seems more fun for the children than focusing on one movement. As some children can't make all movements, it would be nice if it can be chosen what parts of the game to include in what way. Instead of using the required action of turning the block to hear answers, it might be good to choose to move it in the length of the board to train extension of the elbow with some grip. But when children can't make the movements they will come up with compensational movements anyway.

Figure 10.4 A promotion picture of a girl using the Armeo Spring Paediatric, a device guiding movements using gravity compensation and providing feedback with several games shown on a display

This kind of game will be used much faster during therapy according to the therapist. The sessions with the children are already quite hectic and the extra need to prepare and use a laptop to launch games might be too much.

Compensational movements are hard to prevent. Maybe something can be added on the board to tumble the answer block over it requiring more active dorsal flexion. This might trigger dorsal flexion better. The answer block should also have more clear indication or arrow to make clear in which way it should be placed first and in what direction it should be rotated. Shaking the tube is an ok solution for missed detection of a tag.

A second therapist was present while one child played with the game. The therapist stated that the game and board might be most suitable for children that are less affected by CP. A device that guides movements, see Figure 10.4, seems to be more suitable for the more affected children.[7] A possible improvement for the game is in hearing the question. The question should be spoken in a slower pace and/or a way should be present to hear the question again.

Children

When asked whether they want to play the game again the two first participants (the boys with good coordination) answered it with yes, the girl didn't answer. When asked whether she liked the game more than other exercises she answered "yes, I liked it more than the other exercises and games I did". She wanted to go back cooking after finishing the test.

When asked what they liked the first participant stated he liked every aspect of it. The second participant liked the questions. He also stated that he didn't mind he didn't know every question. The third participant liked the questions and the lights. When she was asked "What did you like more the lights or the sounds" she said she liked the lights more.

When asked what they didn't like about the game the first participant again stated he liked everything. The second participant stated that the phrase from the TV-show played when the question was answered wrong is too loud. The third participant found the questions a little bit too difficult.

[7] This device called Armeo Spring[vi] was present for a try-out with the children for the first time. It is likely to be incorporated in CP therapy at the Sint Maartenskliniek in short time.

10.4 Conclusion

The use of co-design led to somewhat different games focusing on to be made movements. The input that could be used was combined and led to a successful game. The SIT part was likely too short to be really efficient. This is also indicated by the observation that ideas created on the end were following each other faster. The interaction relabeling part was understood faster and led to several fruitful ideas. This again indicates that acting out movements is a proper technique to use when creating this kind of physical games.

Some compensation is also occurring in this game. For using the answer block, a suggested solution for preventing compensation/triggering the wanted movement in an active way is to have a small bar over which the block can be tumbled. Another way is to let therapists make different settings of game(s) for the children in which choices can be made for which parts or movements should be required in the game. To prevent problems with technology this could be done starting the game with a setting tag on the board followed by a menu structure. Saving the settings for the different children by using a name tag and using this tag to start the game with the proper settings every time might increase the efficiency.

The game should make use of phrases spoken in a slower pace and should provide a way to hear the last played sentence or sound again. The set of questions could also be corrected by making it fit slightly better to the target group. Some questions were totally unknown although this doesn't need to be a problem as one of the participants stated.

Hearing sounds for several times when playing the game often might get annoying. This can easily be prevented by replacing and renaming the saved sounds on the SD card every now and then. Another option is to play a random sound from a selection of sounds as was done in the earlier created games. It should be possible to undo an action especially choosing the answer as the next steps using this answer require quite some effort.

The game is likely to be used more frequently as the ease of starting and preparation is increased. The game triggered the intended proper movements although the more affected child used compensating movements more often. The less affected children could benefit most of the games as they are likely to also be motivated and can make and train their movements with it. While the more affected children will be making more compensational movements. The game trains several movements in a more motivating way: fulfilling the overall goal.

11. New generations & future development

This chapter is about the possible near future (10 years) of (TagTile) games for therapy. This is done by describing possible next steps for the TagTile in the context of therapy. These steps to keep up with future trends and competition are presented using a roadmap. To come to such a roadmap several steps are taken. Starting with a competition or market analysis to see possible threads and strong points of the TagTile compared to other products usable in therapy for CP. This is followed by a technique called Technology RoadMapping (TRM) and is supplemented with the usage of TRIZ-trends. Traditional TRIZ is a complicated method based on a multitude of patents and reoccurring of solutions and steps in development of products. The traditional TRIZ focuses more on solving problems. The technique used for the TRM is based on the steps in product development which are called TRIZ-trends. This chapter follows the same order starting with the competition. This is followed by the TRM that consists of analysis of the environment (technology, demand and resulting product changes) and ends with the roadmap and explanation hereof.

11.1 Competition

To know what steps should be taken next in the development of the TagTile for therapy it is good to know what current devices and tools might be competing. To this end and to gain a better insight of its applicability, a market analysis is done. A small exhibition for ICT in education (IPON 2011) did not show any competing products. The products that could be competing are found during the earlier steps of the research.

The main characteristic of the TagTile for therapy is its direct interaction using several tangibles and have response occurring at the same location. The TagTile can function as a new tool for therapy bringing something new and an increase of fun of an otherwise less interesting exercise, as is mentioned by therapists earlier in this research and the research of Li et al. (2008). The Blueboard TagTile costs €695.

The TagTile is not the only interactive device that can be used as a therapy tool that brings more fun. Other fun interactive ways of therapy for CP have been proposed or used by the Sint Maartenskliniek or other research. Such as using touchscreen displays, force sensor devices connected to the computer, a storytelling robot and usage of the Wii-Remote. This possible competition and some other are described shortly in this section with its pro, cons and when available an estimation of cost.

Traditional toys As was seen in the literature review and ethnographic study several toys and games can be used for therapy. The advantage is that traditional games and toys are cheap and still deliver some fun. The fun triggered by these toys, games and exercises done with them is higher than traditional care but is still expected to be lower compared to playing computerised games on a TagTile, PC or console. This fun in return can lead to more motivation and movements and therewith better results from therapy.

Touchscreens There is a large range of touchscreens available. The price ranges from about €250 for displays with a touchscreen layer to several thousand Euros for complete multi-touch systems such as the Microsoft Surface table. An advantage for the costs of the traditional touchscreen is that it can be connected to many PCs and operating systems. This also provides the ability to have quick response and as with the TagTile this response is on the same location as the action. The disadvantage is that most touchscreens can't recognise different objects but only push or only some tangibles. In some cases, like the Microsoft surface table it can recognise objects also making use of RFIDs, but the recognised location is not linked directly. It is than much harder to recognise two objects and know which one is where as is possible with the TagTile. The usage of

finger input seems to be unsuitable for several children with CP as the extension of fingers is limited for a large group.

Wii The Wii is a game console that makes use of the Wii-Remote. The Wii-Remote has an infrared operated sensor and an acceleration sensor for the 3-rotational axes. The price of a complete Wii is about €200 but a Wii-Remote is already available for less than 30 Euros. This remote instead of connecting it to the Wii-console can also be connected with a PC through Bluetooth. The input can easily be transformed to keys or a gamepad using for instance the scripting language package called GlovePie. As most people have at least one PC at home this means it is in a price range which would allow children to also use it at home.

Existing games on the Wii could already train some of the wanted movements. One physiotherapist in the UK for instance lists a number of Wii-games and its applicability and problems for use in physiotherapy (Redmond 2010). A game has been developed for children with unilateral cerebral paresis by Newcastle University's Institute of Neuroscience(Sky-news 2008). One of the objectives in this game was exploding balloons and firing a gun with the other hand. This had positive results as children were actively using their affected arm. There is even a company called Limbsalive, founded in 2010, that develops games for people with hemiplegia (not only for people with unilateral CP but also for stroke patients). They make use of two Wii-Remotes to engage the weaker hand. (Limbsalive 2011).

Some therapists, for example Redmond(2010), argue that the Wii-Remote does not sense the movements well and also responds to unwanted abrupt movements as if the wanted movement is made. The improved accurateness using an add-on called Wii-Remote plus could lead to better tracking of movements and which would make this problem less apparent.

There are several remaining disadvantages of using the Wii. The most important is the need to grasp the Wii-Remote and at the same time press a button. Many children with CP will have problems with such a coordinated move. Another disadvantage is that it does not provide a simple way for training different grasps as is possible with tangibles on the TagTile. The complexity of some games can also be problematic and lead to frustration. A last disadvantage is that cause and effect are not collocated which can make it harder for younger children. In the same way as it can be a problem for young children in manipulating an object on a screen while using a mouse.

Kinect and Playstation move The Kinect (running on Microsoft's Xbox 360) makes use of video recognition with a grid of infrared emitted dots. The recognised body and body parts of a person are mapped to a model of human movements in 3D. It supports some speech input for several dialects of languages. Some stories of children with CP playing on the Kinect have been seen and a group of students from Croatia proposed it for therapy of CP mainly in rural areas. As with the Wii it is also possible to connect the Kinect to the PC. The Kinect package needed on top of the Xbox 360 costs about €140. The Playstation Move (running on Sony's Playstation 3) makes use of a remote like the Wii-Remote but with a LED lamp on top of it. This lamp is adaptively coloured in a distinguishable colour and has a fixed size. This makes it possible with using the webcam from the Move to know a 3D position in the environment. The remote is used for detecting the movements and this also functions as back-up when the lamp is obscured. The games for Playstation 3 in general target more experienced gamers. This makes it less suitable to play current games with the Playstation Move for children from the current target group. The Move package with remote and camera costs about €50. The move can also be connected to a normal PC.

Robotics Care for stroke patients can benefit from using a robot guiding movements or even activating movements. The guiding of movements can also be beneficial for the children with CP as it can inhibit compensational movements. For example a system called Dampace developed at the University of Twente is a system in which brakes and weight support is used for an adaptable guided movement to train the arms of mainly stroke patients. A disadvantage is the effort needed for tailoring the system to the patient. Such a passive system is cheaper than comparable active systems but needs longer to make adjustments. The results of different systems, e.g. passive and active systems, most likely depend more heavily on the number of movements made than on the type of therapy (Stienen 2009). The Sint Maartenskliniek already has one of the robots developed at the University of Twente, it is not made part of therapy for the Piratengroep. The devices are designed for adults and are less suitable for children. Very recently the Sint Maartenskliniek has planned on using the device called ArmeoSpring Pediatric for the more affected children. They did a thus far successful pilot with using the adult version set to smallest dimensions. The preparation time was acceptable. The device can guide movements and can counter gravity which was a working principle in an earlier mentioned method using elastics as well. A disadvantage for using these kinds of machines is the needed preparation time, the high costs and the chosen aesthetics that are unsuitable for younger children.

Figure 11.1 Set of E-Link devices for exercises of mainly the upper limbs (from brochure e-link)

E-Link E-Link is a package of sensors and games. It focuses on making exercises more entertaining to improve therapy results. Sensors are developed for different movements. Besides the sensors used for exercises they also provide evaluation tools to measure and record for instance range of motion. A disadvantage is the wires that can get in the way of the movements made. See Figure 11.1 for several devices from E-Link. (Biometrics 2011)

11.2 Technology Roadmapping with usage of TRIZ trends

To generate a roadmap for product development certain steps should be taken. A technique called technology roadmapping is used in which TRIZ-trends are also incorporated (Souchkov 2005). The trends can be used to map the current product and see what the next generation of the product could be.

In the method the first thing to do is identifying market trends coming from the environment. The second step is identifying in what direction the product has to be changed. The third step is analysing technological development that could help in implementing the changes to the product. Another step that has been made part of the technology roadmap is applying the TRIZ trends in product development. This is used to create concepts for the proposed changes to the product. A more detailed description of the steps, generated ideas and used technique can be found in Appendix J.

11.2.1 Market trends, product alterations and usable upcoming technology

The main outcome of the first two steps is that an increase of experienced fun is needed and an emphasis will be placed on independent usage of the TagTile by children. The emphasis on independent usage is following from an expected increase in targeting efficiency in health care. The increased fun will be necessary as children will have increasing experience with console games with new methods of input and feedback. This will result in an increased expectation. The difference between the newer games and the current TagTile will become bigger. In

this way children will see the TagTile as if it is merely a toy like others used in therapy as the gap between toy and the TagTile games will be smaller than the gap between games on future consoles and the TagTile.

For instance the Nintendo Wii and Xbox Kinect have new ways of input, using movement tracked by a controller and by analyses of the body movements. The Nintendo DS 3D uses traditional input of buttons but also uses sound and a stylus controlled touchscreen. The feedback of DS 3D console is an example of increased experience of feedback as it uses a display that mimics 3D. These kinds of technologies will become more widely available and used over the years.

Another type of developing feedback is (advanced) haptic feedback. Known examples of current haptic feedback is for example a force feedback steering wheel which actively rotates during race games, similar to how a real steering wheel from a car or cart responds. Recent development in the area of haptic feedback is done with using ultrasound. This can give a haptic feedback and a tactile sense of a virtual form or a responsive force without actual contact. (Iwamoto and Tatezono 2008)

Besides the new ways of feedback and input an increasing trend in the usage of mobile devices can be seen. This is likely to also pull the fuel cell technology further. For example the first methanol fuel cells are being implemented and have the ability to charge mobile devices for several hours. The energy content will provide longer "battery time" than current Li-Ion batteries used in laptops and the like. Another plus is that it can be seen as a renewable energy carrier and has no harmful emissions. The more widely known hydrogen fuel cells currently still have more hinders to overcome before being consumer ready. Hydrogen is still too hard to generate and store in efficient ways. Methanol fuel cells are likely to become widely available and affordable in the coming decade.

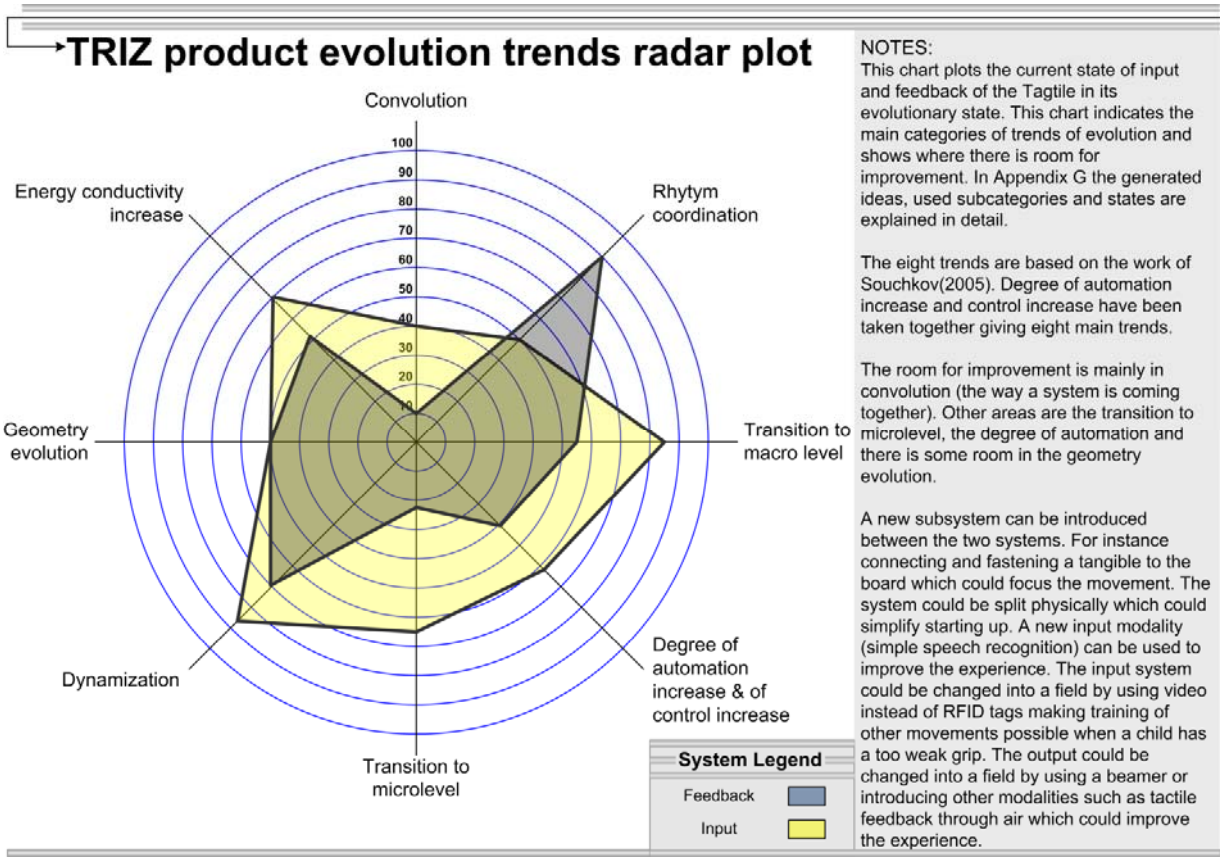

Figure 11.2 Radar plot of 8 main TRIZ trends of product evolution applied to the TagTile

11.2.2 TRIZ product evolution trends

Applying TRIZ product evolution trends generated ideas for improved experience and a reduction in hours of therapists for therapy. A radar plot is used to show where improvement can take place. Several ideas are proposed to fulfil the demands. This radar plot and the most important ideas are mentioned in Figure 11.2. Also see Appendix J for other generated ideas and more detailed description of the trends.

An idea created with the TRIZ-trends is using a tangible construction on top of the TagTile, similar to the created Pirateboat game. This can help in triggering the right movements and at the same time increase the experience. The system could also be split in an input and feedback part with wireless communication. This could make the product smaller or simplify it, which could help in increasing efficiency by reducing start up time. When using video recording instead of tags some movements can be trained even when a child has a too weak grip. Speech, tactile feedback using airstreams and or a beamer could be used to further improve the experience.

11.2.3 Technology roadmap

The generated ideas are combined with technologies into several versions for the coming years. This makes use of the knowledge gathered in the earlier mentioned steps of analysing the market, product and technologies. The roadmap can be seen in Figure 11.3.

v1 Implementation

The first product: "implementation", is in principle the current system with new games. These games can be similar to the created type of games but using the Blueboard to reduce preparation time. In these first games more usage of connected tangibles to guide movements and prevent compensation is advised. As well as implementing a more extensive fantasy, multitude of sounds and displayed pictures and when possible also making use of printed semi-transparent overlays. The strength of the concept should be in the guiding of movements without excessive preparation.

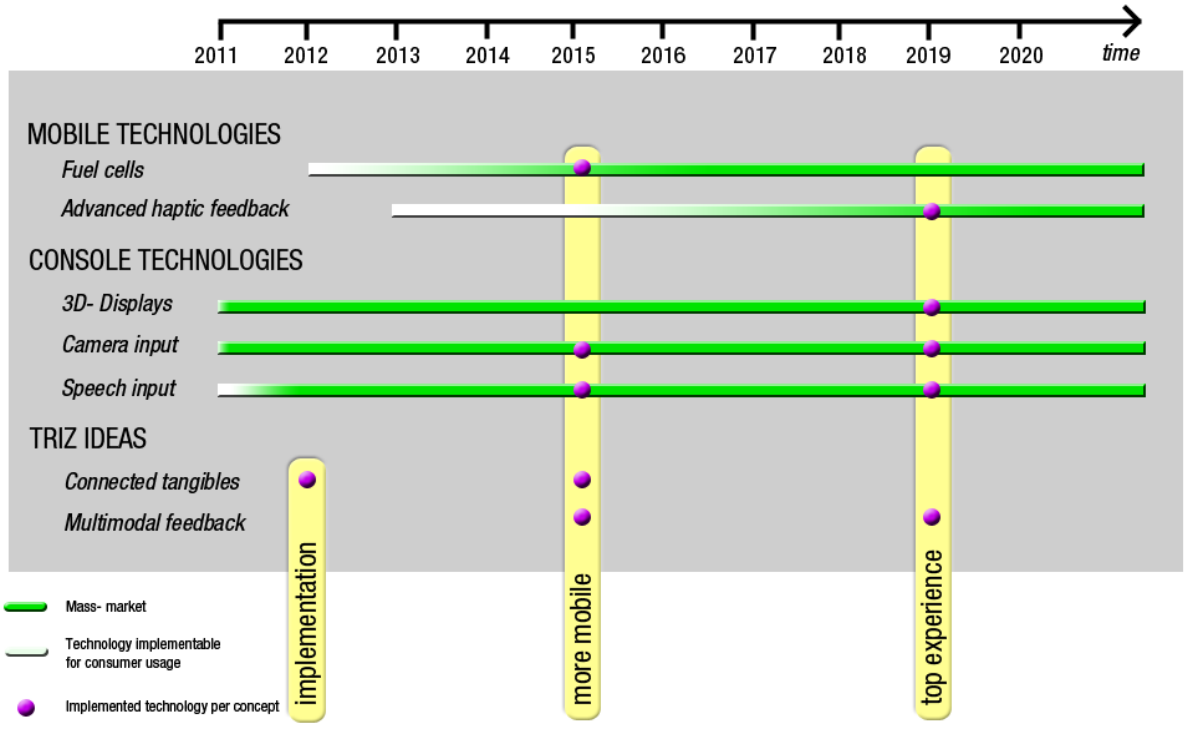

Figure 11.3 A proposed Technology RoadMap for the TagTile, focusing on therapy usage

v2 More mobile and modular

The second product needs alteration of the TagTile to make it more mobile. The proposed changes are also beneficial for the targeted market of primary schools. The usage of a fuel cell would make it possible to have a system without the need of plugging it in. The addition of speech input could help a child in selecting a game in a more natural way. Multimodal feedback should be emphasised to increase the fun. This could be done using the current audio and LEDs more extensively. But using a projection as well could improve the experience and fun by providing more detailed feedback and creating a new wow-factor. A camera could be used to allow movements without needing a firm grasp. The combination of both RFID localisation and camera input might look unnecessary as a camera could also locate objects. However a transition to directly using camera input only would introduce some problems with children grasping objects. The grasp or body obscuring the object could make placement of the object undetectable for the camera. A solution could be the frequently used camera detection from underneath for multitouch systems but this requires larger dimensions. The camera requires placement or install which could lead to problems for the revalidation centres. Secondly it could increase the preparation time again. The system and some games should therefore also be usable without the camera. Leaving a choice for the revalidation centre to include the technology or not, similar to the approach of Sony's Playstation Move. Only using tangibles brings the problem that either a good grip or applying tags to the body is required which will be a selling point for the camera module. To connect the camera output or pre-processed camera output with the TagTile a power efficient wireless connection has to be made. This connection should be chosen in a way that it can also incorporate the possibility of working together with other devices in the future. This design for modularity will prevent the need to redesign the TagTile itself for the third generation system.

v3 Top experience with new parts

The third version should be focusing more on the "top experience". The usage of fuel cells will be less essential for this version as this version will require additional power for some of the optional devices and a fixed space to show large 3D-images and use advanced haptic feedback. It is good to notice that the 3D might lead to problems for some children with reduced depth perception. The earlier focus on connected tangibles is omitted as the visual recognition will be refined to a level in which compensation can be more easily recognised. The usage of 3D-displays could also be done with a projection and this projector and camera could be installed somewhere in the room separately from the system. The proposed wireless communication already embedded in the second version can be used to connect the TagTile with the 3D-display, the haptic feedback system and improved camera. The experience is likely to be improved by adding the 3D technology and new ways of haptic feedback. The haptic feedback can also help with making the games adjustable for the range of capabilities by adjusting needed force. The advantage of using the modularity at this moment is that consumers might chose between different solutions either. The last two versions thus exist at the same time as end-users might chose to exclude 3D and haptic feedback. Not every therapy room will have the urge to install a camera and projector and might be more interested in the mobile aspect others might indeed be attracted to the increased experience. The last two versions could instead of making use of newly designed parts especially for the TagTile also make use of parts of consoles, applications or devices already created at that time.

Alternative

Depending on development and success in the coming years a total switch to another platform for interactive therapy with tangibles could be advisable. This platform would have to be able to track both tangibles and movements as well as track movements without tangibles, be reasonably priced and easy to prepare.

11.2.4 Targeted market

Applicable for all solutions is the need to increase the current possible market. To achieve this for primary schools SeriousToys is currently also targeting other languages than Dutch with the TagTile. The same is needed for games created for therapy to come to a viable market. It would otherwise be limited to the Netherlands as it is depending on spoken language. As the price is likely too high for individual purchase it would have resulted in only 22 systems for the about 22 revalidation centres in the Netherlands that could make use of the system. If English would be included, assuming the same rate of revalidation centres per inhabitant, approximately another 500 centres could be targeted (UK 70, USA 423, Australia 30, New Zealand 5). Although Spanish is a bigger language it might be better to target English first. As distribution and dialects could lead to bigger problems as native Spanish speakers are divided over much more countries. The Chinese market is hard to reach in short term as expenses will be too high for most Chinese and cultural difference might lead to other therapy techniques which are not investigated. Games should be designed in a way that the limited cultural difference of Western European countries would not lead to any problems. It might be good to see if games can be created that are also suitable for stroke patients as same kinds of therapy are needed. This could double the market as the revalidation centres could need more TagTiles.

A more price efficient device would allow it to also be used at home which would significantly increase the market. This way is not chosen as such a price reduction would be hard without fundamentally changing the tangible detection and feedback system thus no longer being a TagTile. For such a price efficient tangible system for therapy, the system has to go more into the direction of implementing the devices from a game console on a PC. Another option in that direction is using a camera processing software package that can be used with a simple webcam which is able to identify tangibles (using visual markers), for example the freely available Reactable software.

11.3 Conclusion

The TagTile has the advantage over other competitors that it can use a variation of tangibles and at the same time has a co-located input and feedback. This can help in training grasps and reduces the needed cognitive effort. The competition in the form of game consoles makes use of new technologies. Some techniques that no longer require the pushing of buttons make it more suitable for children with CP and making the TagTile less fun in comparison. The TagTile should provide new ways of making it fun in the coming decade. Another point of interest is an expected increase of need for efficiency in health care. The games on the TagTile should be focused more on the usage without supervision.

To provide this individual usage it is proposed to make more games with connected tangibles like the Pirateboat game. As such games can guide movements and prevent compensation making supervision less needed for the older children from the target group. To provide more mobility and additional fun a second generation system is proposed that is modular to make it suitable for future changes. This is done using wireless communication. To make it also more mobile it uses a methanol fuel cell (DMFC) as energy source. An external device that can be introduced at that moment is camera input for detecting body movements and using a projection for more fun feedback. This usage of a camera will support training movements that can't be trained otherwise. This is because some children can have a very limited grip making tangible interaction unsuitable. A proposed third generation system consists of additional parts that focus on the experience. This system includes a new way of feedback using ultrasound for haptic feedback and adaptive resistance. It makes use of 3D display or projection systems that will be more common around that time and not using it might look old fashioned in ten years. It will also use the camera input in a more sophisticated way observing more compensational movements and being able to automatically correct those movements.

A thread could be competition targeting home usage with having cheaper solutions. The proposed system is influenced only slightly hereby as most systems will likely have flaws (needed grasp, compensation, required cognitive level and/or obscured tangible problems) and thus be less suitable for the targeted market of revalidation centres. But to have a big enough market not only revalidation centres in the Netherlands for children with CP or stroke rehabilitation should be targeted but also similar revalidation centres in all native English speaking countries, about 500 centres in total. From this group only a part will actually buy the system. Even when all centres have bought a version, new games can still be sold.

12. Discussion and conclusion

This chapter concludes on the done work and gives an overview of the most important insights found.

12.1 Discussion

Children and design Being new to designing with children this research gave much new insight. As with any evaluation the differences between participants heavily influence the feedback and results gathered during interviewing. However in children this seems to be even more extreme as being interviewed by a non-known person is very intimidating for some of them. When a for the child familiar therapist repeated an unanswered question, that was asked to the child by the less familiar facilitator before, this now sometimes led to an answer. This also emphasises the importance of getting familiar with the participants before doing the tests especially for the younger group of two and three years old. This in turn shows the usefulness of for instance Druin's work with children as such lessons are pointed out there as well.

Strict scripted evaluations are very hard to perform with children as their responses are more unexpected and inventive. For instance a two and half year old child refused several times to put on the proper animal. She placed another type of animal two or three times and later on in the test she was totally distracted and was staring at the floor for some time. To still come to reusable and comparable data it seems to be good practice to report these occasions carefully. Another way is to use more extensive pilot tests to prevent certain actions influencing the tests and to prepare responses to questions asked by the children during tests that will be the least interrupting.

Alternative feedback Children seemed to react on the different types of sound and light stimuli positively. The children liked the newness of the device it made them curious. It would be nice to see if other alternative types of feedback would also be beneficial for experienced fun. For instance automatically moving parts could be introduced, a blower which is turned on or a flash which goes off as part of the game. Another interesting addition as is suggested in the roadmap could be making use of haptic feedback. To maintain the interest it could be nice to introduce these new feedback methods into the therapy. In the latest generation of games it is becoming more and more ordinary to have alternative input by guitars, body movements and DJ Tables. But most feedback types have remained very similar, maybe with the exception of gaming with a 3D TV which is likely to gain attention in the coming years and could be included as well. This haptic feedback might be another interesting step after introducing the alternative input of tangibles in interactive games.

Short future The games did bring additional motivation and fun to therapy and they trained the wanted movements. However the therapy sessions are quite hectic and using this kind of technology can be time consuming to prepare. This was one of the reasons the BlackBoard in a longer term evaluation was used only two times during a seven week period although during the previous tests the response of children and therapists was quite positive. The BlueBoard seems to help a lot in starting the games in an easy and more suitable way. The Pirateboat game will be reprogrammed and changed to fit on the Blueboard and some small changes will be implemented in the "Ik hou van Holland" game. Whether the BlueBoard and games with these changes will actually be successful as is expected can only be seen in a longer evaluation.

Longer evaluations A general habit of research projects is to stop at prototype or working level. This most of the times brings enough additional insight or proof for their hypothesis of the designed method/device/test etc. Sometimes implementation without the researchers being present will lead to other unforeseen kind of

problems. This could be seen in the disuse of the BlackBoard in the longer evaluation. The therapists were not triggered enough to use it and had a hard time doing the settings themselves. This gives an indication that although first use testing provides more insight in most cases longer evaluations can show essential problems in the design otherwise left unknown or unmentioned.

Compensation Compensation, circumventing particular movements, is a problem in training the movements, especially when the training should be done without supervision. The improving technology of gesture and movement recognition for instance with the Kinect and Wii are also promising for usage in therapy. The first examples are being developed and as the technology will develop it might be a solution to trigger supination and to prevent compensating movements more. Tangibles also have their advantages as in hand manipulation, pincher grasp and different grasps will be near to impossible to train in entertaining game-like environments without tangibles.

Adaptive vs adaptable systems To make a certain movements can take a long time and the program might adapt to that waiting with feedback or by supporting the effort. But it might also be that the child is distracted instead of having difficulty with the movement. In the first case no reminder should be given as it will disturb the training or frustrate the user, in the second case regaining the attention should be done. It is hard to make an automatic distinction between the two. To this end an adaptable adaptive game is suggested by the therapists. Thus having a setting to choose if the game should be adaptive or in what way it should be adaptive. In some cases the settings should then be done manually. The future versions might focus on making games adaptable as setting some parameters might be enough to make games suitable for a larger group. A good idea is to make saved settings loadable with choosing a certain tag. When several versions are created the settings must be saved easily and loaded automatically to prevent loosing time and to prevent an increase of needed effort for using the technology.

Methodology Most of the used techniques in the design process have been successful and efficient. Especially using active acting out design methods for designing movements are very useful for designing games for therapy for CP. The techniques might also be useful for designing devices for training stroke and traumatic brain injury patients. The ethnography led to implementable ideas but also to an overestimation of the target group. It is thus important to keep in mind some of the guidelines for an ethnographic study from Fetterman (2009) such as inter- and intracultural diversity, especially in such a shortened version that is used in a design process often. Using a technology roadmap was done to plan future versions of the TagTile. Most of the tools were easy to implement and provided innovative ideas which might not have been created otherwise. However, not all are realistic to implement. Another problem is that some implementations, using automated video analysis of movements and 3D feedback, make it more suitable for the competition to work towards the TagTile instead of the TagTile implementing this technology.

12.2 Conclusion

Three games are created for the BlackBoard version of the TagTile and one has been created to run on the BlueBoard. The created set of games train all wanted movements. Most games add entertainment and the last tested game gives an indication that the children are motivated in the wanted and expected way. The use of the TagTile is shown to be promising.

The overall methodology seemed to have worked well. The design methodology is fine-tuned to the available time and context of use. The set of to train movements were the basis for using the acting out of movements as a generative technique. This technique is a very effective and efficient design technique that can be used alone.

Interaction relabeling, that was made part of the technique of acting out movements, is also effective and efficient as a co-design method for creating TagTile games for therapy with two therapists. The ethnography led to directly implementable ideas. The feedback resulting from iterative evaluation was very useful in this case as well. The usage of SIT in the design session was not very efficient thus seems to be unsuitable for such shorter sessions of half an hour. But seeing the improvement at the end of the session could indicate that a longer session might benefit from the technique. The used combination for a co-design session starting with interaction relabeling followed by SIT at least seemed possible to give useful ideas.

The difference between children is big and adaptability seems to be a good addition. Adaptive systems can also be beneficial but might lead to problems because of the attention span problems that several children with CP have. An intermediate solution, letting therapist choose when to use an adaptive system and when to use pre-defined settings, is not yet investigated but might be most applicable.

Sound still seems to bring added fun to games even though it is not new anymore. Losing does not lead to extreme reactions in this group of children. It might even add extra motivation and feeling of fulfilment when in the next attempt one does win. An indication hereof was observed in one of the tests. No indication of being devastated by loosing was seen. The addition of an inter/intra-personal competition feature by using high scores did not lead to noticeable effects in the tests. A positive effect was only observed noticeably in the pilot when a child took on a very proud stance upon hearing he had a high score. The time needed to do a game is influenced by the age of the child.

When using the BlueBoard, the TagTile can be a useable and effective extra tool in therapy for children with cerebral paresis. The interactive tangible interface provides entertainment with games that use sounds and the coloured LEDs. Games on the TagTile can target several to be trained movements. The use of tangibles is especially useful for the training of grasps and in providing a natural form of interaction for children. If games for therapy on the TagTile indeed will be an effective extra tool for therapy on a longer term has yet to be found out.

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[i] Amy and Mike, *no title*, found on July 5th 2011. Google images http://4.bp.blogspot.com/-TVRpc-EVwKg/TfvN5qbEqhI/AAAAAAAAGkA/oqASysuoDPc/s1600/IMGP1626.JPG, www.someyoungs.blogspot.com, original 400x267 : Child unable to relax his wrist into a "natural" straight position.

[ii] Sergiy, N., *Proud for the first football victory teen,* found on July 27th 2011, Google images/CanStock photo http://www.canstockphoto.com/images-photos/head-first.html#file_view.php?id=3567091, up to 7500x5700 : Example of proud stance, similar to body language witnessed during the test

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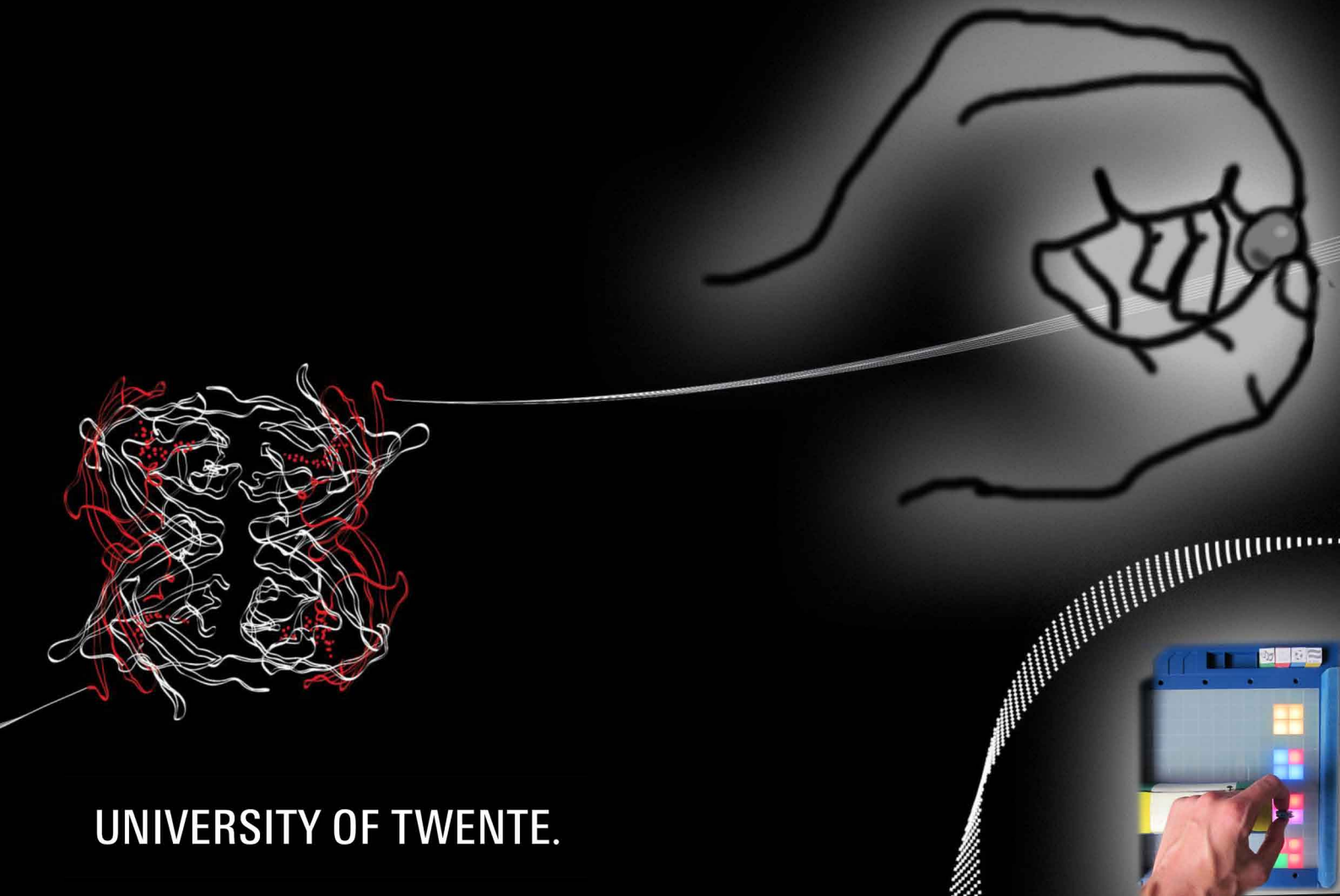
14 September 2011
R.W. van Delden
Master thesis
IDE & HMI

Appendices

Appendices A-J

accompanying the master thesis
"Design of therapeutic TagTile games
for children with unilateral
spastic cerebral paresis"



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Appendix A: Tests for children with Cerebral Palsy

For children with CP several tests exist to classify what their capabilities are. Most of these tests are described here. Not all are targeting children specifically. These tests can be used to verify that therapy is successful. For example the tests can be used to show that therapy with games designed on the TagTile outperforms therapy without the TagTile. The tests can be an inspiration for movements that have to be trained. Knowing the tests also gives more insight in the results of the different therapies. And lastly the tests are used as inclusion criteria for the Piratengroep at the Sint Maartenskliniek thus give more insight into the target group.

The Manual Ability Classification System is a rating system for children with CP. It is a categorisation process of the quality and quantity of the bimanual handling of objects needed in daily use with whatever strategy needed.(Eliasson, Krumlinde-Sundholm, Rösblad, Beckung, Arner, Öhrvall and Rosenbaum 2006)

The Fugl-Meyer Assessment (upper limb section) created for stroke patients gives a score on the amount of 33 upper body movements that can be performed (2pt) or performed partial (1pt). For example, rate the use of elbow flexion during an attempt to touch your own ears. The test on itself can already have a large variation due to test procedure and rating, making it harder to proof improvement of the patient due to therapy. (Deakin, Hill and Pomeroy 2003).

The nine-hole peg test (9HPT) is a timed test of placing 9 pegs upright into a board with holes and then removing them(UniversityofDerby 2010). In the research of Yancosek and Howell (2009) several other suitable tests can be found. The Jebsen Taylor hand function test uses timed subtests on functional tasks such as picking up objects, eating and writing. The Wolf Motor Function Test (WMFT) is a set of timed tests of six movements and nine functional tasks. The box-and-block test (BBT) requires moving blocks of 2.54cm to the other side of a box during 60 seconds.

Naylor and Bowler (2005) used a Quality of Upper Extremity Skills Test (QUEST) for assessing their treatment. According to their description it has four domains dissociated movement, grasps, protective extension, and weight bearing. It is designed and validated for children from 18months up to 8 years. It uses a scoring system for every domain and an average functional score for bilateral functionality. A perfect score is expected for a child with no disabilities, with exception of grasp for an 18months old.

Tests used at the Sint Maartenskliniek

At the Sint Maartenskliniek, next to the earlier mentioned MACS for inclusion, the Assisting Hand Assessment (AHA), the ABILHAND-Kids, the Melbourne Assessment of Unilateral Upper Limb Function, the Canadian Occupational Performance Measure (COPM), and the Goal Attainment Scale (GAS) were used. The AHA is an assessment based on observations on bilateral hand functionality in usual performance. It is meant especially for unilateral upper limb impairment. A session of 10-15 minutes is video-recorded. The kid plays with toys from the AHA test kit. This is scored on 22 items on a 4-point scale (Krumlinde-Sundholm, Holmefur, Kottorp and Eliasson 2007). The ABILHANDS-Kids is based on a questionnaire done by a parent of the child with CP. The parent is asked to rate activities as not-attempted or on a 3-point scale: impossible, difficult or easy. (rehab-scales.org 2007)

The original Melbourne Assessment targets children from 5-15 years. A modified version targets children from 2-5 years.

Both use

> *"16 different tasks are scored from a video tape on range of motion, accuracy, and fluency of movement" [...] "The COPM is a family-centered tool that lists the problem's experienced in daily life through a semistructured interview."*
> *(Aarts, Jongerius, Geerdink, van Limbeek and Geurts 2010, p. 4)*

The COPM results in a 10-point scale rating on current performance and satisfaction. When using the GAS the goals are changed into attainable sub-goals which are rated afterwards on perceived outcome. (Aarts et al. 2010)

A consideration to take into account when using the tests to determine efficacy of CIMT is the difference between children. The cognitive status, developmental changes, the appropriateness of test considering their age and the environment of testing can all influence outcomes. (Gordon, Charles and Wolf 2005)

Study results, the success of mCIMT

Gordon et al. (2005) minimised the risks by careful monitoring and making their therapy child friendly in several ways, such as the reduced intensity, the early positive feedback on effort and added fun of using toys and games. The risks mentioned include the loss of self-confidence by focusing on their impairment and injuries. They did not have substantial evidence for the efficacy of the costly method at that time. The test included 38 children fitting inclusion criteria, 37 successfully ended the program,

> *"1 child with high levels of frustration discontinued the program at the staff's request."*
> *(Gordon et al. 2005, p. 838)*

Naylor and Bowler (2005) used a single case A-B-A experimental design with nine children. In which 'A' stands for 4-week rest period from normal therapy. During B periods children did the modified Constrained Induced Movement Therapy (mCIMT), as mentioned earlier with manually holding the arm that functioned as a fixed restraint and using playful therapy. This was done with an intensity of 1 hour a day for a period of 4-weeks. The test QUEST was used at four times, once every 4 weeks: 'pre-test', pre-therapy, post-therapy and 'post-test'. They compared the scores before the therapy, after the therapy and the improvement during rest. Using the non-parametric Wilcoxon signed rank test on the means of pre- and post therapy scores they found a significant positive result ($p<0.01$).

A recent study of Sint Maartenskliniek used several tests to verify the effectiveness of their therapy method. After reviewing several tests with cIMT and forced use they concluded that earlier results from other research were positive but the effectiveness has yet to be proven with stronger evidence. From the initial 76 screened children 8 did not fulfil the cognitive inclusion criteria another 7 could not combine it with their daily school activities. Their test consisted finally of 50 participants allocated to one of two groups, Usual Care (UC) n=22 or the mCMIT-BiT(n=28), by throwing a dice. The mCIMT-BiT group shows more improvement compared to the UC group. After fulfilling the therapy a 13% improvement on the AHA test (2,5 times more than UC) and a 36% increase on the ABILHAND-Kids (7 times more than UC) was seen. The results of these tests 8 weeks later, without therapy, were still similar, differing 3% or less. Other tests also showed similar trends. COPM-P and COPM-S 117% and 110% improvement compared to 35% and 36% for UC. Melbourne 8% and 2% for UC. The GAS scores were improved for most of the mCIMT-BiT (82%) where only 23% of the UC group showed improvement of 2 points or more on these scores. (Aarts et al. 2010)

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Appendix B: Detailed description of a Piratengroep session based on a performed ethnographic study.

A session of the Piratengroep is described in a chronological order. Specific anecdotal situations are described to get an idea of the target group. Specific details about the games played and preferences for the future system to train the proper movements are also mentioned.

Six children were present during the Piratengroep sessions, five boys and one girl. The first individually observed child was a boy of three years old and the second boy was three and a half years old. From the other children two were four years old and two five years old.

The children are led to the door of the Piratengroep room by the parents. The children all have a small wheeled suitcase. In this suitcase a child has a toy or game suitable to his or her needs. This was lent by the Sint Maartenskliniek to play with at home in order to train specific movements. There is also a personal journal of the children in the suitcase. The tasks which have been done at home with the affected arm are being logged by parents in these journals. For example parents write down that a child has switched into his/her pyjamas without any help. When all the children sit down each of the journals are discussed. The children are rewarded with a sticker if they have done enough with their affected arm, based on the activities mentioned in the journal. When this has been done for all children, the next step is to switch into the pirate clothing.

One child has to go around with a bowl in which brought along fruit is done and this has to be put into the kitchen corner. Everybody gets a foam sword out of a box and this has to be waved around as shown by the therapists during a pirate song. Sometimes a child stopped waving the sword. When a sword fight was mimicked to interact with the child and regain concentration to the task, the similar waving movements continued to be made. The waving targets the extension of the elbow, supination and a firmer grasp. Some of the children were not moving their hands but their entire body instead; an example of a compensating movement. During the turning of the sword one of the children did not succeed, most of the others had trouble with the movement and one was performing very good and fast like a normal child would. One of the therapists high fived with one of the children as he participated so well. During the group phase a therapist announced her engagement. The only present girl seemed to be impressed by this theme of a wedding and was smiling about remarks made by the therapists of a princess bride.

After the song the children were assigned to a specific therapist this is the start of the individual phase. The whole set of activities thus far took about half an hour. In the following individual part the first observed child sat down in a corner of the room at a small desk facing the wall and an open cupboard. The seat for the child was small and adjustable in height with a larger one next to it for the therapist. The ethnographer took place on the other side. In the individual phase a number of games or toys are played with. As a first activity a marbles glide was used. A marble had to be picked using a pinch grip. This was explained to the child as: creating glasses with his grabbing fingers where he could look

through. In this way he had to pick up the marbles, see Figure 0.1 . The marble had to be released on the top of the glide. When the marble rolled down the index finger had to be extended in order to let the marble role out of the glide, this trained the extension of the index finger and coordination. Another task was to release a marble from index finger and thumb while keeping another marble in the same hand. These had to be released next, without using the non affected hand.

Figure 0.1 Holding a marble with a pinch grip

The next game was a board game using a dice with colours. When a colour was thrown the piece of that player could be moved to the nearest place of this colour. This place could than have an instruction for instance move x steps forward. After several attempts the child was still not following the described rules. According to the therapist he did not understand how to play the game because he was too young (3 years old). It seemed to be a problem for such a young child to deal with successive cognitive if-then statements.

The child was now allowed to choose a game or toy. The chosen box contained plastic puppets from Disney's Peter Pan and a rowing boat. These puppets were placed inside and outside a boat as the therapist requested the child to do so. This helped to train different grasps. The specific pinch grip was done automatically by the child when a puppet was hanged on the boat using a small attached string. At the end of the individual session, after about an hour of individual play, the attention was noticeably less. This could be seen by the child turning away, more frequently looking at other children. His name had to be called to get his attention back to the game. Because this concentration was lost; the therapist noticed it was time for the fruit break, which was according to the normal schedule.

The second observed child sat on the end of a large table facing into the room with a mirror right behind him. The child started with a wooden puzzle, this puzzle can be seen in Figure 0.2[i]. The pieces had to be taken out using a small handle on the pieces and put back again in the right place. Amongst others a fire man with fire truck and a doctor with an ambulance were depicted on the wooden puzzle. The child recognised the shapes and placed them back quite easily. Two times he looked at the therapist, smiled and then tried to put in the wrong wooden piece. The therapist corrected the child with a friendly voice "Noooooo, that is not the doctor".

After some different puzzles a box was grabbed with simple small plastic animals which had to be sorted. Some of the animals were picked from a box. The therapist instructed the child for instance to put all the black spiders back in one box and all the pigs into another. During this process the child was distracted by another child sitting at the opposite side of the table. This child was making animal noises and playing with clay. The sounds were soon also mimicked by another child. To stop the distraction the box was placed in the line of sight and this reduced the number of times the child looked away. The kid was trying to get out of his chair several times but was stopped by the design of the chair and by the therapist. He had also put something in his mouth and the therapist had to yell to stop him from doing so again.

The fruit brake was used to train eating with knife and fork. The fruit had been cut into pieces and put into a bowl. This bowl was placed on top of a placemat and the children all sat around the large table. During this break the therapists wrote down the observations/ conclusions they made of the sessions in their logs. Taking turns, two therapists would help while the others would write; this gave them all the opportunity to write. One of the children (5 years, male) could not grasp his fork and turn his hand good enough to eat on his own. Eating curly chips was hard for this child, the others succeeded better. During the last part the children played in the sand box. Only two older children (aged 5) tried to play together. The others were playing more on their own sometimes requesting help of a therapist or the ethnographer. Some conflict was seen when the followed child took a toy excavator away from another child. The other child willingly exchanged his toy after some seconds. The child that had difficulty eating also had problems with fantasy. He was asked by a therapist to make a 'sand tea' and later he actually drank the sand out the cup. Some of the therapists stated that this lack of fantasy and taking things too literal was seen by him before, although not this extreme. This was not seen with other children from the Piratengroep before in this extreme way.

Figure 0.2 Example of a wooden puzzle with firemen

One of the followed therapists stated during one of the two sessions that it would be nice if the envisioned system would also require several grasps as trained today. It would also be a plus if the attention was drawn automatically by the game.

[i] Van der Wal, F. (2010) 2 aparte houten puzzels van de brandweer en politie. Google images. http://www.marktplaza.nl/images/2/23/12873023.jpg, Leidschendam, Marktplaza. original 450x338: Wooden puzzle with firemen

Appendix C: Short description of the criterion fantasy

Fantasy is one of the four main criteria based on individual game play as are identified by Malone & Lepper (1987) to make a game intrinsically motivating. It could be used in the generation of future games for therapy to make these games more intrinsically motivating.

Endogenous and exogenous fantasy

Similar to intrinsic and extrinsic motivation Malone and Lepper(1987) define endogenous vs. exogenous fantasies. In which exogenous fantasies depend on the outcome but the outcome does not directly depend on the fantasy. For instance an exogenous fantasy could be when an answer is right that an animation starts to play. On the other side endogenous fantasy can be used as a metaphor and help constituting the mental framework thus making the outcome also depend on the fantasy.

Curiosity through fantasy by narratives

Although Malone&Lepper(1987) define curiosity and fantasy as two separate criteria; fantasy in itself could also lead to cognitive curiosity. An example of this cognitive curiosity was given by Malone and Lepper(1987) of people wanting to know more when information is inconsistent or incomplete: A brings B flowers, B is mad. This kind of curiosity could be triggered in a fantasy as part of a game leading to increasing intrinsic motivation.

The use of narratives can be a way to achieve this (Dickey 2006). Work of Dickey (2007) is used to explain this principle. It mentions two important ways for motivation: plot hooks and emotional proximity. These are literary techniques resulting in: “what is going to happen?” and the user identifying with a main character motivating further play. Several techniques are used to incorporate the story; these differ heavily based on the type of game. While action games like Doom often only have a backline story to lure one into playing the game (e.g. only presented on the case, in the manual or with an introductory movie), adventure games like Syberia (or Super Mario in a lesser extend) incorporate the story throughout the game (with cut scenes, which are often small animations intertwined in the game, but also with gathering items fitting the story line). An interesting hint for incorporating narrative storylines using the literary techniques is made by proposing earlier work on classical story lines of a quest or hero’s journey. The described techniques could lead to the wanted curiosity and thus intrinsic motivation of a game.

References appendix C

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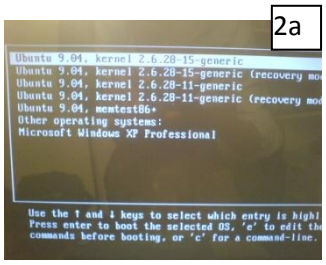
Appendix D: Manual for using the BlackBoard

Handleiding voor de zwarte TikTegel

Voor eventuele vragen kan contact worden opgenomen met de student Robby van Delden via mail robbyvd @ gmail.com *of telefoon 0614028248.*

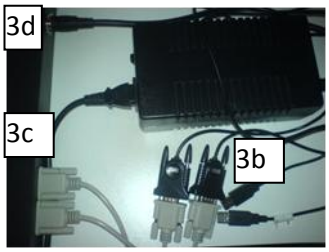


1. Zet de BOBIVA laptop aan

2. Selecteer met de pijltjes op toetsenbord Ubuntu 9.04 , kernel 2.6.28-15 -generic tijdens opstarten .

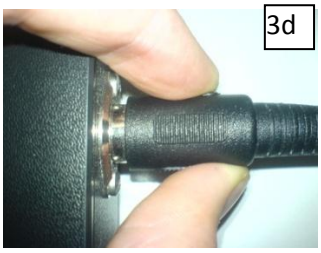
3. Sluit de kabels aan in willekeurige volgorde

a) zorg dat de 2 usb kabels aangesloten zijn op de laptop
b) zorg dat de verlengkabels (van zwart naar de grijze verlengkabel) goed aangesloten zijn, deze schieten nog al gemakkelijk los. Gebruik de grijze kabel ook omdat de zwarte kabels niet naast elkaar in het bord passen.
c) zorg dat deze verlengkabels aan de andere kant goed vastzitten aan het bord.
d) zorg dat de adapter aangesloten is op het bord, pijltje en tekst " TOP UP" juist naar beneden
e) zorg dat de adapter aangesloten is op een stopcontact
f) zorg dat de 6-hoekige stekker goed in de adapter zit.



4. Schakel het bord aan door de aan/uitschakelaar op de adapter op 1 te zetten

Een korte flits van een paar witte lichtjes moet volgen. Gebeurt dit niet controleer dan 2d en 2e of ga eerst gewoon verder want misschien heeft u de korte flits gemist.



5. Starten: klik op bureaublad TagTileTherapy aan

1.) Kies een spelletje en klik op het bijbehorende tabblad.

U wilt <u>geen</u> instellingen veranderen:

2*) Als u niets aangepast heeft klik op het icoontje links onderin en ga naar stap 6

U wilt <u>wel</u> instellingen aanpassen naar uw wensen en dat van het kind:

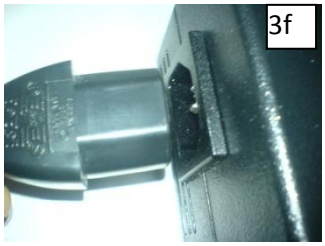
2) Lees de beschrijvingen en sleep vervolgens de 'slider' naar gewenste timing of klik net links of rechts van huidige instelling om de slider te laten bewegen, klik op de rondjes of vierkantjes om een keuze te veranderen.

Als u instellingen heeft veranderd klik op icoontje rechts onderin om het spel te starten,

3) Bevestig dat u de instellingen wil opslaan, doe dit onder de voorgestelde naam config.esp.

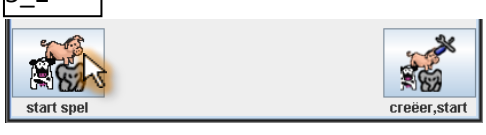
3**) wilt u deze instellingen vaker snel kunnen laden sla ze dan ook op onder een andere naam. Dit doet u door:

- op het icoon te klikken voor bewaren dat linksboven staat.
- het op te slaan onder een andere naam dan config.esp.
- u kunt nu de volgende keren op het laden icoon (3e van links bovenin) klikken en dit bestand selecteren en deze instellingen worden dan ingeladen. Om ze daarna te gebruiken in het spel moet u alsnog op rechts onderin klikken. Dus ook opslaan als config.esp zoals in 5.2 en 5.3 beschreven is.

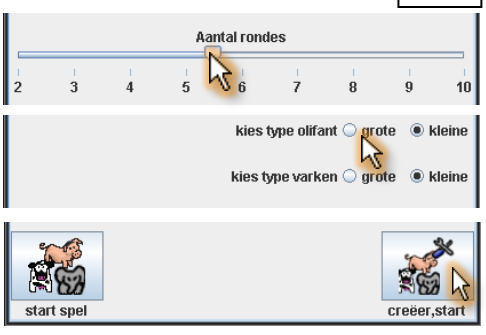


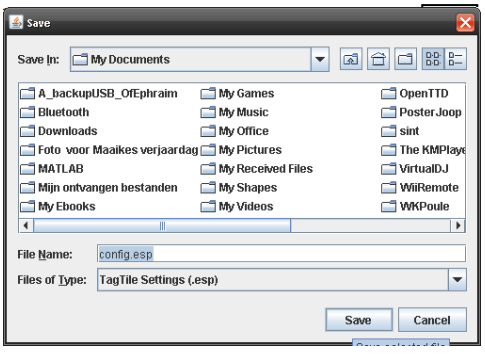
5_1

5_2*



5A_2

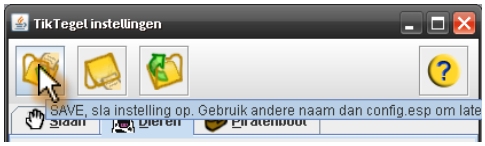


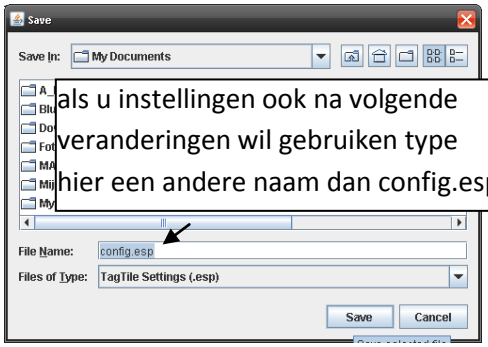


6. Spel beginnen: Wacht kort (ongeveer een minuut na veranderde instellingen), plaats nu het kaartje van een kind op het bord om de uitleg te starten en haal deze erna van het bord af om het spel te starten

Wacht tot het spel is ingeladen met plaatsen van het kaartje, in het zwarte scherm staat daarna de regel SUCCESS! of meteen ..application took…Het bord is dan klaar om het kaartje te zien. De uitleg kan nu gestart worden door een kaartje op het bord te plaatsen. Door het kaartje weer weg te halen begint het spel daadwerkelijk. Dit zorgt voor een duidelijk gecontroleerd begin zodat kinderen eventueel het spel nog een keer mondeling uitgelegd kunnen krijgen en niet afgeleid zijn door het bord voor ze het spel echt snappen. Ook als gekozen is voor geen uitleg moet nog steeds op deze manier, door plaatsen en weghalen het spel gestart worden. Soms is het nodig om nog een keer
het kaartje op het bord te plaatsen en ervan af te halen.

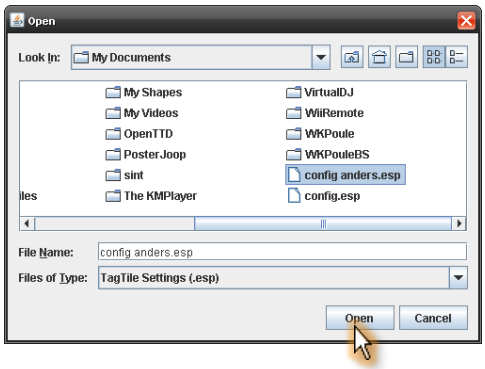
5_3**

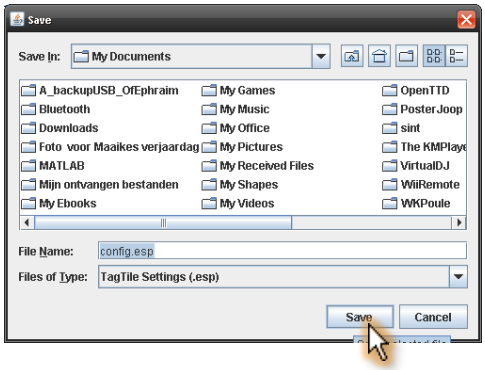




als u instellingen ook na volgende veranderingen wil gebruiken type hier een andere naam dan config.esp

*5_3** vervolg: De instellingen zijn door iemand veranderd*





Problemen:

Probleem: Tijdens starten hoor ik wel de stem/geluid maar toont het spel vervolgens geen lichtjes.

oplossing: *weet u zeker dat u het kaartje/startblokje weg heeft gehaald nadat de uitleg klaar was? Doe dit eventueel nog een paar keer. Of controleer de usb kabel en verlengkabels waarschijnlijk zit de aansluiting wit-zwart los, heel misschien ligt de kabel te dicht bij een grote stroombron (stekkerblok of de adapter)*

Probleem: Tijdens het spelen is 1 van de tags(=sensor rondje) kwijt geraakt

oplossing: *vervang de tag, vertel de computer nu welk nummer deze tag heeft. Open startmenu, tiktegel scanner. Een venster opent, plaats vervolgens de nieuwe tag, een groot nummer verschijnt in het venster lijkend op 831606252, schrijf dit nummer op. Open tags.esp voor de tags van dieren of tags2.esp voor de tags van de boot of de kinderen, beide staan in de map Games. In een van regels staan beschrijvingen van de objecten genoemd met daarachter bv = 831606252. Vervang nu het oude nummer door het nieuwe nummer dat net opgeschreven is. De beschrijving voor dieren bestaat uit de eerste drie letters van de Engelse naam van het dier.*

Probleem: Tijdens het spelen hoor je een 'toenk' foutmeldingsgeluidje en komt er een pop up met teksten zoals "..in container"

oplossing: *het spel is vastgelopen door onverwachte samenloop van omstandigheden en/of verkeerd geprogrammeerd spel, probeer de pop up weg te klikken, eventueel door op enter te drukken als in het andere scherm hierom wordt gevraagd en start het spel opnieuw op. Soms moet dan nogmaals het spel opnieuw gestart worden voor het normaal draait.*

Probleem: Tijdens het spelen gaat er iets fout met uitvoering en je wilt het spel opnieuw opstarten.

Oplossing: *druk in het scherm [plaatje terminal] op ctrl-c daarna ook in terminal op enter als deze nog niet weg is. Start spel opnieuw op (stap 5).*

Probleem: De instellingen kloppen niet en er gebeuren rare dingen.

Oplossing: *gebruik stap 5A en druk op reset, start vervolgens een spel door rechts onderin te klikken.*

Probleem: Geen van de oplossingen heeft gewerkt

Oplossingen: *Als terminal nog niet gesloten is: druk op ctrl-c.*
Sluit programma dan nog steeds niet af, klik dan op het kruisje van het terminal scherm.
Als terminal (het zwarte DOS scherm) weg is kan nog de adapter opnieuw aan en uit gedaan worden.
Reset de instellingen door in TikTegelTherapy op reset (de middelste knop bovenin) te drukken. Start daarna spel (nogmaals) opnieuw op: negeer eventuele foutmelding en klik deze weg.
Werkt dit allemaal nog niet, probeer dan alle kabels opnieuw aan te sluiten. Leg ze niet over de adapter en rol ze het liefst zo veelmogelijk languit. Doe de adapter nogmaals aan en uit. Waarschijnlijk heeft het geen zin maar eventueel kan de computer nog opnieuw opgestart worden. Neem anders contact met iemand anders die meer van het bord weet.

Probleem: U wilt geen TikTegelTherapy programma gebruiken om instellingen te veranderen maar gewoon snel steeds een bepaald spel openen:

Oplossing: *Het programmatje slaat bepaalde instellingen op maar steeds onder dezelfde naam. Dit betekend dat van elk spel maar 1 versie aanwezig is. Om toch bepaalde instellingen vaker te gebruiken moet u 'ingewikkelde' dingen doen wat daarom* ***wordt afgeraden*** *ivm stabiliteit van het spel. Nadat een spel met de juiste instellingen gestart gestopt is, kunt u van dit spel een kopie maken. Dit doet u door van de .ebc versie van het desbetreffende spel (eindigend op Jar) een kopie te maken met een andere naam in dezelfde map. U kunt vervolgens deze openen met de ebc-player. Het is goed om te weten dat een gecompileerd spel als extensie(bestandstype) .esp heeft en een gecompileerd spel .ebc. Oftewel een .esp moet eerst omgezet worden naar een .ebc en kan dan pas gestart worden. Voor een .ebc hoeft dit niet en kan daardoor veel sneller worden opgestart. Een .esp kan behalve met de TikTegelTherapy ook in de terminal worden gecompilleerd. Dit doet u door naar de juiste map te gaan in de terminal en dan het commando: sudo espranto [bestandsnaam met .esp]. Vul vervolgens het wachtwoord [smkergo] in. Het starten van een .ebc in deze terminal kan door: ebc-player [bestandsnaam met .ebc].*

Appendix E: Longer evaluation

Set of hypotheses

Hypothesis 1:
The games on the board are entertaining alternative for training the movements (with exception of training supination at the moment).

To test this hypothesis it is split in several sub-hypothesis which should amount to this verification of the hypothesis.

Hypothesis 1.1:
The amount of play is not drastically reduced after some time.

A wow-factor could be the only reason for playing the games and is likely to be gone after some usage but this will not be the case here. If usage is however reduced drastically over time it is likely to be because of this wow-factor. This would mean not the entertaining value of the games but the wow-factor of the board and technology seem to be the main reason for playing.

Measurements: The number of times each child plays the games.

Hypothesis1.2:
All three games are entertaining.

When all the three games are entertaining the games will be played roughly the same amount of times. This will be at once a week on average per person.

Measurements: A) The number of times each child plays a specific game. B) The interpretation of the therapists on enjoyment of the games compared to alternative methods using a 5 point Likert-scale survey.

Hypothesis 1.3:
The games train the same movements with exception of supination as effective as other used toys and games do.

Children are triggered to make the movements which need to be trained during the games. Compensating movements are inhibited.

Measurement: The interpretation of the five therapists on effectiveness after seeing the children playing the games, compared to alternative methods using a 5 point Likert-scale survey.[1]

Hypothesis 1.4:
The game can be prepared quickly for use

If this takes too long time the therapists will state this and it will result in a decline of usage, thus making it no alternative for current use.

[1] A*n alternative method would be to use a comparable control group not using the board in the therapy sessions and to compare their results. Both groups would need to make a hand function test for indication of abilities of the upper extremities before and after the therapy. For instance the Jebsen Taylor hand function test, Wolf Motor Function Test (WMFT), box-and-block test (BBT), the Fugl-Meyer Assestment: Upper limb section or the nine-hole peg test (9HPT) could be used for this. This is however out of the scope of this research.*

Measurement: Opinion of the therapists in a 5-point Likert scale questioning whether the games could be prepared fast enough.

The following hypothesises are part of secondary goals of the test.

Hypothesis 2:
The game adaptability is a wanted added function for the games.

The therapists know how to use the program for changing settings and will use this because of the differences between children. They will also use the personalized keys which indicate which child is playing.
Measurement: A) The used settings and changes of settings per child over time. The changes per child per attempt after fine-tuning to the child are less than the changes made between the children.
B) The opinion of the therapists tested in a 5-point Likert-scale did they use it and did they like the functionality.

Hypothesis 3:
The games can be further improved

During use the therapist will think of improvements for the games. This is more likely to be forgotten after some weeks when it is not written down.
Measurement: Number and type of remarks by children and therapists made about the games. This will be recorded in a journal lying next to the board.

Interview question list

0. (added) Hoeveel therapie sessies zijn er geweest voor deze piratengroep nadat het bord klaar stond (vanaf 20 April dus)?

---

1. Hoe vaak hebben jullie in de afgelopen weken ongeveer met het bord gewerkt?

---

2. Wat zijn de redenen om het bord wel te gebruiken? En wat zijn de reden om het juist niet te gebruiken

---

---

3. Hoe lang denk je erover te doen om het diertjes of slaan spel op te starten? (Evt melden 3-6min)

---

4. Welk aspect van de spellen had anders moeten zijn om het vaker te gebruiken?
   - Als de spellen attractiever voor de kinderen zouden zijn of betere training zouden geven waren ze dan vaker gebruikt?

---

5. Behalve ……. wat kan nog meer aan de spellen verbeterd worden? *(bijvoorbeeld al aangegeven palmair flexie in survey, aantrekkingskracht in vorige vraag)*

---

6. Zijn er nog speciale ontwikkelingen in de Sint Maartenskliniek geweest sinds de start van mijn afstudeeropdracht: reorganisaties, in twijfel trekken budget /eventuele subsidies of vergoedingen voor piratengroep?

---

7. Welke andere tests zijn er geweest bijvoorbeeld iets van Patrick of van Suzanne of Pauline?

---

8. Zijn er nieuwe of aangepaste methodes uitgeprobeerd in de afgelopen paar weken, indien ja, welke?

---

9. Wat was handig/onhandig aan dat je je eigen instellingen kon maken? *(voordeel via een programma op de laptop komt ook later)*

   - zouden enkele standaardinstellingen ook genoeg zijn, zoja hoeveel?

   - In hoeverre zou het handiger zijn als de respons van het kind automatisch gemeten werd (adaptief testen), en op basis daarvan de instellingen van het spel automatisch aangepast zouden worden, bijv langzaam slaan→ grotere verspring tijd.

---

10. Je zou ook instellingen op het bord kunnen maken, zoals de USI studenten blijkbaar ook hebben gedaan, doormiddel van een blokje links of rechts te leggen. Of bijvoorbeeld het neerzetten van dieren die je wilt gaan gebruiken. Wat lijken jullie de voordelen en nadelen aan deze twee varianten, programma op PC of op het bord?

---

11. Wat zou je dus handiger vinden om de aanpassingen te maken via het bord of via het scherm?

---

12. Welke van mijn spellen vinden jullie het leukste en waarom?

---

13. Welke van mijn spellen was het minst leuk en waarom?

---

14. Welke van mijn spellen zou je het vaakst gaan gebruiken en waarom?

---

15. Welke van mijn spellen zou je het minst gaan gebruiken en waarom?

---

16. Is het aantal repetities dat gedaan wordt genoeg in een spel of zouden er nog meer in een spelletje moeten kunnen?

---

17. Welke ervaringen hadden jullie met de TikTegel voor mijn spellen?

---

18. Zijn deze ervaringen veranderd die jullie voor de spellen van mij/USI studenten hadden? (bijvoorbeeld het gedoe met opstarten)

---

19. Toen ik hier kwam kreeg ik te horen dat de huidige spellen niet goed werkte en af en toe vastliepen, hoe ging dit bij mijn spellen?

---

20. Als je mijn spellen vergelijkt met die van de USI studenten wat is er dan beter aan hun spellen?

---

21. Als je mijn spellen vergelijkt met die van de USI studenten wat is er dan beter aan mijn spellen?

---

22. De spellen van Ying Li zijn nooit gebruikt, wat was volgens jullie de belangrijkste reden?
    - Ik begreep van Willem Fontijn van Serious Toys en uit zijn paper dat dit ook vooral te maken had met het aantal kinderen dat in staat was het spel te gebruiken en compenserende bewegingen (wrist/palmair flexie), klopt dat?

- Als je het vergelijkt met mijn spellen zie je dat dan als een vooruitgang of heb je weer te maken met dezelfde problemen?

---

23. Het bord heeft de mogelijkheid om verloop van spelletjes vast te leggen. Denken jullie hier iets me te kunnen doen en zo ja wat zou je dan willen gebruiken?

---

organisatorisch 1 : in verband met het zwangerschapsverlof van Ingrid, iemand moet (delen van) het verslag doorlezen en waarschijnlijk goedkeuring geven voor sommige gedeeltes zoals beschrijving therapie. Het zou ook zeer gewaardeerd worden als iemand een middag bij eindpresentatie aanwezig kan zijn in begin September.

---

organisatorisch2: Is het al zeker dat ik de spellen kan testen in Augustus met de wat oudere doegroep? Welke bewegingen willen jullie dan terug zien in dat spel? Wat moet er nog meer anders volgens jullie?

---

organisatorisch3: Zouden jullie of 1 of 2 andere therapeuten eventueel bereid zijn om mee te doen aan een korte ontwerpsessie in begin Juli?

Organisatorisch 4: Hoe verliep de test met de USI studentenen wanneer was dit gedaan?

Organisatorisch 5: Zouden jullie de vragenlijst ook aan Jan, ?Marriete? en Suzanne kunnen geven en naar me opsturen?

Organisatorisch 6: Kan ik in begin Juli het blauwe of zwarte bord weer lenen om daarmee aan de slag te gaan?

Survey usage TagTile

Deze vragenlijst bestaat uit twee kantjes met in totaal 18 stellingen waarbij uw mening ingevuld moet worden. Dit duurt ongeveer 5 minuten om in te vullen. De resultaten worden anoniem (in hoe verre dat mogelijk is) verwerkt. Bij elke stelling is er de mogelijkheid om Niet Van Toepassing in te vullen mocht u het bord nooit daarvoor gebruikt hebben.

1. De kinderen vinden het geheel van alle oefeningen bij de piratengroep met deze spellen erbij leuker dan zonder deze spellen.

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

2. De kinderen wilden graag nog een keer het spel met het bootje doen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

3. De kinderen wilden graag nog een keer het spel met slaan met het bandje doen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

4. De kinderen wilden graag nog een keer het spel met de diertjes doen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

5. Het spelen van de set spellen is even effectief (of effectievere manier) om gewenste bewegingen te oefenen. In vergelijking met de huidige set van methodes die gebruikt wordt in de Piratengroep zoals gebruik van de kleine voorwerpen zoals kraaltjes rijgen/de houten puzzels/de knikkerbaan/het omdraaien van de kaarten en het actief meedoen met liedjes.

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

6a. Minstens één van de spellen kan gebruikt worden om dorsaalflexie te oefenen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

6b. Minstens één van de spellen kan gebruikt worden om het strekken van elleboog te oefenen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

6c. Minstens één van de spellen kan gebruikt worden om pinchgrip en andere grepen te oefenen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

6d. Minstens één van de spellen kan gebruikt worden om de coördinatie te oefenen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

6e. Minstens één van de spellen kan gebruikt worden om krachttraining (meerdere herhalingen) te doen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

7. In minstens één van de spellen werd tijdens de oefeningen palmair flexie gebruikt

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

8. De spellen(inclusief randapparatuur) kunnen snel genoeg worden klaar gezet en opgestart

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

9. Ik vind het handig dat de spellen buiten de Piratengroepzaal zelf staan

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

10. Ik gebruikte het programma op de laptop iedere keer om de instellingen van het spel aan te passen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

11. Ik wist hoe ik het programma moest gebruiken om instellingen aan te passen

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

12. Deze spellen kunnen ingezet worden in de therapieën van de piratengroep.

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

13. Andere nieuwe spellen voor het bord zouden ingezet kunnen worden in de therapie van de piratengroep.

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

14. Het zwarte bord kan gebruikt worden als onderdeel van de therapie van de piratengroep.

NVT O

1. Helemaal mee oneens	2. Oneens	3. Noch mee eens, noch mee oneens	4. Eens	5. Helemaal mee eens
O	O	O	O	O

Survey Answers

Table 1, Survey results

question	P1	P2	P3	P4	Avg	Median	Mode
1	4	4	3	3	3,5	3,5	4
2	3	2	4	3	3	3	3
3	2	3	5	4	3,5	3,5	#N/A
4	4	5	3	4	4	4	4
5	3	3	3	3	3	3	3
6a	4	4	4	4	4	4	4
6b	4	4	4	4	4	4	4
6c	4	4	4	4	4	4	4
6d	4	4	4	nvt	4	4	4
6e	2	3	4	4	3,3	3,5	4
7	4	4	4	4	4	4	4
8	2	2	3	3	2,5	2,5	2
9	4	3	5	4	4	4	4
10	4	2	2	nvt	2,7	2	2
11	4	4	2	nvt	3,3	4	4
12	4	3	4	4	3,8	4	4
13	5	4	4	4	4,3	4	4
14	4	4	4	4	4	4	4

remarks 6e: power 2, repetition4
5: animals 4, wrist (hitting) 1, boat 3
6e: reaction time also plays role

Transcript interview

Legend

[???] = inaudible word

Cursief = Robby (interviewer/researcher)

Normaal = Ingrid(Occupational therapist/ company tutor)

<u>Underlined = Ruth(Physiotherapist)</u>

Present: Robby van Delden (interviewer researcher), Ingrid(Occupational therapist/ company tutor), Ruth(Physiotherapist)

Ik neem het gesprek even op want ik moet het straks helemaal uitschrijven. Helemaal goed

1. *Hoeveel therapie sessies zijn er geweest voor deze piratengroep nadat ik het bord hier neer heb gezet?*
   Niet zo veel, schandalig
   Nee de sessies zelf,… vanaf 19 April dus
   3x6=18 , 18 één handig
2. *Hoe vaak hebben jullie in de afgelopen weken het bord gebruikt? [zie ook 34]*
   Hebben het aan het begin gebruikt.
   <u>Twee handige fase hebben we dat niet meer gebruikt want dan werken we aan de tweehandige [???]</u>
   Ja en dan nog 2 keer sinds hij aan is, dan is ie 4x gemiddeld per kind gebruikt
   <u>Ja</u>

3. *Wat zijn de redenen om het bord wel te gebruiken?*
   Sowieso dat het iets anders is.
   Het lokt wel uit, ook wel voor kinderen is het weer wat nieuws. Sommige spellen zijn gewoon leuk voor kinderen om te hebben. Dat wil ik nog wel vaker kunnen doen zeiden ze ook
   Ja
4. *En wat zijn de reden om het juist niet te gebruiken*
   De techniek
   Ja het klaarzetten,
   Het klaarzetten is helemaal niet moeilijk maar je zit toch met die snoeren
   Ja en het staat toch in een andere ruimte en dat is wel fijn dat het in een andere ruimte staat maar ..
   Maar voor het klaarzetten niet
   Het moet vanaf vandaag ook meer in ons systeem komen van dat je denk oja ,
   Ja dat gaan we gebruiken
   Dat gaan we gebruiken ook omdat je het dan dus niet in je vizier hebt, dat je denkt dan kan ik nog wel eventjes toepassen, misschien kan ik dat spel gebruiken.
   En de techniek is dat dan vooral dat klaarzetten wat je lastig vindt?
   Ja dat is vooral dat klaarzetten
   Hij liep toch nog een soort van vast
   Hoe was het nou ik ben het even kwijt wanneer gebeurde dat nou toch
   Ja maar liep die nou vast? Het ook hoe je hem moet wisselen, van de een naar de andere
   Van het een naar het andere spel?
   Dat je even moet kijken van hoe en wat
   Ja en dan is dat kind ….als je dan 1 op 1 bent met het kind,dat is dan gewoon nog niet zo handig, dan snapt dat kind niet zo goed waar je mee bezig bent
   Dat zou dan nog eenvoudiger kunnen
   Wat vind je dan belangrijkste reden [Ruth] van die twee is het dan de techniek en hoe je het klaar zet en hoe dat makkelijk te gebruiken is? Of is het dan dat je het in de andere ruimte moet hebben dat je dus uit de zaal moet gaan?
   Ik denk dat vooral is dat het niet in de ruimte staat en dat ik hem daarom minder snel gebruik
   Maar goed het andere heeft er ook weer mee te maken..
   Ja precies
   Want als je dan met het kind weggaat moet het ook meteen werken eigenlijk
   Ja want dan ga je misschien wel makkelijk
   Vind jij [Ingrid[dat dan ook het belangrijkste
   Nee ik vind vooral dat klaarzetten
5. *Hoe lang denk je erover te doen om het diertjes of slaan spel klaar te zetten?*
   Ja 10 minuutjes zeker,
   Ja
   Het zou mooi zijn als het gewoon draait, zoals het spel zoals we dat nu hebben met de E-Link.
   Dat hebben we nu eventjes niet, maar dan het staat dan ook gewoon niet klaar en dan gebruik je het gewoon minder, zoveel tijd hebben we ook niet individueel met dat kind,
   nee
   Dus dan wil je ook meteen aan de slag kunnen . Als je nu een doos pakt dan denk je hupakee ik ga meteen aan de slag en dan binnen een minuut ben je bezig met een kind, dus dat moet inderdaad geen 10 minuten duren

   - *Owkee. En die E-link wat is dat dan?*

   De E-Link dat is van Biometrics

TJaaaaaa

Als je dan E-Link en Biometrics intypt dan zie je het, daarmee kan je kracht meten en bewegingsuitslagen. Maar daar kan je ook spelletjes mee doen

Maar ook daarbij is het weer die link met die spelletjes, dat vind ik ook heel onduidelijk. Dan heb je het kind wel opgeslagen maar dan moet je op een gegeven moment snappen wat dan het level is van dat kind. Dan mis je als therapeut gewoon het inzicht in hoe zo een programma makkelijk werkt

En dat maakt natuurlijk uit doe je het heel veel dan gaat het steeds makkelijker

Maar gebruik je het niet veel dan moet je altijd weer denken hoe was het ook alweer

ja

jah

6. *Welk aspect van de spellen zelf had anders moeten zijn om het vaker te gebruiken?*

Bij de polsbandjes, de bandjes zelf, die zaten bij sommige kinderen niet lekker of die verschoven. Of het was ook onduidelijk dan had je hier het bandje, op zich het idee was goed. Was ook prima maar we hebben dat kennelijk dan toch overschat dat zo een kind niet snap dat hier een zendertje zit en waar je die dan moet drukken.

Ja hij moet dan vrij precies er opkomen

Ja en dat ging dan ook vaak mis?

Ja die polsbandjes. Dat met die dieren wilden ze echt herhalen “o mag ik nog een keer”, en dan zelf die dieren uitzoeken, dat was al een activiteit op zich. Die bandjes dat was dan als dat klaar was dan was het ook goed

Ja weet je wat het is, het is natuurlijk zo voor de kinderen is, is het soms al mooi dat ze gewoon hun pols recht kunnen houden. En moeten ze dan ook nog dorsaalflexie maken en dan nog richten, dan wordt het gewoon lastig, dus dan zal het bij wijze van spreke ook schuin kunnen zijn. Dan heb je weer niet dat dorsaalflexie moment en dan is het ook maar weer lukraak. Dus misschien voor de veel betere kinderen dat dan pas kunnen doen. Maar daarin zit je dan toch vaak weer meer op de wat fijnere motoriek, dan op de dorsaalflexie

Dan hebben ze dat toch al vaak gehad

En de optie om er gewoon op te slaan in plaats van dat je ook het pols op het bord moet houden ?

Ja op zich dat werkte ook maar dan nog is dat richten vrij lastig.

Ja en dan kwam alleen de hand op het bord en dan was de pols nog niet op het bord en dan pakte ie hem niet.

Ja maar je kon ook zonder

O ja o wat erg

als je dan zonder deed dan maar ja dan nog zat je met dat richtten

O ja dat blijft ja dat blijft een probleem

Maar op zich die feedback van houdt je pols op het bord dat was dan wel weer goed

Dat was weer duidelijk?

Ja

- *Was dat niet te streng?*

Nee,

Nee op zich niet, nee

7. *Behalve dat pols bandje wat zou dan nog meer aan de spellen verbeterd kunnen worden? [ORG Behalve ……. wat kan nog meer aan de spellen verbeterd worden? (bijvoorbeeld al aangegeven palmair flexie in survey, aantrekkingskracht in vorige vraag)]*

Ja dat was bij die boot, dan richtten ze goed dan dacht ik ook waarom doet hij het nou niet die reactie snelheid lijkt anders te zijn ofzo
Ja het gaat dan gewoon te traag
Ja dat is dan wat jammer want dan hebben ze reactie gegeven of dan hebben ze wat gedraaid en dan "poef" denk ik dan en dan gebeurde dat niet
Ging dat lichtje dan ook mee
Nee niet altijd en dat snapte ik niet. Ik kon nog niet achterhalen wanneer ie nou wel of niet goed deed
Dat is heel lastig, waarschijnlijk dat het een prototype bord is denk ik.
Ow dat is dus gewoon een beperking van het bord
Je kan gewoon 1 keer per 200 milliseconde alles uit lezen maar als je dan ook nog eens wat moet tekenen dan gaat het gewoon langzamer.
Ja
Volgens mij ….kon dat niet veel beter.
Op zich was die boot heel leuk. Daardoor was het nu ook met de boot die afgelopen keer zoiets van laat maar. Dus die hebben we toen ook niet bij alle kinderen gedaan. Toen weer bleek van het is eigenlijk jammer. Want op zich het idee dat was heel goed…. vind ik nog steeds ook.
Ok… de beweging die zou er wel in zitten zeg maar
Ja
Ja ,.. jah

8. *[ORG eerder] Als de spellen attractiever/ uitdagender zouden zijn zouden ze dan wel vaker gebruikt worden*
Op zich
Ja ja op zich … met die beestjes dat is leuk genoeg voor die kinderen,
Ja
Daar hoeft niet nog meer disco omheen hoor. Ik bedoel dat beestjes niveau dat was goed
Ja ja precies
En die boot dat was op zich ook goed
Maar ja dat slaan dat is dan minder dat ze dan minder denken van ja wat doe ik nou
Ja
Dat kan nog wat aantrekkelijker. Dan hebben kinderen, dat is ook lastig, het idee dat ze meer kunnen, dan moet je weer beetje bij helpen of wat dan ook. Ja het succes is wat minder leuk en dan willen ze niet zo snel nog een keer
Ja

9. *En als het meer training in zo een spelletje zou zitten, dus dat het iets effectiever werkt. Nu had je bijvoorbeeld bij die dorsaal flexie dat wordt wel getraind maar dat was nog niet helemaal goed. Omdat je bij die kinderen die het dan niet kunnen, die kunnen het dan ook net niet trainen dus dan zou je eigenlijk iets moeten maken dat dan zulk soort verbeteringen erin brengt. Zou het dan vaker gebruikt worden denk je?*
Ja
Ja dat denk ik wel ik denk dat
Ja ja
De grootste belemmering was niet het dierenspel, die was juist goed. De techniek
Ja

Waar zette je het bord dan neer?
In dat hokje

En de laptop?
Op de plank en dan zit je sowieso wel met de draden dat je zelf niet valt. Voordeel is wel dat aandacht bij het spel blijft omdat het een andere ruimte is.
Als je een vaste opstelling hebt zou dat al weer makkelijker zijn

10. *Zijn er nog speciale ontwikkelingen in de Sint Maartenskliniek geweest sinds de start van mijn afstudeeropdracht: reorganisaties, in twijfel trekken budget /eventuele subsidies of vergoedingen voor piratengroep?*
    Nee
    Nee
11. *Welke andere tests zijn er geweest bijvoorbeeld iets van Patrick of van Suzanne of Pauline?*
    Nee van de USI niks [niet in de afgelopen weken]
    Wat we volgende week hebben is weer een pilot. De VA zijn we nog steeds aan het verbeteren, de VOAA, daar zitten we nu in afrondende fase van. Dat is een voor en na meting van de hele groep die er geweest is
    De USI studenten zijn rond December hier langs geweest,
    Pattrick, heeft alleen een interviewtje gedaan, verder niets
12. *Zijn er nieuwe of aangepaste methodes uitgeprobeerd in de afgelopen paar weken, indien ja, welke?*
    Ja de Popgroep en we hebben nog de Tovernaarsgroep. Die is voor de Piratengroep geweest. Die groep was vooral voor kinderen die problemen hadden met de praxis, het handelingsplan.

13. *Wat was handig/onhandig aan dat je je eigen instellingen kon maken? (voordeel via een programma op de laptop komt ook later)*
    Het was fijn dat je de snelheid kon veranderen. Bij de dieren was het fijn dat je ook de kleine dieren kon pakken in plaats van de grote of allebei.
    Er was ook bijvoorbeeld een jongetje die haakt snel af, die heeft wat meer last van kleurenblindheid, dan was het makkelijk dat je dacht dan doe ik alleen die die en die. Dat je niet te veel variatie hebt, als je ze allemaal hebt dan zien ze het niet meer. De reactietijd schiet dan ook niet op terwijl ze best een redelijk greep hebben. Dus bij de één kun je dan naar wat meer dieren gaan.

    Als het kind dan kleurenblind was had je de instelling dan ook veranderd, dat je eerst de naam van het diertje hoorde of juist eerst de kleur zei?
    Nee, eerst de kleur.
    Die had ik laten staan
    Ja dat kan wel inderdaad
    Ow nee dat wist ik niet, ja dan kan je beter het dier zeggen. Want nu was het oranje euhh ja is dat dan het varkentje of moet ik na die kreeft hebben.
    Ja op zich die aanpasinstellingen was wel toereikend
14. *zouden enkele standaardinstellingen ook genoeg zijn, zoja hoeveel?*
    Ja dat is wel handig, want nu moest ik steeds kijken. Welke kleur, welke wel welke niet. Dat je gewoon grote of kleine dieren doet. Want je gebruikt dan toch de grote of de kleine. Misschien dat je dan nog aanklikt hoeveel.

15. *In hoeverre zou het handiger zijn als de respons van het kind automatisch gemeten werd (adaptief testen), en op basis daarvan de instellingen van het spel automatisch aangepast zouden worden..*

Ja dat zou makkelijker zijn.
Jazeker
Want Sven had nu ook moeite met die omschakeling.
Nu is het een inschatting dat je denkt zo zou ie het goed moeten doen. Zou goed zijn als het dan tijdens spel zich al aanpast.
Ja vind ik ook
Bij Levin die heeft moeite met concentratie dan moet je juist weer hebben dat het niet aanpast.
Dus zou je een keuze moeten hebben om het aan te laten passen of niet.
Ja, ligt aan wat je doelstelling is.
Levin moet gewoon aan een herhalingsmaximum komen in een bepaalde tijd

16. *Je zou ook instellingen op het bord kunnen maken, zoals de USI studenten blijkbaar ook hebben gedaan, doormiddel van een blokje links of rechts te leggen. Of bijvoorbeeld het neerzetten van dieren die je wilt gaan gebruiken. Wat lijken jullie de voordelen en nadelen aan deze twee varianten, programma op PC of op het bord?*
Ik zou het handig vinden als ik die dieren op het bord zet en dat hij dan snapt wat we gaan doen.
Ik weet het niet, ja anders blijf je op je laptop kijken. Stel je selecteert alleen grote of kleine dieren. Je kan ook gewoon hebben ik zet die, die en die erop en klaar dan ga ik daarmee aan de slag.
Variatie in tijd is ook handig, maar daar variëren we minder mee dan de keuze van diertjes zelf. Als je het vaker gaat gebruiken denk dat je dat dan eerder nodig hebt. Misschien kunnen we daar nu nog niet zo goed over oordelen.
17. *Wat zou je dus handiger vinden om de aanpassingen te maken via het bord of via het scherm?*
Voor sommige denk ik computer, voor aantal onderdelen het bord.
Ja
Bijvoorbeeld dat je diertje op bord zet, snelheid misschien niet of dat je dat automatisch aanpast, dat zou dan optimaal zijn.
Ja dat denk ik ook
18. *Welke van mijn spellen vinden jullie het leukste en waarom?*
Ik dacht dat ik de boot het leukste zou gaan vinden, maar op gegeven moment omdat het niet zo goed werkte, de dieren vonden ze gewoon leuk.
En daar hebben ze ook wel interactie mee, dat vond ik wel een leuke de leukste.
Ja
Qua functie was de boot wel mooier dus beetje tussen die twee in
19. *Welke van mijn spellen was het minst leuk en waarom?*
Dat was met die pols, zei het minste voor het kind. Zat minste verhaal achter. Daarnaast ook niet zoveel succes. Wij willen natuurlijk ook beloond worden.
Tja wat de kinderen leuk vinden dat vinden wij natuurlijk ook leuk.

Stond volume voluit?
Ja, dat had je toen al goed ingesteld.

20. *Welke van mijn spellen zou je het vaakst gaan gebruiken en waarom?*
De dieren
Jazeker de dieren
Die kan ook bij heel veel kinderen.
Ja bij wat grovere kinderen kan dat ook nog wel.
Als de boot wat aangepast is kan dat ook nog wel
21. *Welke van mijn spellen zou je het minst gaan gebruiken en waarom?*

De pols, zit weinig aantrekkingskracht aan. Je kan dat kind niet alleen laten met dat spel. Je moet nog steeds dat kind entertainen.

Dat was niet entertainend genoeg van zichzelf

Dat was bij die dieren echt niet nodig.

Nee precies, het is dan ook dat je dat bandje aan moet doen. Dat kind kan dat zelf niet dus moet dan eerst worden gedaan.

22. *Is het aantal repetities dat gedaan wordt genoeg in een spel of zouden er nog meer in een spelletje moeten kunnen?*

Dat kon je ook nog instellen, dat was wel genoeg

Ja vond ik ook

23. *Welke ervaringen hadden jullie met de TikTegel voor mijn spellen?*

Dat was helemaal met die blokjes met die Piraatjes

Dat was ook wel ene leuk spel, maar daar zat wat minder variatie in en actie.

Ook daarbij kon je wel die herhaling doen

Maar het is wel leuk maar zolang alles werkt. Dan zijn we nog niet eens de meest onbereide therapeuten.

Je hebt inderdaad ook nog een aantal digibeten

Sommige denken bij de eerste keer al nee.

24. *Zijn deze ervaringen veranderd die jullie voor de spellen van mij/USI studenten hadden? (bijvoorbeeld het gedoe met opstarten)*

Ik zie nog steeds meer mogelijkheden in meer spellen. Doordat je nu weer andere dingen hebt ontwikkeld denk ik van ja er zit wel iets in.

Er zijn best wel mogelijkheden om het voor therapieën aantrekkelijk te maken.

Ook gerichter voor de doelgroep. Dat was een nadeel die greep met die piratenpoppetje was niet logisch. Bij die dieren was dat logischer.

Soms had je het daar ook nog wel, dat kinderen zo deden.

Maar je kon ook wel iets meer.

25. *Toen ik hier kwam kreeg ik te horen dat de huidige spellen niet goed werkte en af en toe vastliepen, hoe ging dit bij mijn spellen?*

O ja die liep steeds vast.

O ja

Jou spellen liepen niet vast. Als je eenmaal gestart had kon je niet meer verder. Dat icoon was ook weer verdwenen van de TagTile. Met zoeken en alles heb ik hem weer gevonden.

Zijn er dan nog andere mensen die de laptop gebruiken

Raar he iets zit er fout.

Ideaal je kan nu gewoon van spel 1 naar spel 2 en het liep niet vast.

26. *Het bord heeft de mogelijkheid om verloop van spelletjes vast te leggen. Denken jullie hier iets me te kunnen doen en zo ja wat zou je dan willen gebruiken?*

Op dit moment gebruiken we het vooral als therapie middel en niet als meting. Op dit moment is het nog niet zo belangrijk wat Levin vorige keer heeft gedaan. Dat is bij kinderen toch anders dan volwassen revalidatie.

Ja, ook als er wel aanpassingen kunnen komen voor automatische aanpassingen voor snelheid of wat dan ook. Dan zit je toch al heel snel weer in de instellingen voor dat betreffende kind.

Misschien wie weet ooit voor onderzoeken, dat zit nu nog niet in de pen. Gaat nu vooral om therapiemateriaal te ontwikkelen. Dat je straks zelf mee aan de slag kkunt gaan, dat een kind losgelaten kan worden achter de laptop en de TikTegel.

Ja dan zou het wel op een manier opgeslagen moeten worden. Dat ze gewoon kunnen openen Levin start en Levin weet dat ie met de kleine dieren aan de slag gaat

27. *Hoeveel kinderen hebben er nu in totaal mee gespeeld?*

Jens in begin nog wel en op einde niet. Twee kinderen hadden geen of onvoldoende grijpfunctie ontwikkelt. Jens vond die dieren wel leuk.

Was dat gemiddeld?

Dat is niet gemiddeld voor de piratengroep.

Normaal hebben we zes kinderen en dan hebben we alle zes die daar wel mee kunnen deelnemen.

Het waren maar vijf die deelnemen en vier gestart. En uiteindelijk dan maar drie die deel konden nemen.

Het was meer leeftijd en functie dan iets anders als beperking.

Alle drie hebben het geprobeerd en vonden alle drie ook leuke spellen.

Sven nog het minste he?

Ja die vind dat moeilijk met verwerking.

Dat paste dan niet helemaal niet in het structuurtje

Dat is toch ook een kenmerk van CP?

Jazeker, daar heeft één kind meer moeite mee dan de ander.

De informatie was ook wat lastiger dan.

Bij hem bijvoorbeeld ook met omkleden. Hij was al best goed met omkleden in begin. We dachten die snelheid gaat ook nog wel toenemen. Maar hij heeft gewoon een bepaalde remming. Hij kan gewoon niet al die handelingen zo snel achter elkaar doen. Dat zie je ook terug bij zo een computerspel

28. *Hoe oud is Sven?*

Bijna 4, over 2 weken

Die andere

Sophia is bijna 5

Harm moet nog 3 worden of is al drie

Ja is Harm is al 3

Maar dat was geen probleem bij Harm daar zou het nog gekker bij mogen zelfs

29. *Als je mijn spellen vergelijkt met die van de USI studenten wat is er dan beter aan hun spellen?*

Zag er wel wat professioneler uit.

De kleuren, de spelletjes zelf ook?

Dat lokt eigenlijk wel meer. We hebben ze uiteindelijk nog niet gekregen dus.

30. *Als je mijn spellen vergelijkt met die van de USI studenten wat is er dan beter aan mijn spellen?*

Dat dierenthema dat past gewoon bij deze kinderen. Dat was goed.

En dat het werkt.

Was dat bij USI nog anders

Tja dat hebben niet met zoveel herhaling geprobeerd alleen die middag.

En dat met die handschoentjes was helemaal niets en dat was beetje vergelijkbaar met je polsspelletje. Dat was hem ook niet, het aandoen werkte ook niet.

Wat hadden ze dan nog meer?

Iets met een gieter een kopje en regen vangen

Ja dat was ook niet zo handig daar was het kopje verkeerd aan.

Iets met piano spelen en duim extensie

Ja had ze ook verteld dat dat niet reëel was.

Ik had wel meer het idee dat je de CP doelgroep voor ogen had. Maar ja dat van hun was wat aantrekkelijker. Dus als jij die aantrekkelijkheid nog wat vergroot dan…

Dan zit het helemaal goed.

31. *Ben je ook bij spel van Ying Li geweest?*

Nee

Hij had een spel gemaakt waarin je met een hamer moest slaan met een van de 6 verschillende zijkanten om supinatie te trainen. Ik begreep van Willem Fontijn van Serious Toys en uit zijn paper dat dit ook vooral te maken had met dat alleen kinderen die al heel goed waren daar in staat in waren. Ook was er een aantal compenserende bewegingen (wrist/palmair flexie of bewegen hele lichaam), was dat bij mijn spellen ook zo?
Nee dat was bij die boot juist zo …
geïsoleerde bewegen dat was wel mooi, dan kun je ook niet. Dat is hetzelfde wat je niet hebt als je pols niet op het bord hebt en je moet die dorsaalflexie maken met dat bandje. Dan zorg je door dat vast te leggen dat het kind dan minder kan compenseren. Dat beperkt een kind om dat te kunnen doen. Dus op die manier heel goed maar ja dan op een andere manier.
Ja

32. *In het boekje stond iets over polsextensie?*
    Ja dat is die dorsaal flexie.
    Je zei dat dat teveel was?
    Ja vonden het lastig om dat steeds weer op te tillen.
    Ben je ook overgegaan om het dan zonder de pols funcite te doen?
    Ja wat dan het nadeel vindt, dan is het gewoon weer beetje rammen. Dan heb je weer niet die goede positie[???]. Dit was eigenlijk heel mooi die controle
    Pauline zei dat je als je hem doordrukt dat je dan wel weer die beweging hebt.
    Ja maar dan is het nadeel als je eenmaal gereageerd hebt dan blijft ie het daar doen. Hetzelfde als die kinderen een diertje bleef aandrukken dan reageerde ie daar weer op " ja dat is fout" maar dan zat je al in het volgende diertje.
    Sommige zette hem ook neer. Ook als je hem zo doet dan is het beter als het kind staat. Dan moet je een andere uitgangshouding kiezen en dat heb ik niet gedaan. Dan zou je meer dorsaalflexie hebben weer.
33. *Heb je het boekje in één keer ingevuld?*
    In het begin een keer en daarna nog een keer dus twee keer
34. *Sorry op welke middagen had je het spel nou gebruikt?*
    Twee keer in wk vijf zes en twee keer in week twee was dat al.
    Dat was ook al met de kinderen ?
    Ja dat was ook al met de kinderen, ja.
    Had je hem ook nog zelf een keer gebruikt?
    Ja ieder geval met de instructie met Mariet en Jan. Dat was nadat jij hier was geweest toen alles klaar was.
    Heb je dat boot spelletje dan dus niet meer geprobeerd in de laatste sessie?
    Wel nog geprobeerd. Maar toen dat weer hetzelfde negatieve effect gaf dacht ik ja dus dan houden we ons nu even bij de pols en de dieren
    Dus de laatste twee keer niet
    Bij de derde keer nog wel gepoogd en de vierde keer dus niet meer.
35. *Je had nog stukje in dagboekje geschreven over dieren onder interessante verhalen?*
    Ja dat kinderen dat gewoon leuk vonden. Dat het interessant is voor de kinderen.

Organisatorisch

organisatorisch 1 : in verband met het zwangerschapsverlof van Ingrid, iemand moet (delen van) het verslag doorlezen en waarschijnlijk goedkeuring geven voor sommige gedeeltes zoals beschrijving therapie. Het zou ook zeer gewaardeerd worden als iemand een middag bij eindpresentatie aanwezig kan zijn in begin September.
Dat moeten we dan even checken met Pauline wat daarin mogelijk is denk ik. Verwacht het ik weet

niet hoeveel verslag je hebt…
In de vakantie ga je daar dan nog mee bezig?

Ja dat is volgende puntje

organisatorisch2: Is het al zeker dat ik de spellen kan testen in Augustus met de wat oudere doegroep?
Die week gaat definitief door dus dan kan je daar aan werken dan kan je het beste contact hebben met Ruth of niet?
Ja, ik ben er waarschijnlijk nog wel
Ruth is in de zomervakantie ook nog meer aanwezig dan anderen.
Dat is mooi.
Welke bewegingen willen jullie dan terug zien in dat spel?
Ik weet nog niet welke kinderen er precies inzitten. Ga je dan deze spellen aanpassen?
Ik wil eigenlijk een nieuwe maken. Ik had ook de opdracht gekregen om supinatie te trainen. Daar had ik eerst het bootjes spel voor bedacht maar dat is lastig. Dit komt doordat de greep dan gekoppeld wordt aan die beweging.
Ja die pro-supinatie zou mooi zijn, maar dan misschien ter informatie alvast: als je iets aantikt is prima dit [180 graden draaiende beweging] hoeft niet.
Pronatie die kant op hoeft niet eigenlijk sowieso niet
Precies pronatie is minder belangrijk begreep ik?
Ja, Ja
Hebt wel bepaalde hoeveelheid nodig maar supinatie wil je dan wel ja.

Wie gaan er ook alweer meedoen?
Weet ik eigenlijk niet
Bram zou ook komen
Zou kunnen

De leeftijd is dat dan wel bekend 8-12?
Ja dat is nog steeds hetzelfde

Zijn dat dan ook weer vijf kinderen?
Nee zijn er nu al zeven
en het worden er nu acht zelfs. Maar dat is wel fijn voor jou.

organisatorisch3: Zouden jullie of 1 of 2 andere therapeuten eventueel bereid zijn om mee te doen aan een korte ontwerpsessie in begin Juli om een spel te bedenken?

Ja hoor
Ja ik ben er dan niet meer

Jan eventueel nog?
Ja hoor denk het wel.

Hoeveel tijd zou dat mogen kosten?
Ja een uurtje ofzo
Ja
Op een dag, ik weet niet hoe Jan met zijn planning zit.
Bijvoorbeeld Dinsdag middag of Donderdag middag 5 Juli of 7 Juli. 4 Juli trouwens ook dan hebben we nog een overleg.
Kan mooi als jullie daarmee klaar zijn, want dan zitten jullie al bij elkaar.
Dat mail ik dan nog wel even

Organisatorisch 5: Zouden jullie de vragenlijst ook aan Jan, ?Marriete? en Suzanne kunnen geven en naar me opsturen?
Mariet heeft alleen gezien.
Heeft er niet aan mee gedaan maar heeft wel de instructie gekregen.
Dan toch maar de naam erbij zetten.

Ik vraag Pauline of dat we eventueel bij de eindpresentatie iemand aanwezig bij mag kan zijn.
Ja die moet er dan waarschijnlijk ook iets over zeggen om het te beoordelen.
[uitleg afstudeerproces, zou goed zijn als er iemand van SMK bij zit]
Kan je dat op de mail zetten, ik ben Donderdag hier voor het laatst.

Organisatorisch 6: Kan ik in begin Juli het blauwe of zwarte bord weer lenen om daarmee aan de slag te gaan?
Als het op het blauwe bord kan dan hebben we minder op de laptop nodig. Blauwe bord kan je ook lenen staat bij mij onder het bureau. Marlies was er ook mee bezig eventueel voor haar kinderen. Anke weet het ook wel.

Bandje met dat spel dat was gewoon lastig?
Lastig, zat niet lekker en zoiets.

En USI dat was van elastiek?
Ja als je shin splint hebt dan krijg je ook zo een bandje om [hier om je knie]. Dat zit ook lekkerder
Ja verstelbaar en elastisch
Ja een dikker elastiek ofzo
Maar dat huishoud elastiek zit ook niet lekker hoor.
Misschien is het dan wel handig dat je hier [boven op de hand] een plaatje hebt op dat bandje dan kan je beter richtten.

Hoe ging het mikken nu
Ja zat nu hier onder zit het ergens.
Misschien dat je hem op een viervlaksding zou mogen raken.
Ja was nu ook een blok van 15 blokjes
Maar dat was niet heel makkelijk
Ruth gaat ergens vanaf half September weg en wordt contact persoon
Hoeveel veel tijd zal verslag doorlezen kosten?
Ik maak wel onderverdeling met wat echt gelezen moet worden.

Appendix F: Design session with therapists

Interaction relabeling and Systematic Inventive Thinking

To let therapists participate in the concept generation an idea generating session was developed. The session consists of four parts.

- Presentation about the session and introduction to interaction relabeling
- Interaction relabeling session
- Introduction to SIT
- SIT session proceeding on results of the interaction relabeling

The presentation (part one and part three) can be found in Appendix G. In short interaction relabeling uses the standard interactions of an object to translate this into new interaction methods for another product. Systematic inventive thinking is a way to alter a product, or to overcome a problem, by using one of five thinking patrons. These thinking patrons are based on TRIZ which is based on an empirical study by Altshuller on patents and inventions.

A pilot was run to test whether these methods and the complete session would be beneficial for the concept generation. This pilot was also used to find possible improvements for the session.

Pilot session

The pilot session was done with three students from the University of Twente, aged 23,26 and 27. For the pilot sheets were added to bring them up to date of the targeted group and movements.
The session took exactly 30 minutes and a diner break was present between the interaction relabeling session and the introduction to SIT.

Interaction relabeling

During the explanation of interaction relabeling already an idea was suggested. Sixteen ideas for exercises, games or part of games were generated. One game (type of Jenga) was directly abandoned and thus not included. Because, according to the participants: “it would be unsuitable for the target group”. The other ideas were:

1. Lid covers a colour, when lid is raised it indicates which colour piece has to be moved. Maybe let a dice decide where to.
2. 2 dices, one tells what to grab the other tells where to
3. Throw a dice into a cup
4. Make a spinning wheel and point out the right indicated number as fast as one can
5. Kind of Tetris: show a shape, look for object with similar shape, place this object which will project the indicated shape and make a puzzle with it. OR similar:
   an outline is shown and pices have to be used to fill the outline which than can be slided to make a puzzle (sort of up side down Tetris)
6. When the board turns red: press an external big red button

7. Keep score like in monopoly with the new credit card system
8. Break into a safe, turn a wheel which gives a number, when every number is found give a reward OR make a sort of Mastermind (placing several pins in right order and colour)
9. Thread a necklace
10. Tug-of-war
11. Place indicated object from or on the board. One object gets lighten with a different colour, you have to grap this one (resembling the game Jungle Speed) . The speed of the game should be important.
12. 3D Tic-tac-toe, play a game of tic-tac-toe and winner can place one tic or toe in a rubus cube like shape
13. A game of battleship but with several layers, for instance 16x16x8
14. An X-Y-table, objects can be moved by two wheels (x direction &y direction), follow a track, sort of a sketchpad/"draw and doodle thing" toy.
15. Turn a scroll wheel very fast and make it a race game.
16. Higher/Lower, look at a card, place a piece in one of the two areas which indicates for example that next card will be higher, turn card when correct the piece can be moved (like a game of goose) or only a cool sound could be played "TADA"

Observed drawbacks from the interaction relabeling session

- Participants hesitated to grab a prop from the table
- One of the participants hardly participated and was hard to let him participate him more actively
- During session most ideas were not forming a complete game idea
- Hard to keep in mind the target group, the movements and creating fun games at the same time.

SIT session

One of the participants could not make it to the second part of the session. Thus only two of the three participants present in the interaction relabeling session participated. The ideas that were generated are not of big importance to mention for the project. Thus only the first idea is described entirely as an example:

Lid game system

- A lid
- Something underneath
- A piece
- A destination for the piece

Dividing for instance the lids can give two lids in the game, thus actually multiplying. This could require usage of both hands at the same time. Dividing something underneath could give multiple colours or even a pattern, thus actually multiplying. Change the game in recognising a pattern making it a memory game and placing the piece there, sort of a "big brain academy" exercise (a console game for Nintendo

DS and Wii, http://www.nintendo.com/sites/bba/). Dividing the piece, making it pieces which can be placed on top of each other like legos. For instance make pieces available after a successful attempt resulting in a finished piece when the game is won.

These were three of the twelve generated ideas during the SIT session. Five game ideas were tried using multiplying, dividing, unification or subtraction as thinking patron. The fifth thinking patron, switch of dependency, was not tried within the available time.

The session did lead to more in depth ideas but not on a too detailed level. More interesting for the project are the possible improvements for the method based on the pilot. Based on the session the following points suitable for improvement of the method were found:

- Dividing actually became multiplying
- Not enough time to try every thinking patron.
- Some ideas did not profit from SIT. For instance throw a dice in a cup would have unpractical implications according to the participants, automatically leading to less effort for building a concept out of it.
- Sometimes did not go into enough detail, leaving the proposed games unfinished and hard to analyse.

Changes in session

Not all SIT patrons could be used. Not even all products could be analysed with one patron in the available time. This lead to the following changes:

- Shorter relabeling
    - Use only the more appropriate props
- Selection of most promising ideas
- Writing out the ideas on a clean sheet directly after selection
- Longer SIT session
- The facilitator helps in making the list of components

Users did not use the props themselves instead they kept on referring verbally to a prop instead of acting out the movements with the prop. The props with several interactions led to more complete ideas.

- Try to use props with multiple interactions
    - The stapler
    - The rubikscube
    - A complex screwdriver, one with multiple heads and that can also be pushed instead of turned to make the head spin.
- Order the first participant to tell what interactions the prop has

After the pilot participants asked why they participated, they wondered what their participation brings to the table.

- The co-design session opens mentioning the reason of participation.

In a conversation after the pilot one of the participants stated he did not exactly understood the example of the gun used in the presentation of interaction relabeling.

- A next step in the process is added in the explanation. After thinking of ways of interacting give an example of possible implementation. In this case from gun back to agenda. For instance aiming to make an appointment now becomes the concrete feature aiming the camera of a PDA to make an appointment with that person.

Co-design session

This section starts with a summary of the session followed by a more in depth description. The session was similar to that of the pilot using the earlier proposed improvement. One more change in the session compared to the pilot was added. To try to force a break from their every work a piece of cake was offered to be eaten during (the preparation of the) presentation.

Session summary

- One of the therapists could not make it to the meeting thus two therapists participated
- The relabeling session including explanation took about 20 minutes.
- The selection procedure and SIT session including explanation took about 30 minutes
- Using four props eight ideas were generated
- Four ideas were further improved with SIT.

Session walkthrough

At the start of the session it was explained that not being a therapist means you have some extra limitations in seeing how children would react and foreseeing possible movements. Due to some interruptions the actual session started a little bit later reducing the time with about 10%.

Interaction relabeling

The relabeling session was started with ordering the first participant to use a prop. The first product selected was a stapler because it contained the most interactions.

When the usage of relabeling was explained it led to some questions. Such as: “Does it have to be ideas for games? “ and “For which age group are we designing again? “. Also the beginning of the session was focused too much on the prop at hand. This was corrected by reminding them that the interactions matter not so much the object in their hands.

The back-up list, containing metaphors meant to trigger ideas in case no ideas were generated, was not used. It seemed unnecessary because once set in motion the ideas kept on coming.

The design relabeling was done using the following props: the stapler, the rubikscube, a complex screwdriver and a small transparent box containing an USB-stick and a magnet too keep the lit closed.

This resulted in eight ideas for games/exercises.

These ideas for games are:

- Squeezing game, for instance make music by squeezing an object in the hand. Would increase strength and in hand manipulation.
- Pinball game, shoot a small away by loading a spring, aiming and releasing. Could be used to trigger dorsal flexion and or two handed coordination.
- Jar game, using a rotatable shape on a jar certain objects can be shaken from the jar while other remain. Several levels using an increasing number of shapes could be made. Trains supination and grasps when putting things into the jar.
- Motor cycle racing, by turning or keep on rotating the gas throttles with a certain frequency make a virtual motor speed faster and slower on a racing track. Trains dorsal flexion
- Screwdriver game, let children rotate a screw which will result in some action in a virtual world. Trains supination.
- Catching flies, let a magnetic lit almost closed as long as possible. For instance giving feedback from green to red. Will result in coordination, improving grasp and possibly supination or dorsal flexion.
- Turn and press cube, a cube consisting of two rotating parts should be turned to form a patron and then put on a surface. Trains dorsal flexion supination, grasp and extending elbow. (This game is based on and is similar to the game with a cube of Li , Fontijn and Markopoulos (2008)). This failed because the cube was too big and could thus not be grabbed by the children.)
- Keep a cube in the air, keep a cube in the air for a long time and then hit a target on a surface. Trains grasp and extending the elbow.

In both parts, the relabeling and later on in the SIT part, a lot of linking and comparing to already existing games occurred.

The games that were seen as more promising were the pinball game, jar game, motor cycle racing and a combination of the two cube games. Because the third therapist could not be present multiple games were selected by the therapists.

A second interruption occurred after the selection procedure this used to write down all the generated ideas. This is also led to the participants talking about arbitrary non-work related daily stuff.

Systematic Inventive Thinking

The usage of SIT worked but lead to some confusion in the start. It was not directly clear how it should be used. The normal SIT procedure of using all thinking patrons on a selected component was abandoned. Instead only one or two arbitrary chosen patrons were used on one or two components per idea.

Due the schedule not all patrons could be used on all the selected ideas. Thus instead it was chosen ad-hoc to use only one or two thinking patterns for every idea.

The cube system has the components:

- (Number of) sides
- Surface
- Turning mechanism (when multiple part cube idea is used)
- Combinations

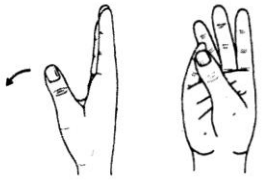


Figure A, the (thumb) movements abduction(L) and opposition(R)

Combining a component with other products, features or components led to the following ideas.

- Adding a small round target on the side of a cube. This target should be placed with certain accurateness depending on the user. One has to turn the cube to see where the target is and if it is going to be accurately placed on the surface. This addition can be used to enhance repetition and accurate coordination because several attempts could be needed.
- A button could be added which has to be pressed at the moment a target has to be hit. This will additionally lead to other needed movements opposition, thumb abduction (see figure A) and more grasp coordination and possibly in hand manipulation.
- The cube could be made heavier; this can make it suitable for power training. Making it lighter for some users might make it suitable for a bigger target group.

The motor cycle game was omitted after some debate. It was presumed by the participants that it is too hard to effectively make use of the strengths of the board with this idea.

Pinball game system has the components:

- Spring
- Lever
- Barrel
- Ball
- Surface

Removing a component led to the following ideas

- No spring instead shoot the ball with your hand.
- No surface only use a barrel. Measure the speed of the ball at the end and give a score to this.

The first idea was retracted because the part in which the spring was to be compressed or extended seemed fun to do.

The jar game system has the components:

- Container
- Holes
- Objects (different shapes)
- Surface to collect shapes on

Dividing and multiplying resulted in the following ideas

- Use two jars or a two sided jar. One side some shapes can get out on the other side others could get out.
- Use a jar with two plates with holes. An object can be moved in from both sides. Special combination have to be fund. The objects have to be connected in the middle. When a combination has been found a sound or movie is played resembling the connected shape. It is exploratory puzzle so it is not yet know which shape combination will lead to a successful combination. A pro is that it will result in several repetitions, a child will keep on trying to find the right combination.
- Multiple plates with holes, make it adjustable to the level of the child. An advanced child will use a set of smaller holes while a less able kid would make use of a plate with bigger holes.

Removing the container led to the next idea:

- Like the child game in which shapes has to be put in. For instance a coloured triangle and circle put through a wooden hole.
- Keep the plate with holes in one hand and put the objects through it.

Feedback and discussion

The therapists liked to do the exercises and said that the interaction relabeling could have been useful in the process. Looking back at the available amount of time and that needed to explain SIT and needed to get familiar with it for the participants, it seems better to omit its usage in such a short session. However when an entire afternoon would have been available the results might have been much better and leading to the more in depth ideas. The usage of interaction relabeling was successful and is likely to inspire in another way than ordinary brainstorming techniques for instance using written mind maps. A combination of such a more traditional technique might however be a good replacement for SIT in such a short session. Especially since a lot of ideas were already based on known games or exercises.

The results can be used in the next step in which a more detailed concept has to be created. The inclusion of participants from the beginning could result in better implementation of movements in the games. This can only be evaluated when the actual games are tested in the last evaluation.

Reference appendix F

Li, Y., Fontijn, W. and Markopoulos, P. (2008). A Tangible Tabletop Game Supporting Therapy of Children with Cerebral Palsy. *Proceedings of the 2nd International Conference on Fun and Games*, Eindhoven, The Netherlands, pp. 182-193. Springer-Verlag.

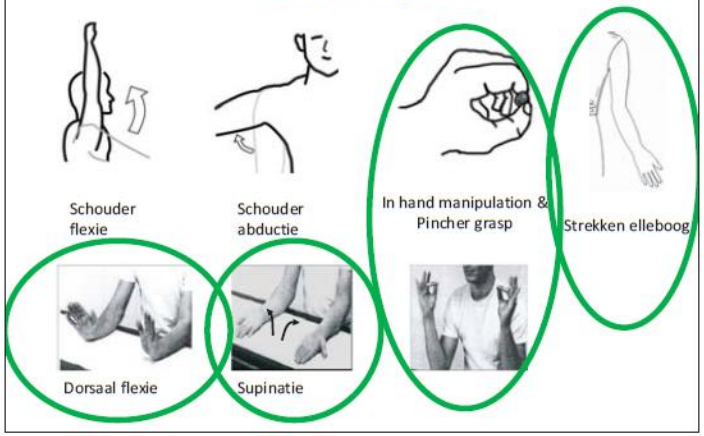
Ontwerpsessie

Ontwerp van een fysiek spel met behulp van interaction relabelling and Systematic Inventive Thinking

Planning

- Presentatie uitleg interactie relabeling 3 min
- Simpele ideeën creëren 20 min
  - Interactie relabelling
- Presentatie SIT 5 min
- Verder bouwen op gecreëerde ideeën 25 min
  - Systematic Inventive Thinking

Bewegingen



Doel: ontwerp spellen +

Hoe? Interaction relabeling

- Voorwerpen gebruiken ter inspiratie
- Vertel hoe huidige voorwerp gebruikt kan worden → maak hier een spel van

Interaction relabeling

- Bijv geweer→ agenda
  Relabelling
  - Kogel → afspraak
  - Op iemand richten → een afspraak aanvragen
  - Vuren is afspraak maken
  - Volume van vuren geeft het belang aan

  De resulterende bewegingen en interacties zijn van bela persé de metafoor

Verder denken met interactie geeft dan :
Met camera van mobiel een foto schieten→ aanvragen afspraak

Voorwerpen

- Touw
- Beker
- Dobbelsteen
- Kaarten
- Pion
- Blok klei
- Stukje lood
- Gekleurde papiertjes
- Zaklamp
- Koptelefoon
- Rekenmachine
- Doosje
- Rabobank RandomReader
- Glazen bol
- Theedoek

BV dobbelsteen

- Dobbelsteen kan je rollen
  - Rol dobbelsteen over het bord
  - Maak de dobbelsteen van verschillende kleuren
  - Maak een figuurtje door de dobbelsteen op de juiste plaats met juiste kant boven te rollen
- Dobbelsteen kan gebruikt worden voor beslissen
  - Als 1-3 dan moet touwtje op bord gelegd worden
  - Als 4-6 dan moet Pion 1 naar voren toe.

Laten we ontwerpen!

- Voorwerpen gebruiken ter inspiratie
- Vertel hoe huidige voorwerp gebruikt kan worden → koppel dit aan een spel

- Alles is goed bestaat geen foute input
- De resulterende bewegingen en interacties zijn van belang niet persé de metafoor
- Voer de bewegingen ook echt uit
- Je mag ook extra functionaliteit toekennen, bijvoorbeeld toverstaf ipv zaklantaarn

Selectie maken

- Iedereen 1 favoriet kiezen maar niet 1 die al gekozen is

Systematic Inventive Thinking

- TRIZ
  - Ook in ontwerpen zit veel systematiek
  - 200.000 patenten onderzocht
  - Herkende veelvoorkomende patronen
- SIT is samenvatting van enkele vaak gebruikte TRIZ technieken

SIT

- Pak het idee/product
  - Benoem de onderdelen
- Pak 1 van de 5 denk patronen
  - Bv delen
- Visualiseer wat het wordt
- Kijk of er behoefte aan is

Sit – 5 patronen: aftrekken

TV
1. Scherm
2. Luidsprekers
3. Behuizing
4. Afstandsbediening
5. Snoer

Sit – 5 patronen: aftrekken

TV
~~1. Scherm~~
2. Luidsprekers
3. Behuizing
4. Afstandsbediening
5. Snoer

Sit – 5 patronen: aftrekken

TV
1. Scherm
2. Luidsprekers
3. Behuizing
4. Afstandsbediening
5. Snoer

Radio met afstandsbediening
of
Goedkope TV voor blinden

VB badpak → bestaande producten

- Onderdelen
  - Touwtjes over de schouders
  - Badpakstof
  - Logo
  - 4 Gaten

Badpak - vermenigvuldigen

x2

Badpak - vermenigvuldigen

?

Badpak - vermenigvuldigen

wetsuit

Badpak - delen

Badpak - delen

Badpak - delen

Bikini

Badpak : iets weglaten/aftrekken

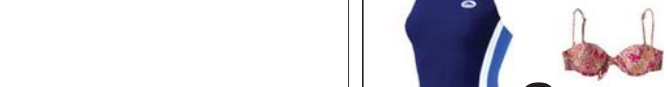
Badpak : iets weglaten/aftrekken

Badpak : & samenvoegen

&

Badpak : & samenvoegen

&



Push up bikini

Lastiger: afhankelijkheid omkeren

- Stoel
  - variabele bv lengte, component van poten
  - eerst is de gebruiker afhankelijk van de stoel
  - maak stoel verstelbaar dan is de stoel afhankelijk van de gebruiker
- Auto berg op
  - stand wielen is afhankelijk van hellingvlak
  - Hellingsvlak afhankelijk van wielen →
    - Heuvel op wielen voorwielen iets omlaag, heuvel af achterwielen iets omlaag

    → Auto blijft rechter, bijvoorbeeld voor wagenziekte

Badpak : afhankelijkheid omkeren

- Variabele: maat
  - Gebruiker is afhankelijk van de maat

    →Maat is afhankelijk van de gebruiker

    ?????

Badpak : & samenvoegen

- Variabele: grote
  - Gebruiker is afhankelijk van grote
  - Grote is afhankelijk van gebruiker

1. Benoem de onderdelen van het idee
2.
   - Delen & Vermenigvuldigen
   - Iets weglaten / aftrekken
   - Dingen samenvoegen
   - Afhankelijkheid omkeren
3. Kan ik er wat mee?

Appendix H: Questions used in the “Ik hou van Holland game”

Cat I Well known Dutch people | Bekende Nederlanders

i) 2pt What is the name of the queen of the Netherlands | Hoe heet de koningin van Nederlanders
I Beatrix
II Irene
III Anja
IV Margriet

ii) 4pt Which duo has a program in which their names are sung “bleuh than you should watch…… and the rest”[audio fragment] | Welk tweetal heeft een programma waarin hun namen gezongen worden gevolgd door "... en de rest" (echte tune gebruiken)
I Samson en Gert
II Bert en Ernie
III Piet en Jan
IV Ersnt en Bobby

iii) 2pt Who is the presenter of the TV-show Ik hou van Holland | Wie is de presentatrice/vragensteller van de TV-show Ik hou van Holland?
I Hootsy Pootsy
II Linda de Mol
III Sacha de Boer
IV Irene Moors

iv) 8pt Which successful duo is born in Volendam | Welk succesvol zang duo komt uit Volendam
I) Nick & Simon
II) Frans & Bauer
III) Gordon & Joling
IV) Bobby & Ernst

Cat II Songs and TV programs | Liedjes & TV programmas

i) 8pt Which singer and current captain of a team in Ik houd van Holland scored a hit with the text “kedekekden …. Kilometers of rail are flying by underneath my feet” | Welk zanger en huidige captain van een team in Ik houd van Holland scoorde een hit met de tekst "kedekedeng ... kilometers spoor vliegen onder mij door"
I) Herman van Veen
II) Guus Meeuwis
III) Gerard Joling
IV) Jan Smit

ii) 4pt What is the name of the well known TV-show for children named after a piece of an apple | Hoe heet het bekende kinderprogramma vernoemd naar een stuk van een appel dat al sinds 1988 op TV is?
I) Sesamstraat
II) Bob de bouwer
III) Telekids

IV) Klokhuis

iii) 2pt What are the next lines of the song “head knees toes” | Wat zijn de volgende zinnen van het liedje "hoofd knieen teen"
I) hihahah and I stood watching| hihi haha stond er bij en keke erna
II) knees and toes | knieen teen
III) in the middle of the week but not on Sundays | midden in de week maar zondags niet
IV) watch out you fool a coconut | kijk uit maloot een kokosnoot

iv) In a typical Dutch song “there is a [BEEP] in the corridor yes yes a [BEEP] in the corridor” [sound fragment] the name of an animal is mentioned which animal is this | In een typisch nederlandse lied "er staat een PIEP in de gang" komt een dier voor welk dier is dit
I) Pig | Varken
II) Dog | Hond
III) Monkey | Aap
IV) Horse | Paard

Cat III Sport
i) 4pt The elfstedentocht is the most famous iceskating match on natural ice. But why is it called the elfstedentocht(eleven cities tour). | De 11 stedentocht is de bekendste schaatstocht op natuurijs maar waarom heet ie zo?
I Because it takes eleven minutes to finish | Omdat hij 11 minuten duurt
II Because the riders have to drive by eleven Frisian cities | Omdat er langs 11 Friese steden gereden moeten worden
III Because eleven participants are allowed to participate . | Omdat er 11 deelnemers mee mogen doen aan de wedstrijd
IV Because it became a match after the elevenist tour | Omdat het een wedstrijd werd na "den elfsten tocht".

ii) 8pt Ajax is the most successful football club in the Dutch competition. In the season 2010/211 they earned their third star. What does this represent ? | Ajax is de succesvolste voetbalclub van de nederlandse competitie, in het seizoen 2010/2011 behaalde ze hun derde ster. Waar staat dit voor?
I Because they won the national cup three times | Voordat ze drie keer bekerkampioen werden
II Because they were champions thirty times | Voordat ze dertig keer kampioen werden
III Because they ended third most times of all teams | Voodat ze het vaakst derde werden
IV Because they won a match three times in the competition | Voordat ze drie keer een wedstrijd wonnen in de competitie.

iii) 4pt What is the name of the horse-rider that won a medaille on the last five Olympic games. | Hoe heet de paardrijdster die de afgelopen vijf Olympische spelen een medaille haalde.
I Anky Panky Paardensport
II Hinnik de Pinnik
III Anky van Grunsven
IV Angela van Amerooy

iv) 2pt What is the name of the most populair autorace competition, looking at the number of followers over the world, in which Vettel was champion in the last year | Hoe heet de populairste autorace competitie, wat kijkers betreft, waarin Vettel vorig jaar kampioen werd.

I Formule I
II Carting | Karten
III Forza
IV Broembroem

Cat IV Dutch habits | Nederlandse gewoontes
this question is based on a question asked in the board game of Ik hou van Holland. As the question there was what snack is named a Dutch donut. Answer a Donut.
i) 4pt A typical Dutch snack that is eaten with oldyears eve and new-year's day is called Dutch donut in other countries. Which snack is this? Een typische Nederlands lekker hapje dat gegeten wordt met oud en nieuw wordt in het buitenland ook wel Dutch Donut / Nederlandse Donut genoemd. Welk hapje is dit?
I Dutch Donut | Oliebol
II A pie | Pasteitjes
III Syrup waffle | Stroopwafel
IV Spiced nuts | Pepernoten

This question is based on a board game question. Only the extra ansers have been added.
ii) 8pt Dutch eat a lot of potatoes but how many potatoes does a Dutch person eat in one year on average. | Nederlanders eten vaak gekookte aardappels maar hoeveel kilo aardappels eet de gemiddelde Nederlander in een jaar?
I) About 80 kilos, as much as a grown man weights | Ongeveer 80 kilo, zo veel kilo als een volwassen man weegt
II) About 4 kilos, as much as a cat weights | Ongeveer 4 Kilo zoveel kilo als een kat weegt
III) About one kilo, as much as pack of sugar| Ongeveer een kilo zoveel als een pak suiker
IV) About 1000 kilos, as much as a small car weights | Ongeveer 1000 kilo zoveel als een kleine auto weegt.

iii) 2pt Eating a haring is seen as a typical Dutch habit. But how does a living haring move | Een haring eten wordt gezien als typisch Nederlands. Maar hoe beweegt een nog levende haring?
I) Walking like a dog | Lopen zoals een hond
II) Swimming like a dolphin or a goldfish | Zwemmen zoals een dolfijn of een goudvis
III) Crawling like a cock-roach | Kruipen zoals een kakkerlak
IV) Flying like a seagull "Vliegen zoals een meeuw

iv) 2pt Wat krijg je als je een "patatje met" besteld in de snackbar?
I) Chips with curry | Patat met curry
II) Chips with ketchup | Patat met ketchup
III) Chips with mayonnaise or oil-based mayonnaise | Patat met mayonaisse of fritessaus
IV) Chips with shit | Patat met poep

Appendix I: Manual for using BlueBoard and the *"Ik Hou van Holland"* game

Voer de SD kaart met het spel in

Zet de TikTegel aan, doe de adapter in de TikTegel.

> De TikTegel start op. Het blauwe laadbalkje beweegt. Vijf vierkantjes worden getoond
>
> Het spel laad automatisch, een oranje lichtje knippert.

Plaats het blauwe antwoordbolletje op een vakje aan de linkerzijkant. Soms twee keer, één keer om spel te starten en één keer om instelling te doen.

> De hoogte geeft aan hoeveel antwoorden (4-16) minimaal gegeven moeten worden om het spel uit te spelen, waarin het vakje linksonder staat voor het minste aantal antwoorden. Als van één categorie alle vragen beantwoord zijn en dit ingestelde aantal vragen goed beantwoord zijn dan wordt "we are the champions" gespeeld en het spel beindigd waarna terug gegaan wordt naar menu. Om spel weer te starten SD kaart eruit halen (zachtjes duwen) en weer terug erin doen.

Kies één van de vier categorieën: muziek & TV, bekende Nederlanders, sport of Nederlandse dingen. Doe dit door een houten blokje te paken en op het bord te zetten

> Een icoontje van de categorie verschijnt op het bord, de categorie wordt verteld

Schud een vraag uit het vragenpak

> De vraag wordt gesteld.

Kantel de antwoordenbalk over het bord om de antwoorden te horen.

Plaats het antwoordenbolletje op het juiste antwoord

Laad dit antwoord met behulp van de buis. Haal pas nadat de vraag gesteld is het bolletje weg, doe het daarna in de buis. Plaats de buis met het antwoordbolletje op het bord. Schud de buis om het antwoord goed te laten laden.

Gooi het antwoord op het bord en hoor of het goed is.

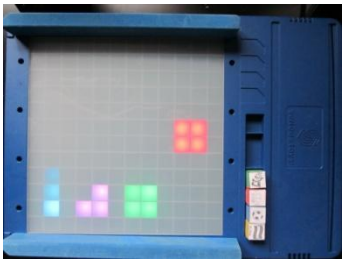
Bij fout antwoord nog een poging. Bij een goed antwoord wordt begonnen van af het kiezen van de categorie tenzij het spel uitgespeeld is.

Problemen

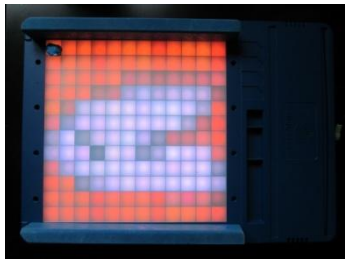
Bij vastlopen van het spel: haal de SD kaart eruit en doe hem opnieuw erin, het spel start opnieuw op. Als dit niet werkt haal dan stekker eruit en doe de stekker erop nieuw in.

Verloop van gebruik van het spel in stripvorm

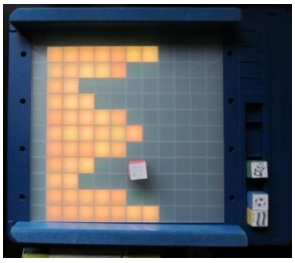
Geluid, SD en stroom



de tiktegel laad

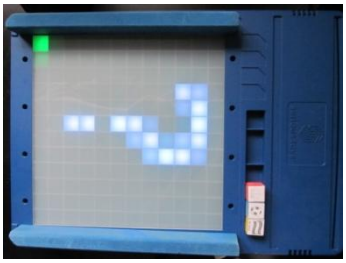


stel aantal herhalingen in



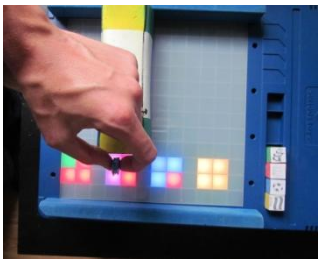
kies categorie

schud een vraag
uit het vragenpak



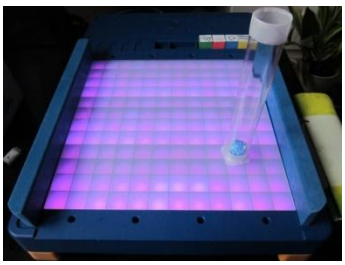
vraag wordt gesteld

hoor de antwoorden

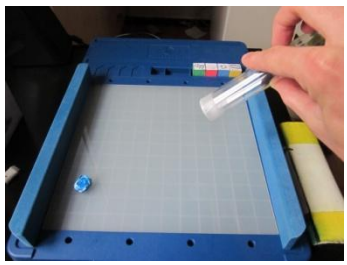


kies antwoord

laad antwoord



antwoord is geladen



kijk of antwoord goed is

fout: nog een keer
goed: kies weer een categorie

Appendix J: Technology RoadMapping

This appendix describes the necessary taken steps for the technology roadmapping as described by Souchkov (2005). This technique is used to plan and create ideas for future deployment of concepts. The result a technology roadmap is shown and explained in the report itself. The created radar plot is also already shown in the report itself.

Market evolution: the technology pull-side

The first step is identifying trends in the current market from the environment. All the earlier created requirements can be influenced hereby and it is important to identify how this will be affected. A small set of trends is identified for the short term and midlong term.

Short term 0-3y:

- Efficiency should rise: same effectiveness less manhours or increase of effectiveness. Budget will get smaller and as health is more and more becoming a business in which efficiency becomes more important. This is mainly driven by politics that started this strive for increase in efficiency. This is triggered by health's increasing costs because of the obsolescence of population and needed reduction of government expenses. In the next decade this process is likely to continue. First effects are allready affecting the Sint Maartenskliniek.

- Children need more triggers to be entertained. Children are more and more submerged in technology. One of it effects might be that concentration spans are reduced in the last generations.

Midlong term 3y-10y:

- Children expect ambient interaction games on top of or instead of tangible interaction. As Kinect and the like increase popularity, the technology is becoming more and more mature and wide spread. The expectations of children is likely to be changed hereby.

- Children will expect a bigger immersion in feedback. 3D technology is being deployed in home cinemas and game consoles more and more. An increasing part of the children will have come in contact with immersive environments (but still a minority).

- Increased number of therapists that will have a feeling for working with programming languages. Programming will have also become easier

Product evolution

The product evolution states the characteristics for the changed demands and directions to be able compete in the future market.

Short term 0-3y:

- Children have to be able to play alone with the game to reduce number of hours needed by therapists.
    - To be able to play alone compensating movements have to be prevented automatically.

    - Safety measures have to be increased
- The games should provide more triggers to entertain the children
    - Introduce new modalities for feedback

Midlong term 3y-10y:

- Include new ways to incorporate non-tangible interaction while remaining advantage of tangible product manipulation.
- Increase experience by introducing new ways of interaction.
    - Provide new ways in generating feedback that will generate a wow-factor over a longer time span (>5 times of play)

Technology evolution: the technology-push side

It is important to know what technological development could be of use for the product. These could help to satisfy the required product evolution. There is some overlap with the market as the market is influenced by the technology as well. Another source for generating new concepts based the technology side is using TRIZ trends in an evolutionary potential assessment. First existing technology trends are mentioned followed by the evolutionary potential assessment. The ideas generated in this last step are already made more concrete. Implementation of the existing technology development is straight forward and explained also in the report.

Short term 0-3y:

- Increase usage of sensors in games. For example the Nintendo Wii, Playstation Move and Xbox Kinect. These sensor technologies could be used to detect movements and detect compensation. Especially in combination with platforms becoming more transparent for end-user development. For instance the Wii-controller can easily be connected with a PC.
- Mobile devices have more powerful processor units.
- Increased usage of 3D technology in displays, for example Nintendo DS 3D and 3D LED TV (eg. Samsung, Sony Toshiba, Philips and Sharp). Pricing remains high but as it is become more and more a mass sold product prices can be expected to drop.

Midlong term 3-10y

- Mobile technology is becoming more and more important. The frequently used Li-Ion battery will be replaced by fuel cell technology. For instance powered by methanol which has a much higher energy density per weight and volume as Li-Ion.
- Advanced haptic feedback for instance using ultrasound (Iwamoto & Tatezono, 2008)

EVOLUTIONARY POTENTIAL ASSESMENT: indicating current state of evolutionary trends

History is said to be repeating itself, so does inventing. This is the general idea behind a method called TRIZ. Inventions have evolutionary steps and many problems are solved applying the same ideas on different products. This can be used to predict or generate future concepts. For all trends the current state of the product is identified. This is normally done per subsystem however here the system is divided in a mental division of feedback and input a third part “generation of games and usage” is dealt with differently.

The usage of Evolutionary Potential Assessment is thus implemented in a loose way and not following all of the guidelines strictly, to result in more time efficient but possibly less thorough ideas/solutions. Ideas are highlighted in grey, current state is made bold. This analyses is based on trends from a application called Techoptimer and the identified TRIZ trends (Souchkov, 2005). Both versions did not map one-on-one. The interpretation of the trend from Techoptimizer used is matched to a TRIZ trend this is mentioned after the slash. The most important changed market demands are efficiency increase and improvement of experience.

Demands: Efficiency & improved experience
Component: Feedback LEDs&Sounds
Trends:

- Convolution
    - Introduction of modified substances/Ideal substance
        1. **-**
        2. Modified substance into in an object
        3. Modified substance around one object
        4. Modified substance around both objects
        5. Modified substances between the objects.
    - Function sharing
        1. (no-trends found) The lights are shared with the RFID voids. The sound is combined with the lights output by the SDK. An improvement could be to make use of the voids for generating sound.
    - Function self-delivery
        1. (no-trends found) The lights and feedback are already directly triggered by the input; the feedback is a function in itself. This requires energy however. A totally mechanic equivalent which would generate output with input could circumvent using energy.
    - Transfer to supersystem
        1. (no-trends found) It is incorporated in the supersystem, this might be improved. As the start up and trigger to use might be improved if it would be made part of an ambient technology. Thus splitting the system and instead using a transfer.
- Rhytym coordination
        1. Change to pulsating action
        2. Ensuring resonance of pulsation
        3. **Combination of actions (using both sound and visual stimuli at same time)**
        4. **Using a travelling wave (light emitting diode, the way it was invented)**

- Transition to macro-level
    - Mono-bi-poly: various objects
        1. Introducing one object
        2. Introducing several objects

3. **Combining objects into a common system (LEDS are multicolour and embedded with RFID technology making use of the void, however the number of LEDs is limited especially compared to current display technology.)** An improvement could be to include more LEDs to generate a clearer image and more attractive feedback. Emitting sound could be embedded with the upper plate functioning as a speaker.

- Mono-bi-poly: similar objects
  1. **-**
  2. Introducing one object
  3. Introducing several objects (Use other displays, ways of feedback)
  4. Combining objects into a common system

- Automation & control
  - Action coordination /Human Involvement Decrease
    1. Partial
    2. Full
    3. **Using pause of action (using wait times the feedback can even be given in-between actions)** Include feedback of proper usage to prevent compensation.
  - Controllability over objects
    1. **– no control**
    2. Change to semi-automatic control
    3. Change to automatic control
  - Controllability over "fields"
    1. Change to semi-automatic control
    2. **Change to automatic control (LEDs are automatically put on or off)**
  - ~~Biological field~~
  - Use of senses
    1. (no trends given) Both visual and audible are triggered. Smell/taste is not triggered. Tactile is triggered by passive objects not in an active way. Using active moving parts could increase training and lead to totally different placement of the product. However safety especially with children would become essential. Another way is to use tactile feedback making use of blowers which can give a variable resistance.
  - Colour transparency (also in microlevel)
    1. (no trends given) The lights can be dimmed and can mimic transparency with fading out. The software makes use of layers. Currently blending making use of alpha values is not possible. The board itself is not transparent as it also contains the PCB and antennas for the RFID localisation.

- Transition to micro level
  - Surface segmentation
    1. **- Flat surface**
    2. Creating a protrusion
    3. Creating roughness

4. Activating a surface (e.g. using air for tangible feedback)

- Space segmentation /Volume voidness
    1. Introduction of void
    2. **Segmentation of a void into parts (LEDs are divided in 12x12 grid with void used for the RFID sensors, this also generates a more equal light per square)**
    3. Creating pores and capillaries
    4. Activating pores and capillaries (the pores might be used for yet another function, e.g. using it to transmit located sounds)
- Substances and objects segmentation
    1. Into 2 parts
    2. **Into several parts (one can also say a field as light and sounds travel through the field, using the emitting point it consists of multiple parts)**
    3. Into a powder
    4. Into a paste or to a gel
    5. Into a liquid
    6. Into foam
    7. Into an aerosol (add smell as feedback method)
    8. Into a gas
    9. Into as plasma
    10. Into a field
    11. Into a vacuum (use a beamer, use tactile feedback (or sensors) that are connected with a suction cup)

- Dynamisation
    - Object
        1. **Ensuring of partial mobility of parts of objects (feedback is on plate but can be discontinues and independent)**
        2. Increasing the degrees of freedom (two boards can be used together already)
        3. Change to flexible object
        4. Change to molecular object
        5. Change to field object
    - Substance
        1. Ensuring of partial mobility of parts of objects
        2. Increasing the degrees of freedom
        3. Change to flexible object
        4. Change to molecular object
        5. **Change to field object**
    - Field
        1. Ensuring of partial mobility of parts of objects
        2. Increasing the degrees of freedom
        3. Change to flexible object
        4. Change to molecular object

5. **Change to field object**

- Geometry
    - Linear
        1. \- point
        2. Point to line
        3. **Bending line on plane (lines can be depicted with LEDs)**
        4. Bending a line in space
    - Volumetric
        1. **– current state (purely 1D LEDs and stereo sound)**
        2. Bending surface in one direction
        3. Bending surface in two directions
        4. Changing to compound and combined surfaces
    - Symmetry/Trimming
        1. Delete one part of an object
        2. **Delete several parts of an object (the extra screens have been removed)**
        3. Delete an entire object
- Energy conductivity increase
    - Introduction of new substances / Substance adaptation
        1. New substance into an object
        2. **New substance around one object (the light)**
        3. New substance around both objects
        4. New substance between the objects
    - Reducing energy loss
        1. (no trends given) The processors and sensors used require energy (approximately 47 VA). The input could be used to generate energy. Or another type of energy source could be used (e.g. battery or fuel cells).

Demands: Efficiency (reduction of compensation) & improved experience
Component: Input by tangibles RFID and RFID antenna.
Trends:

- Convolution (2/x →40)
    - Introduction of modified substances/Ideal substance
        1. -
        2. **Modified substance into in an object (usage of tags itself)**
        3. Modified substance around one object
        4. Modified substance around both objects
        5. Modified substances between the objects. Extra tangibles connected to the board could be used. This can help in allowing certain movements without requiring more energy. It can also function as extra type of feedback.
    - Function sharing
        1. (no-trends found) The RFID voids are shared with the LEDs.
    - Function self-delivery
        1. (no-trends found)
    - Transfer to supersystem
        1. (no-trends found) It is incorporated in the supersystem, this might be improved. As the start up and trigger to use might be improved if it would be made part of an ambient technology. Thus splitting the system and instead using a transfer.
- Rhytym coordination (2/4)
        1. Change to pulsating action
        2. **Ensuring resonance of pulsation (by using multiple antennas)**
        3. Combination of actions
        4. Using a travelling wave (make use of the magnetic field emitted by humans as is done with a certain old electrical instrument, this will no longer require tags for instance for the hitting game and might be more energy efficient)
- Transition to macro-level (6/7)
    - Mono-bi-poly: various objects
        1. Introducing one object
        2. **Introducing several objects** (multitude of tags can be detected in any object)
        3. Combining objects into a common system (use the environment itself instead of bringing things into it)
    - Mono-bi-poly: similar objects
        1. -
        2. Introducing one object
        3. Introducing several objects
        4. **Combining objects into a common system (antennas and tags are designed in such a way that they combine their info and "calculate" the location accordingly**
- Automation & control (6/x →60)
    - Action coordination /Human Involvement Decrease

1. Partial
2. Full
3. **Using pause of action** (antennas are read sequentially).

- Controllability over objects
  1. **– no control**
  2. Change to semi-automatic control.
  3. Change to automatic control (make it impossible to make compensating movements by guiding the movement e.g. robotic arm. The system could make use of its adaptive skills which could decrease the needed human involvement.
- Controllability over "fields"
  1. Change to semi-automatic control
  2. **Change to automatic control (RFID is passive)**
- Biological field
- Use of senses
  1. (no trends given) Only makes use of the tactile sense. Could also make use of very simple speech input from a set of possible answeres e.g. yes/no.
- Colour transparency (also in microlevel)
  1. (no trends given) The used tags are embedded in a plastic casing, the Sokymat tags used for the blackboard are made of non-transparent plastic, the smaller tags used for the Blueboard are transparent. One could make use of personalised (transparent) 3D printed object in which the tags are embedded. For example a logo of school or avatar.

- Transition to micro level (8/19)
  - Surface segmentation
    1. Flat surface
    2. Creating a protrusion
    3. Creating roughness
    4. **Activating a surface** (magnetic fields are sensed above the surface, it is in that way activated)
  - Space segmentation /Volume voidness
    1. Introduction of void
    2. **Segmentation of a void into parts (divided in 12x12 grid with void used for the RFID sensors)**
    3. Creating pores and capillaries
    4. Activating pores and capillaries (the pores might be used for yet another function, e.g. using it to transmit located sounds)
  - Substances and objects segmentation
    1. Into 2 parts
    2. **Into several parts (makes it possible to detect location)**
    3. Into a powder
    4. Into a paste or to a gel
    5. Into a liquid (make the RFID "printable")

6. Into foam
7. Into an aerosol (add smell as feedback method)
8. Into a gas
9. Into as plasma
10. Into a field (medium but not the system and sensor itself, making use of video integrated somewhere in the room one can also detect movements without need of a grip of an object)
11. Into a vacuum

- Dynamisation (11/15)
    - Object
        1. **Ensuring of partial mobility of parts of objects**
        2. Increasing the degrees of freedom (two boards can be used together already)
        3. Change to flexible object
        4. Change to molecular object
        5. Change to field object (video)
    - Substance
        1. Ensuring of partial mobility of parts of objects
        2. Increasing the degrees of freedom
        3. Change to flexible object
        4. Change to molecular object
        5. **Change to field object**
    - Field
        1. Ensuring of partial mobility of parts of objects
        2. Increasing the degrees of freedom
        3. Change to flexible object
        4. Change to molecular object
        5. **Change to field object**

- Geometry (6/12)
    - Linear
        1. - point
        2. Point to line
        3. Bending line on plane (lines can be depicted with LEDs)
        4. **Bending a line in space**
    - Volumetric
        1. **– current state (2,5D (x,y and up/downstate)**
        2. Bending surface in one direction
        3. Bending surface in two directions
        4. Changing to compound and combined surfaces
    - Symmetry/Trimming
        1. **–all needed**
        2. Delete one part of an object

3. Delete several parts of an object (the extra screens have been removed)
4. Delete an entire object

- Energy conductivity increase (4/x → 70)
  - Introduction of new substances / Substance adaptation
    1. New substance into an object
    2. New substance around one object
    3. New substance around both objects
    4. **New substance between the objects (The tags ability to be recognised increases as it is lifted slightly above the board. It is therefore advised to use a felt underneath a RFID tag. Although this is not really applicable to this parent category of energy.)** Extra tangibles connected to the board could be used. This can help in allowing certain movements without requiring more energy. It can also function as extra type of feedback.
  - Reducing energy loss
    1. (no trends given) The processors and sensors used require energy (approximately 47 VA). The input could be used to generate energy. Or another type of energy source could be used (e.g. battery or fuel cells).

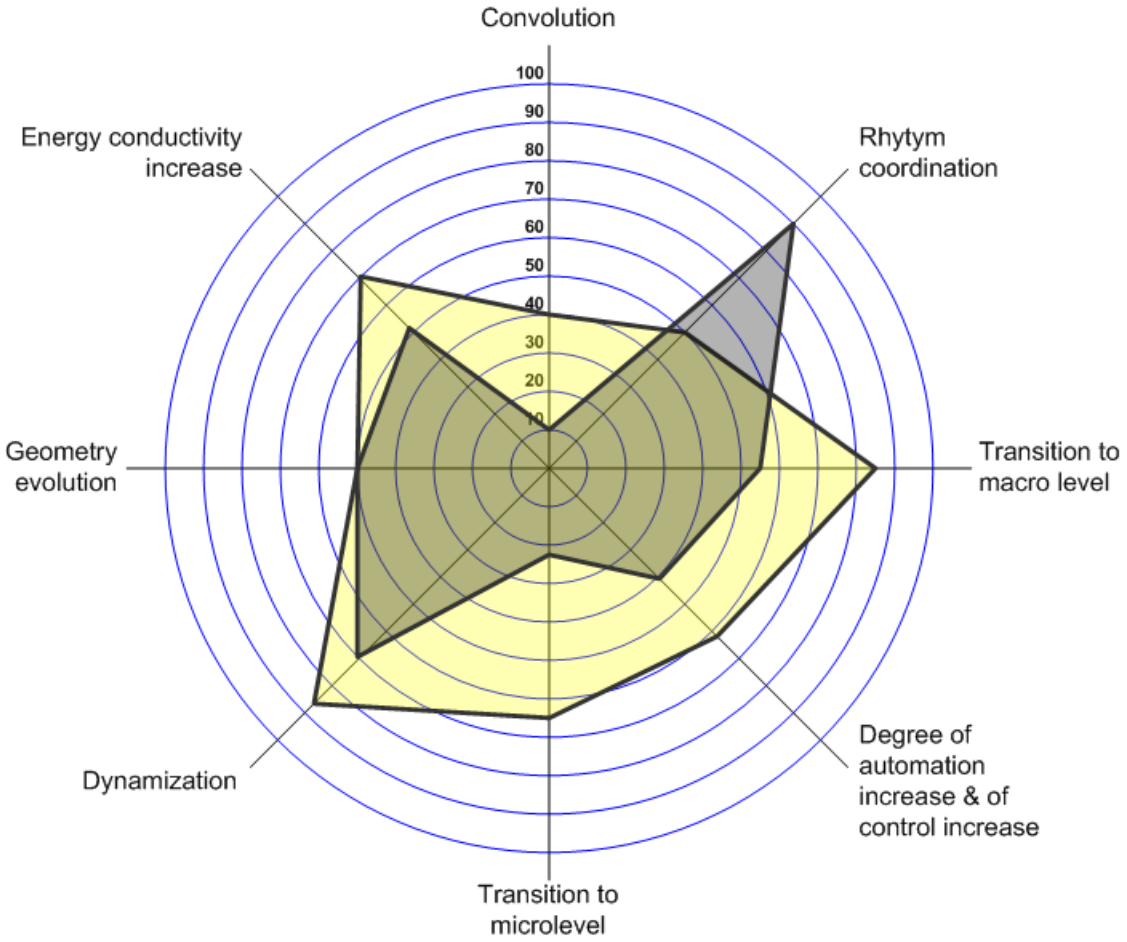
Demands: Efficiency (reduction of preparation time) & improved experience
Component: Usage and generation of games
Trends: most trends are hard to apply as it is not really the subsystem of the whole. Instead use witnessed trends and opportunities. Adaptability, the games can be altered to wishes of individual user. The programming language is supposed to be end-user friendly. However it still requires a great amount of getting acquainted with the concepts of the programming language. More graphical programming languages can be taken as an example for this. In the COMMIT program SeriousToys will further develop the suitability of the language as an end-user friendly programming language. Thus this might in the future lead to direct generated content for the TikTegel in theraphy, if other therapists with more affinity for programming would be interested.

Conclusion evolutionary potential assessment

The chart plots the current state of input and feedback of the Tagtile in its evolutionary state. This chart indicates the main categories of trends of evolution and shows where there is room for improvement.

The nine trends are based on the work of V. Souchkov. Degree of automation increase and control increase have been taken together giving eight main trends.

The room for improvement is mainly in convolution (the way a system is coming together). Other areas are the transition to microlevel, the degree of automation and there is some room in the geometry evolution.



A new subsystem can be introduced between the two systems. For instance connecting and fastening a tangible to the board which could focus the movement. The system could be split physically which could simplify starting up. A new input modality (limited speech recognition) can be used to improve the experience. The input system could be changed into a field by using video instead of RFID tags making training of other movements possible when a child has a too weak grip. The output could be changed into a field by using a beamer or introducing other modalities such as tactile feedback through air which could improve the experience.

Reference appendix J

Souchkov, V. (2005). Innovation roadmapping - introductory course. Enschede, University of Twente & XTRIZ**:** 1-43.