

# CHALMERS



## Development of Interactive Product for Children with Autism

Practicing communication skills

*Master of Science Thesis in the Master Degree Programme, Industrial Design Engineering*

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Department of Design and Human Factors  
Division of Product and Production Development  
CHALMERS UNIVERSITY OF TECHNOLOGY  
Gothenburg, Sweden, 2012



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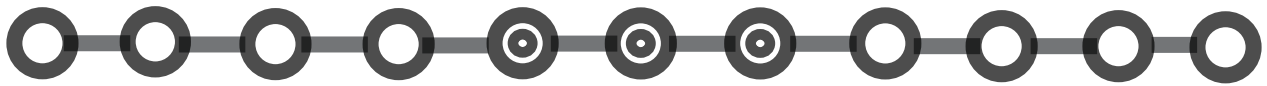
Cover:

*Children playing with an application and a physical toy developed to help children with autism to practice communication skills*

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# Abstract

Autism is a syndrome often described as affecting three main areas:

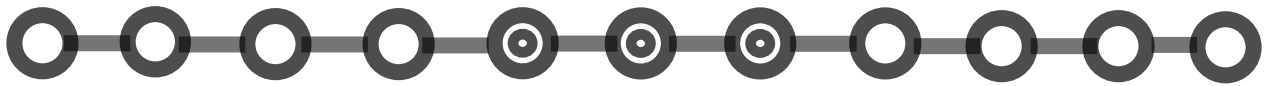
- Limitation of the capacity for reciprocal social games
- Limitation of the capacity for mutual communication
- Limitation of behaviour, interests, and imagination

In an attempt to enlighten the diagnose autism, and what difficulties might come with it, theory regarding autism has been integrated throughout a development process of an interactive aid, aimed at children with autism and a cognitive age of four to seven. Since communication and social interaction is becoming increasingly more important in todays society, the purpose was to develop a concept that promotes practicing communication skills and making contact with others under fun circumstances. The main aim was to practice turn taking by creating a system where two persons have to give turns in order to reach a goal together.

Discussion regarding development guidelines in general vs. guidelines for children with autism, has driven the design process forward throughout the project with a final result consisting of two main concepts. The two concepts are an application for tablets and a physical toy. Both were chosen because of their potential to compensate each other when it comes to strengthen the total ability for practicing communication skills.

The child with autism may in the application build a train together with a neurologically typical person by taking turns in choosing parts. When the train in the application is finished, the players can build an identical replication in a physical train, by using the application as a draught. By choosing and placing the parts, specific rhythms will be played; therefore, by building the train, players will also build music.





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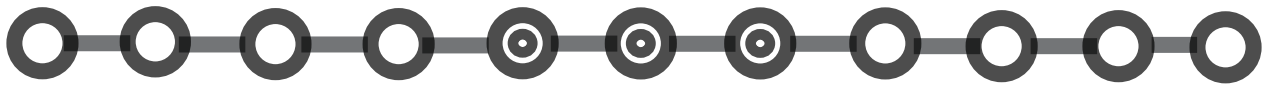
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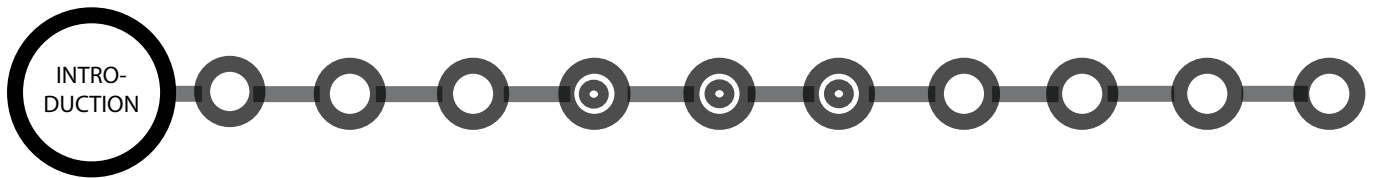
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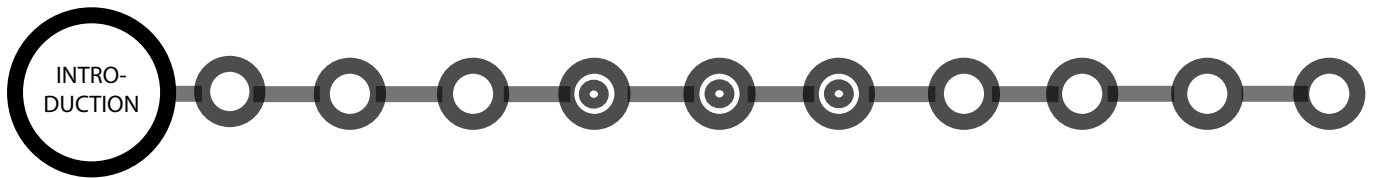
# 1. Introduction

## 1.1 BACKGROUND

Autism is a functional disability that often is referred to as affecting three main areas:

- Limitation of the capacity for reciprocal social games
- Limitation of the capacity for mutual communication
- Limitation of behaviour, interests, and imagination

Working with autism with aim to develop skills that are impaired is tricky since the diagnosis is highly individual, yet so important for the person with autism. Communication and social skills are today becoming more and more needed in society but the communication is often adapted to neurologically typical persons who rarely have knowledge about autism. To help enlighten the diagnosis, and to contribute with an innovative aid, this thesis will treat a development of an interactive product with focus on practicing communication skills. Special aids for persons with autism today are often functional, but this thesis will focus on the importance of “learning by playing” and especially by having children with autism interacting with neurologically typical persons. The term neurologically typical is in this report referred to a person with no neurological disability. Since autism is a broad spectra, the final product is not meant to be used as a single treatment and should not be interpreted as a complete solution for a specific problem area.



## **1.2 AIM**

The aim of the project is to through theoretical and empirical studies of autism and cognition, contribute with help and develop a tool for fun and effective learning for children with autism. The concept should help the child practice communication skills, creativity and flexibility by focusing on turn taking and learning by playing.

## **1.3 GOAL**

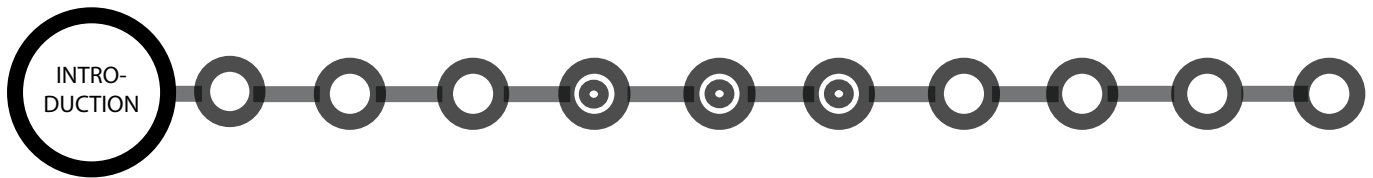
The main goal of the project is to create a concept meant for children with autism, to facilitate learning communication skills at home and in daily activities by focusing on giving it an expression of something fun rather than an aid. The goal is further to create a prototype with at least some level of functionality.

In order to meet the expectations of the goal, a few research questions will be considered throughout the process:

- How to motivate as many children as possible within the target group, to learn by playing?
- How to make use of the individuals strong abilities?
- How to use sensory stimuli in a way that rewards a broad group of children with autism?
- How to create an concept where flexibility might be practiced without losing important predictability?

## **1.4 LIMITATIONS**

The age of the target group is not possible to decide because of the high variation of individual cognitive levels and supplementary disabilities. There are different levels of how much autism affects a persons functionalities and difficulties. Common terms to describe the levels are low-, mid- or high functioning. The limitations are set as low- to mid functioning persons with the cognitive age of four to seven. More specifically, the person has no or limited speech but certain interests and skills of that age. Supplementary disabilities taken under consideration are limited to mild mental retardation and mild difficulties with muscle motor activity. The development process will however not emanate from an exclusion of other supplementary disabilities since it is fully possible that persons, not included in



the target group, might as well find good use of the final product.

The concept will be developed to the extent that it will be producible, but it will not be prepared for production. Construction will, in that sense, not be considered in an extensive manner.

Cost depends on construction, production methods, materials, components and period of time. Neither detailed construction nor production methods or exact use of components will be considered, therefore cost will not be exactly calculated. However, estimations will be made in order to control that the final product will be able to have a relevant pricing.

Basic laws regarding safety will be considered but standards and certificate requirements will be left for future development.

Finally, considering the target group, there will be no possibility to make any adequate evaluation of the product since the possible effects might show very soon or very late in time. Of this reason only a shorter evaluation of the results will be done.

## **1.5 METHODS**

A set of methods has been used throughout the project. All used methods are briefly explained in this chapter and put in context during the development phase of the report.

### **1.5.1 Qualitative methods**

#### *1.5.1.1 Interviewing*

Interviewing is a qualitative method where one or more persons are asked questions regarding a certain topic. In product development, interviews are common for finding deeper understanding of the user and the usage of the product. Interviewing might seem to be a simple method but the reality proves that in order to get relevant answers one need to ask relevant questions, and that is not to be understated. As an interviewer it is important to think about how the question is put, both to adapt to the level of the interviewee and to make sure that the question does not become neither leading nor overly abstract. Also, if the interviewee has problem to express him/herself the interviewer need to have good skills in reading between lines in order to probe to get more information. Probe means asking follow-up questions to dig deeper in the understanding and to gather more valuable information from the interviewee.

#### 1.5.1.2 Focusgroup

A focus group could be seen as an open discussion between selected people representing a target group. Focus groups are often used for finding opinions about certain aspects of a product. This is because some opinions might be hard to find solely by personal interviews where the interviewed might not come to think of as much as after discussion with others. One important role in a focus group is the moderator. He or she is responsible to direct the discussion to gain relevant information without restricting the participants and most often these questions need to be intuitive in order to follow the discussion properly. One of the benefits with the focus group is as mentioned, the many ideas and opinions that might not have been found without a discussion in a group, but in order to have a successful session the participants need to feel comfortable with the company (Johannesson et. al, 2004).

#### 1.5.1.3 HTA

Heuristic task analysis is a method used for breaking down a task in smaller steps in order to create a better overview. The HTA may then work as help when analyzing the task in different aspects. A main goal for a task is decided and then it is broken down into sub-goals and operations needed to achieve the goal (Bligård, 2011).

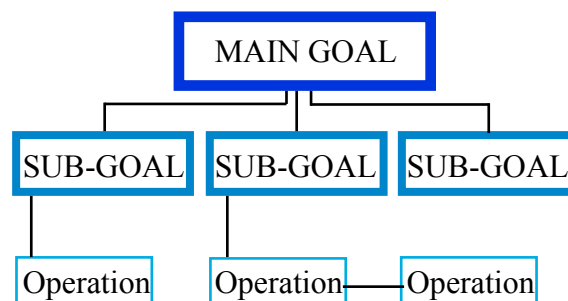
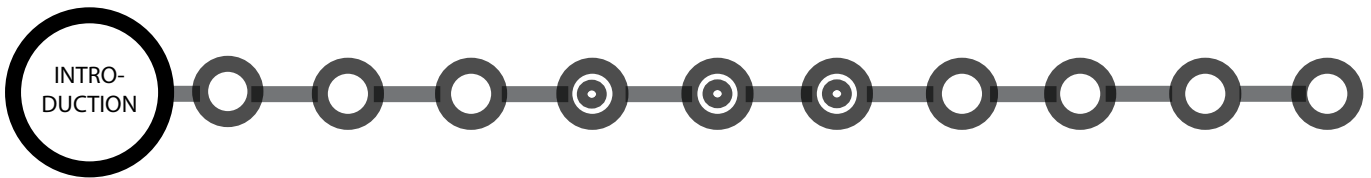


Figure 1. Simple model of a Heuristic Task Analysis

#### 1.5.1.4 CW and PHEA

Cognitive Walkthrough, CW, and Predictive human error analysis, PHEA, are methods used for analyzing usability and possible errors that might be done using an interface. The methods are performed by asking questions regarding what, if, how and why errors might occur. Using the break down of tasks by a HTA is often helpful in order to structure the analysis (Bligård, 2011).



### **1.5.2 Quantitative methods**

#### *1.5.2.1 Survey*

Surveys are done with aim to collect opinions from a population regarding a certain topic. It could have the form of a questionnaire or it could be open questions.

### **1.5.3 Creativity tools**

#### *1.5.3.1 Brainstorming*

Brainstorming is best done in a group of 5-15 persons with one appointed leader. It is a method for coming up with a variety of ideas where the group members spontaneously can speak out without judgment. During a session, any criticism of ideas is forbidden since it restricts creativity and the quantity of ideas is sought to be high. By delivering extraordinary ideas, combining and associating other's ideas, creativity may be increased (Johannesson et. al, 2004).

#### *1.5.3.2. Theme x-ing*

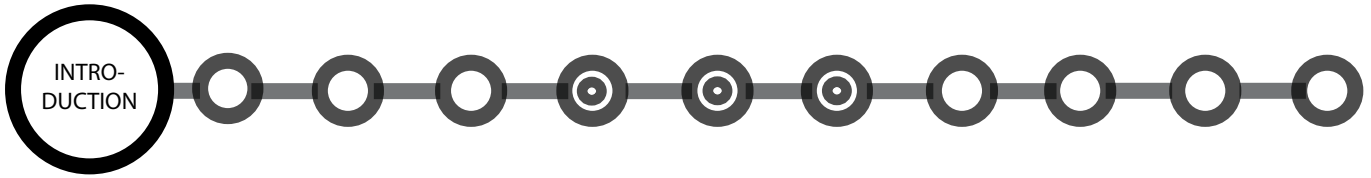
The method is inspired of variants of brainstorming and the point is to create a set of themes relating to a problem area. The participant(s) are to write down as many substantives relating to each theme as possible. Using post-its the persons places all words in the right theme on a table, wall, board or another suitable place. Next step is for all participants to pick one note from each theme. I.e. they will end up with three words. The point with this method is to help increase creativity by associating the word combination into a principle or idea relating to the topic of the problem. The associations of the word combination does not have to include the words even if that is possible too, the point is to produce associations of any kind.

#### *1.5.3.3 Mind mapping*

Mind mapping is a conventional and easy way of structuring thoughts and ideas. Beginning with a certain topic, ideas are written down in branches from each other. Ideas may be found and evolved through words, course of events, associations etc.

#### *1.5.3.4 Personas*

A persona is a short description of the “typical” user and his/her needs. Personas are something that may be used to give a designer a quick overview of the target group and its needs. It may also be used to clarify aim and decisions to different stakeholders (Österlin, 2010). Experience from earlier projects shows that the description should be written in a more personal sense. This means, not only taking direct requirements and needs as a background but also other aspects such as hobbies etc., if this is relevant to the project. Irrelevant facts are on the other hand not to be added since it may confuse the reader's image of the target group. If a



picture is used it should be chosen with care. Styles of hair, clothes and accessories may provoke personal bias regarding the persona, which in turn might affect the interpretation of the whole target group.

#### **1.5.4 Visualization tools**

There are many methods for visualization and depending of what is to be visualized suitable methods differ.

##### *1.5.4.1 Sketching*

Sketching on paper is a good method for example when one would like to make a quick representation of an idea. Sketches could also be done with great effort and consume a lot of time if the result is to be used for presentation material etc. “Quick and dirty” is an expression for making many and very simple sketches.

##### *1.5.4.2 Digital sketching*

Digital sketching builds on the same idea as conventional sketching with paper and pen. The difference is that the sketches are made with help from computers, gadgets and software that enable more techniques and applications to be used.

##### *1.5.4.3. Sketch models*

Sketch models could be seen as a simpler version of a prototype. A prototype is the last model made before production. I.e. a prototype should have the same features as the, to be, ready product. A sketch-model on the other hand is often used earlier in the development process where they represent ideas. The features on the sketch-model does not have to be fully working, they should only be represented. Therefore, sketch-models could be a quick and easy way of visualizing an idea in 3D. Any material might be used to create the model but some common are clay and paper. Paper could be good to use for larger objects to visualize a volume for example. Clay on the other hand is good for smaller objects in for example form development, where shapes and forms need to be felt by the hand.

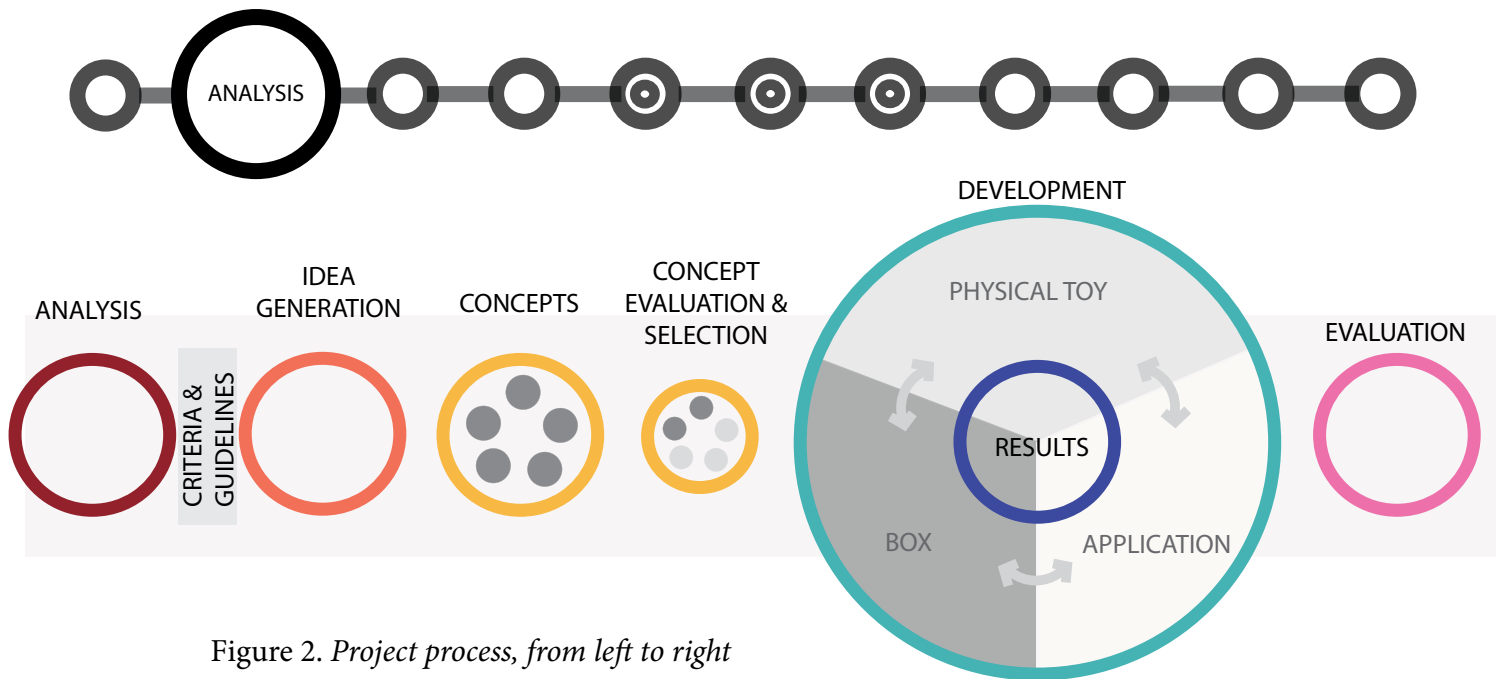
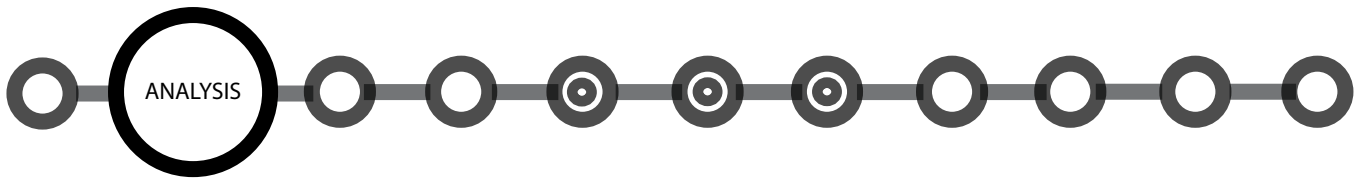


Figure 2. Project process, from left to right

## 2. Needs and Requirements Analysis

Finding needs and requirements concerning a target group is important in development of any product. The analysis lays a foundation for design choices in later processes of a project, and this particular analysis starts with an extensive literature review regarding autism and some of its dimensions important for the project. Except for books and articles, information has been given by personal interviews with professionals working with, and parents to, children with autism (Appendix 1). Additionally a focus group has been held where persons with any connection to autism was invited to exchange experiences of, and about, the diagnosis. The literature review together with the personal interviews mentioned above, and the focus group was done in order to create a good understanding of how autism can affect a person and what is important to have in mind when designing products for this target group. Personas (Method 1.5.3.4, Section 2.1.11) were made to create a perspicuous picture of autism, and they also were to be used as inspiration when creating the criteria list (Section 2.4).

When aiming to develop any product or service with some level of innovation, one need to analyze the market in order to find out what is currently missing. This typically includes investigation of trends and available products or services. Possible needs and requirements that had not been brought up during the literature review was sought to be found by scouting for available products as well as by performing a trend analysis (Section 2.3). Information was gathered from the literature review, personal interviews, newspapers, toy stores, technology- and aid retailers, web pages of institutions and companies working with the development



of society (Chapter References - *Web pages*). The information and learning's from the needs and requirements analysis was converged into a list of guidelines used for evaluation of concepts in later process phases (Section 2.4)

## **2.1 LITERATURE REVIEW**

### **2.1.1 Children's evolution**

At four years a neurologically typical child is developing better and better concentration abilities. The social interaction with friends is becoming more important and the child is at moments quite independent of the parents. Around year four and five the child also develops a deeper understanding of everything and more interest in drawing, numbers and letters. At six years old children often have a turbulent time where competing and styling in front of others are common interests. At the age of seven, awareness of the own body as well as the ability of seeing things from others perspective is developing together with the ability to concentrate for longer periods (Psykologiguiden, 2012). As will be explained in this chapter, these milestones cannot be adapted to all children, especially some children with autism, but are brought up to provide the reader with an understanding of that particular period in life, since it regards the age span of the target group.

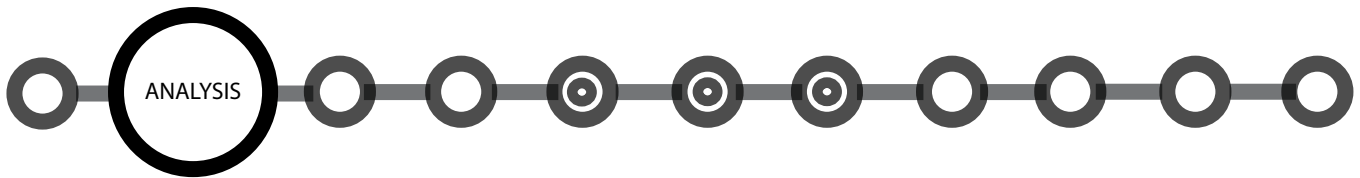
### **2.1.2 Autism**

Autism spectrum states are seen as cognitive dysfunctions emanating from a dysfunctional central nervous system (Rutter, 1983 in Sjöholm-Lif, 2004). It may affect a person's cognitive abilities in many ways and the diagnose follows throughout the whole life (Autism och Aspergerförbundet, 2012). According to (Powell, Jordan, 1998), there are four key features that describes the condition and possible differences with non-autistic persons, those are; How the person interprets information, How the world is experienced, How information is interpreted, stored and received in the memory and The role of the emotions.

Having autism could be described as seeing the world more objective. It is another way of thinking and reacting to the world and given sensory stimulus, a way that non-autistic persons might find hard to understand, and as (Powell, Jordan, 1998) implies, autism itself should not necessarily be related to flaws or scarceness. It is common that autism is combined with other functional disorders such as low hearing, vision, epilepsy and mental disorders (Autism och Aspergerförbundet, 2012).

It is important to stress that autism is an individual diagnose where difficulties and qualities varies endlessly. This is only a short introduction to the Autism spectrum and only some of the most prominent features are brought up.





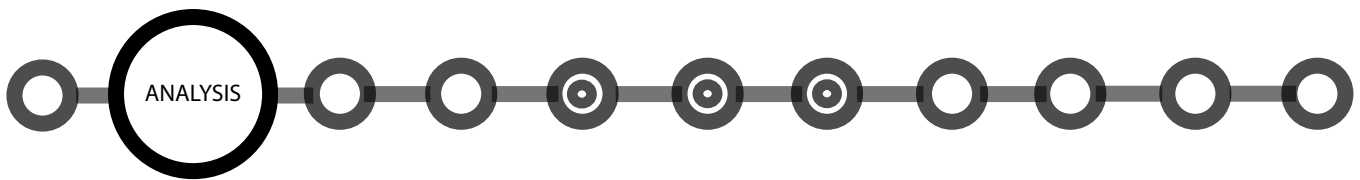
### **2.1.3 Working with autism**

The earlier one can detect autism and set diagnosis, the more beneficial it is for the person with autism who then will be offered support at an earlier stage which is positive for the cognitive development. With early knowledge of the diagnose, it is possible to adapt the support that is required in order to meet the individual needs the person has in educational and environmental terms (Autism och Aspergerförbundet, 2012; Powell, Jordan, 1998; Haglund, 2004).

Going through literature one find that there are many approaches in how to work with autism, e.g. there is ABA (In Swedish IBT, TBA), TEACCH, Psychodynamic child psychology and Snoezelen, which are just a few of many approaches. Common for all of them is to either improve the social, cognitive and linguistic abilities or to reduce certain behaviours that might demand attention valuable for learning. Methods differ in approach, e.g. Snoezelen focuses on the person's own curiosity and sensory stimulation, while in ABA the idea is to set goals that are achieved step by step through continuous training with special education teachers.

TEACCH (Treatment and Education of Autistic and related Communication Handicapped Children) is one of the most established methods working with autism in the USA. Focus is mainly set on developing communication skills and self-dependency rather than decreasing destructive behaviours. The TEACCH-program is a collection of many methods in itself, this to ensure that the person with diagnose will be able to develop its cognitive processes in the most efficient manner. Of that reason, the treatment plan is completely personalized, using methods that seem to suite the person best. Another important aspect of TEACCH is that it both include and engages the parents. They are to actively participate in work with exercises and both professionals and parents are supporting each other. Within TEACCH, parents are recognized as knowing a lot about their children, giving the professionals an opportunity to learn from parents in order to become more efficient in their approach to the person with autism. Typical exercises are for the sense of time, room and communication using symbols, pictures, text, structure of the room, signs for non-verbal communication etc. (Heimann, Tjus, 1997).

The use of computers as an aid for persons with autism has historically not been overwhelmingly successful. In the earliest attempts back in the 1970's, a man called Kenneth Colby designed software where children could play with and discover linguistics. The problem was that the computer needed such high capacity for running the software that it was just not available for the general public at that time. The development of technology did of course contribute to new solutions



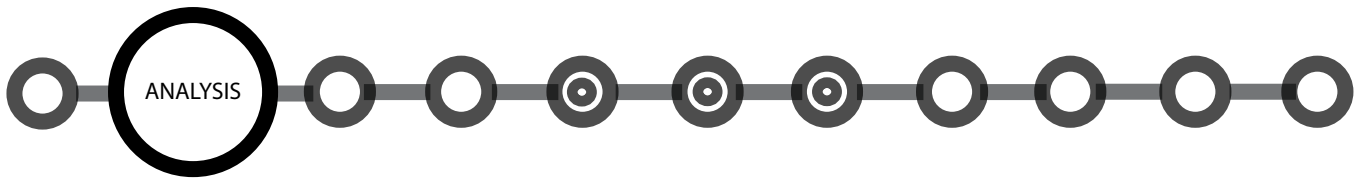
but due to scepticism mainly from parents and teachers; during the 90's the computer was still not really accepted as a method for working with autism (Heimann, Tjus, 1997). Nowadays this is not just a relatively popular method, it has been found that these kinds of products seem to appeal a group of persons with autism and further, there have been progress documented for many of the persons using it. Even more significant for the development is that today many of the creators of smart phone applications for autism are actually the parents themselves.

There is a boom of new technology and the development is fast in the area of computers, smartphones, and tablets. This will by definition bring us increased possibilities for creating new cognitive developing methods.

An application is a sort of software that can easily be downloaded to a smart phone or tablet giving the device higher functionality. Typical applications are games, tools for organization and booking systems. In the world of applications, where technology rapidly develops, imagination and creativity are the main limitations, which also show in the extensive collection of applications that already exist only a few years from their first appearance on the market. Software for PC and Macintosh computers is also available on the market. The cost is often a bit higher but that could be seen as compensated by the higher capacity for the software that is available.

Music is an expression and a form of communication. For persons without speech, music can provide a fundamental lifeline to human interaction and communication. There is extensive evidence of the strong physical, as well as deep emotional effects can have on listening and playing music (Zeedyk, 2008). When working with persons with autism music is often used for practicing gross and fine motor skills, turn taking and the sense of time. Instruments give instant feedback, something that is important for the person to understand that he or she is in control and that action gives reaction. Rhythm is also something that we seem to be born with, instinctively one can sense when a song is about to stop or continue just by hearing the pitch and structure of the song. This is used for training turn taking, for example it is common to let the person with difficulties in communication to fill in words that are left out in a well-known song (Hartman, 2012).

As pointed out before, autism is a very individual diagnosis and therefore no method is recognized as the only true one. Research contribute with new approaches but what is clear once again is that training must be individualized and a method that is suitable for one person might even be harmful for the other.



#### 2.1.4 Learning

Knud Illeris, an international profile and professor in research areas of learning, has written several books, reports and articles in the subject. In his book “Lärande” published 2007 by Studentlitteratur in Lund, he suggests a learning model. The model is meant to illustrate what he believes is the three dimensions that constitutes what we think of as learning.

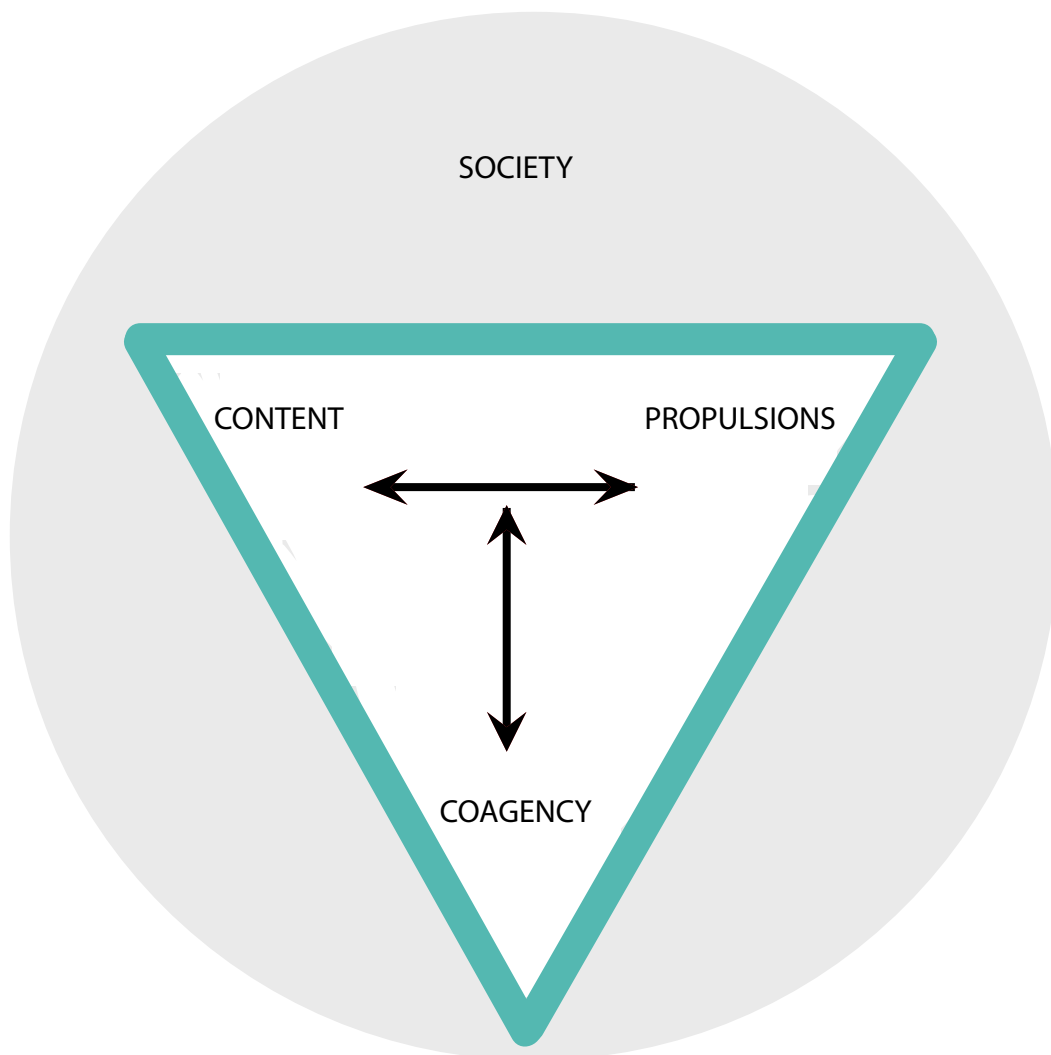
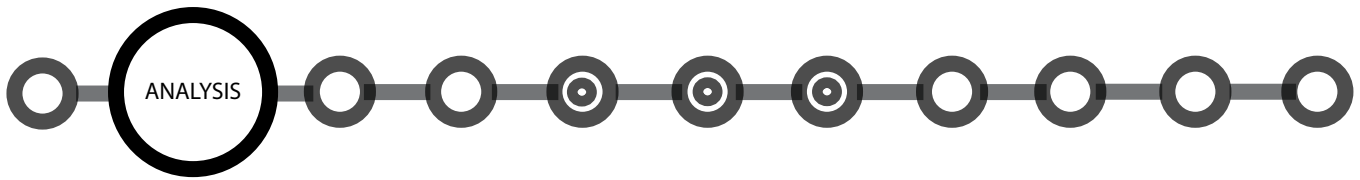


Figure 3. *Three dimensions of learning (Figure inspired by Knud Illeris book “Lärande”)*

The three dimensions are; The Content dimension, The Propulsion dimension and The Coagency dimension. (The text is translated from Swedish and notions such as Content, Propulsion and Coagency might not be identically used as Knud Illeris would. They are used in this text only for clarifying the idea of the learning model and its dimensions.)



*The content dimension* is involved with what is to be learnt.

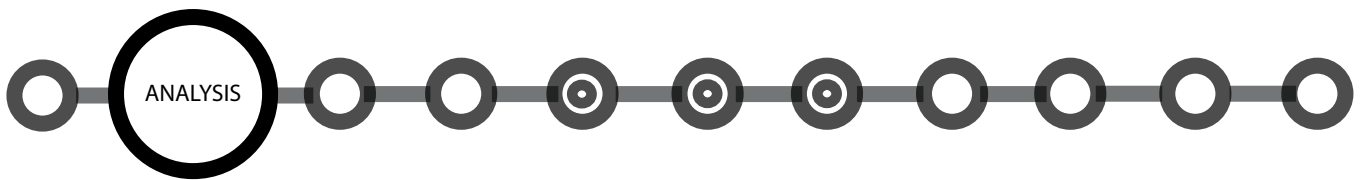
*The Propulsion dimension* is the motivation- or demotivation forces, emotional awareness and the attitude towards learning.

*The coagency dimension* is the interaction of the individual and the surrounding world in terms of the social situation and situation in society.

Illeris advocates that all dimensions are involved in any learning situation. Propulsions and content are closely affecting each other and results in what is called the adoption of information. (Information could here be interpreted as any stimuli or information originating from oneself or the surrounding environment.) For example, a person who loves mathematics, who is used to feel good about the subject often also have higher motivation in learning more. Therefore follows often a higher amount of learned information as well as a deeper understanding and knowing when to use the information in relevant situations. The contrary is of course just as likely to happen if the person of some reason does not like math and cannot find motivation to learn it. On the other hand, propulsions may affect the attitude towards content to the positive and the content itself may affect the motivation negatively.

This is partly supported by literature regarding autism. It is stated by (Sjöholm-Lif, 2004) that there is a lot of documentation supporting the efficiency of making use of the strengths and interests that the person with autism has, when learning functional skills. It is here however made clear that Illeris derives his model from neurological typical persons since there is an essential difference from persons with autism. It is fully possible that a person with diagnose has high propulsions for learning and will learn with a high result without really understanding when it is relevant to use the knowledge in other situations (Powell, Jordan, 1998). The model is however still relevant for creating an understanding of what will affect learning but should not be seen as an empirical fact, especially not for persons with autism who might diverge from that theory in some aspects.

With the coagency dimension Knud Illeris want to illustrate that all learning is situated and therefore the learning situation is not only affecting the learning itself, it is actually a part of learning. The notion situated is made up by a double sense; the direct surroundings such as persons, material, architectural spaces etc., and the society with its norms and structures. This again means that the situation affects learning. All together it is interpreted that conditions and ability for learning is possibly a matter that concerns far more individual requirements than what is offered and thought of generally in the society. School, as an example, is actually an institution driven by political decisions of what is desirable knowledge and



skills in the future (Illeris, 2007).

With this said, it is possible that the structure and way of learning in school is not the most efficient for all individuals. To relate this to a person with autism, one could easily imagine and understand possible effects on learning when there is a higher sensitivity to specific stimuli, changes in routines and maybe even people in the surrounding that cannot understand attempts to communication. This is not to say that persons with autism have difficulties in learning by definition, there are components such as communication, sensory stimuli, imitation and executive functions, all affecting learning and often found as difficult areas for persons with autism (Rogers 1998b in Sjöholm-Lif 2004). Learning situations should therefore be adapted to the individual to reach the highest efficiency.

### **2.1.5 Memory**

The general concept of memory is presented in (Osvalder, Ulfvengren, 2009). Mainly there is a short-term memory and a long-term memory. The short-term memory is also known as working memory and this is where information, such as sensory impulses, is stored temporarily to be processed and perceived. The long-term memory is where we store the information. The data that is stored is more based on meaning than information, and what quality and amount of what is learned depends on the ability to connect the information to a meaning (Osvalder, Ulfvengren, 2009). As (Powell, Jordan, 1998) says, persons with autism might have difficulties in connecting a social or personal meaning in things that are being processed (e.g. what is seen and what is heard). This in turn could support their statement that stresses the importance of encouraging persons with autism to reflect over what have been done, said or learned.

The long-term memory is divided into four subgroups, Procedural memory, Perceptual memory, Semantic memory and Episodic memory. Procedural and perceptual memories are non-declarative, i.e. they contain data that cannot be expressed in words. Semantic and episodic memories are on the contrary things we can express and declare (Osvalder, Ulfvengren, 2009).

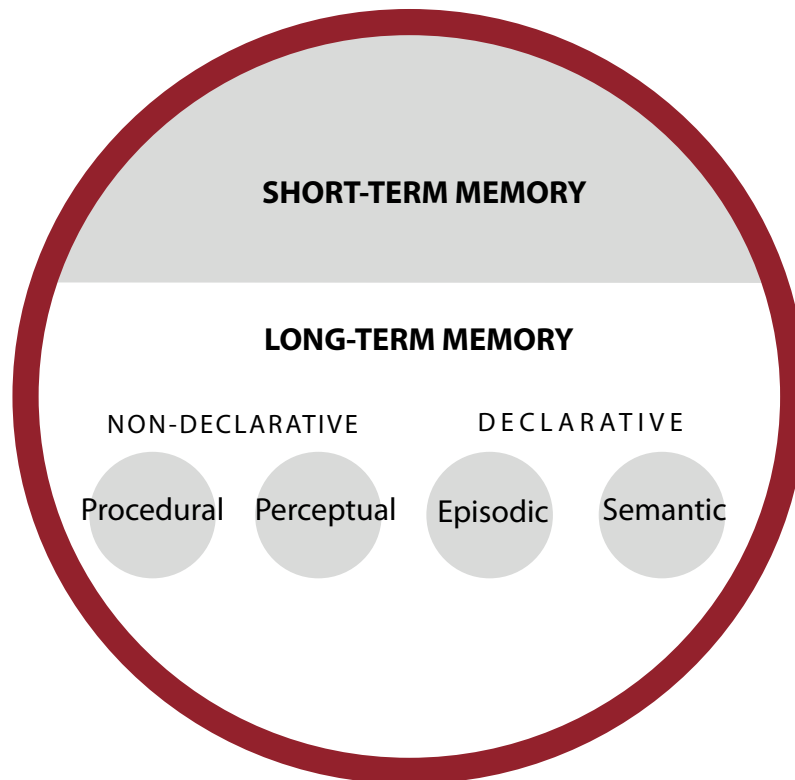
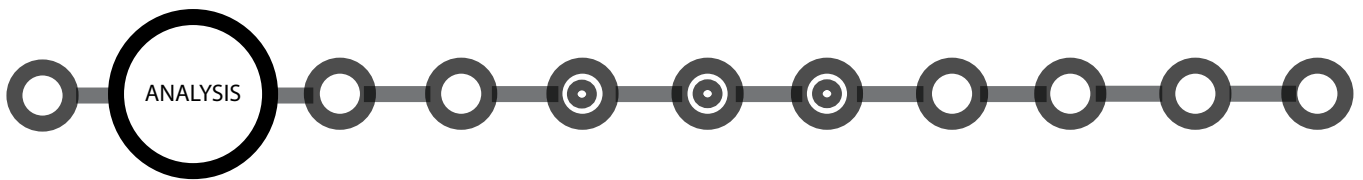


Figure 4. *General concept of memory*

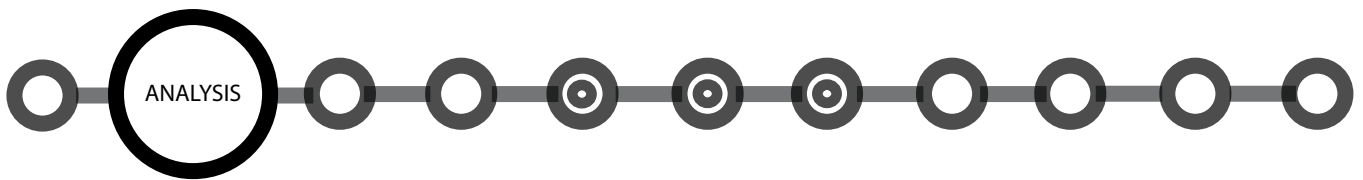
*The Procedural memory* is our ability in motor activities such as knowing how to ride a bike or swim even many years of not trying it.

*The Perceptual memory* helps us to identify objects, words, expressions and surroundings, giving us knowledge that we don't have to reflect over.

*The Episodic memory* gives us e.g. the ability to remember things in the past. It contains events that are connected to our own experiences.

*The Semantic memory* is our factual knowledge base. This is where we store knowledge such as language, and general information. The semantic memory also helps us understanding the equalities in objects such as interpreting that two different looking tables both really are tables. I.e. this could be expressed as the knowledge of for example tables' shapes and their meaning.

Memory for persons with autism is something scientists have different opinions about, especially when it comes to Episodical and working memory. There are many studies of how the memory works for persons with autism but the results give no clear answer. Some studies show that there is a difference in autistic persons memory contra non-autistic persons, and some studies shows that there



should not be any difference. There is no one that has been able to prove whether persons with autism have a non-working memory or just another way of organizing memories. However, the semantic memory seems to be something that has been agreed on as being intact even if there might be some difficulties depending on the individual (Autismforum, 2012).

### 2.1.6 Perception

Perception is described by (Osvalder, Ulfvengren, 2009) as :

*“...the capacity to become aware of information from the environment...”*

First there has to be a stimulus, which normally produces a sensation. The sensation is registered in the brain, i.e. perceived, before it is processed in certain areas of the brain and connected to cognitive associations, normally giving meaning to the stimulus and sensation. Figure 5 shows a simplified model of cognitive processing and how different aspects can affect response in e.g. actions and reactions to stimuli.

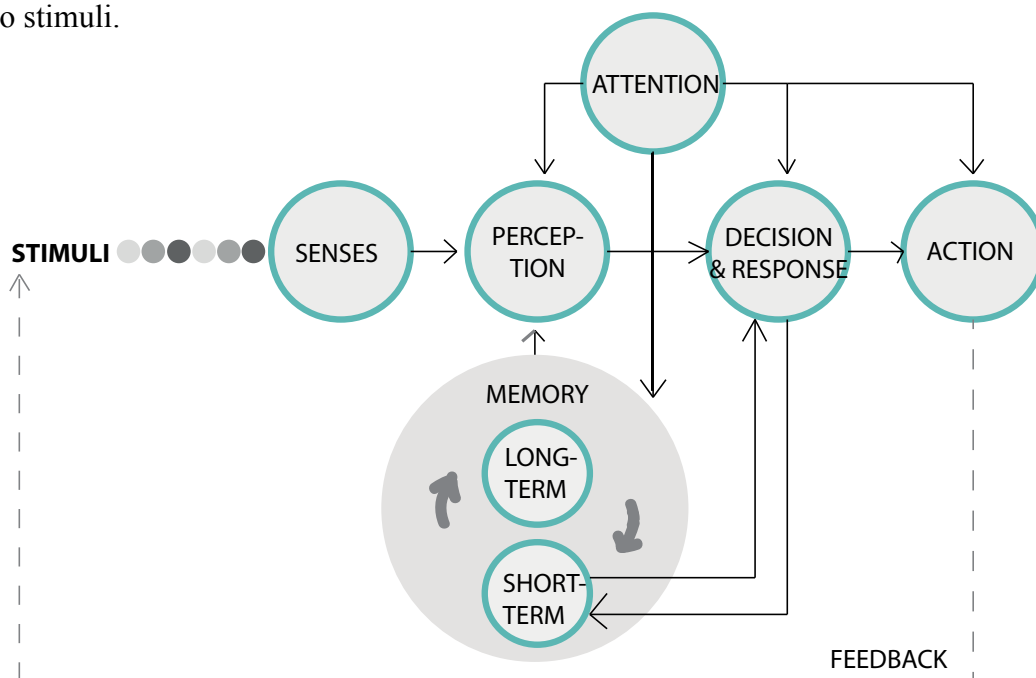
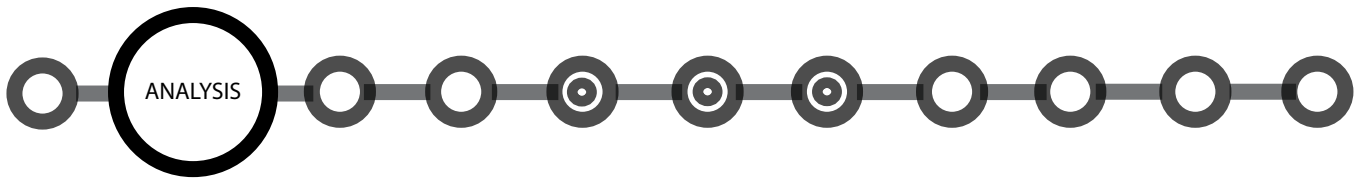


Figure 5. *Simplified cognitive processing model*

Information about the surrounding world is given through our sensory systems. Traditionally, humans are said to have five senses; Vision, hearing, taste, smell and touch (Osvalder, Ulfvengren, 2009). Added to these should also be the vestibular system, which detects movement and changed positions in the head, and the muscular sense, relating to movement and positions of the body (Bogdashina, 2003).



The body uses receptors in order to capture sensory stimuli. These receptors are for example our eyes, ears, mouth and the skin. Sensory nerves connected to the receptors send the stimuli information to the brain where it is to be processed and interpreted.

#### *Vision*

Organs used for vision are the eyes. The sensory receptors are rods and cones whose task is to record various colours of light. Processing the light gives us abilities such as, contrast sensitivity, colour vision, depth perception and movement detection (Osvalder, Ulfvengren, 2009).

#### *Hearing*

The ears detect mechanical vibrations in the air, i.e. sound waves, and the information goes to the auditory cortex (the region for sound in the brain) in the opposite cerebral hemisphere (Osvalder, Ulfvengren, 2009; Bogdashina, 2003).

#### *Taste*

The receptors for taste are called taste buds; these are located on the tongue, inside the cheeks, in the throat and in the roof of the mouth. The buds are divided into categories for the primary tastes: bitter, spicy, sour, salty and sweet (Bogdashina, 2003).

The sense of taste is connected to the sense of smell. With reduced sense of smell it is harder to actually feel taste (Bogdashina, 2003).

#### *Smell*

In our nose there are millions of receptors. They detect and respond to smell molecules and there are at least 20 different types, each detecting different ranges of molecules (Bogdashina, 2003).

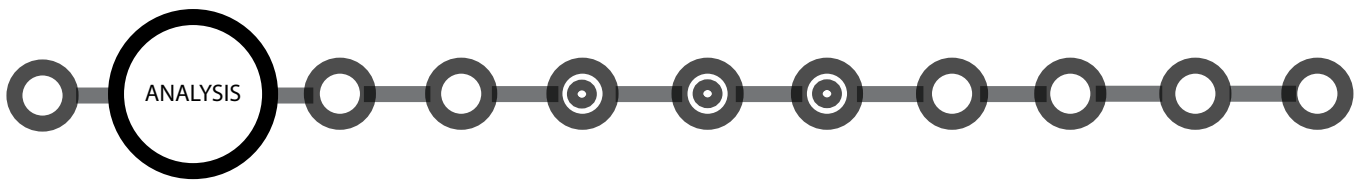
#### *Touch*

Is known as the tactile sense. There are three types of receptors in our skin: thermoreceptors, mechanoreceptors and free nerve endings. As the name implies, thermoreceptors help us feel temperature changes. Mechanoreceptors give us ability to feel pressure, vibration and touch, and free nerve endings make us feel pain or movement when hair on the skin is bent (Osvalder, Ulfvengren, 2009).

#### *Vestibular system*

The vestibular system located in the inner ear, helps us with balance and to determine the direction of our body relative gravity. The balance organ uses a fluid and works like a spirit level. When the fluid moves as we change position of the head, tiny hair cells are stimulated and information is sent to the brain. The balance is also closely coordinated with the vision and movements in joints and muscles (Osvalder, Ulfvengren, 2009; Bogdashina, 2003).





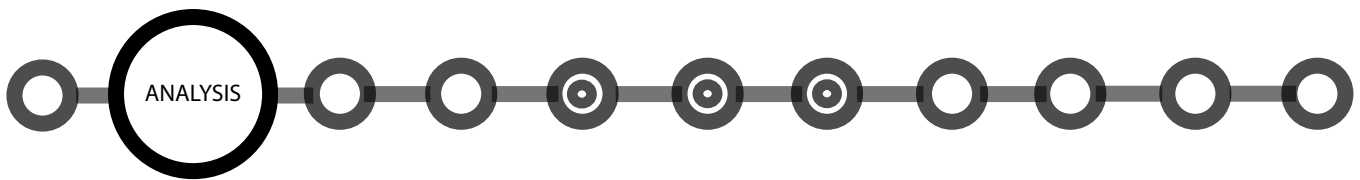
### *Muscular sense*

The muscular sense gives us awareness of the body's position and movement. We have something called proprioception, the system that gives us information about position in body and extremities in space, and something called the kinaesthetic sense, giving us information about movement in the joints. The receptors are found in the skin, tendons, joints and muscles where they register stretching, tension and strain. The muscular sense is involved with both conscious and unconscious movement patterns giving us the ability to perform certain tasks without having to direct much attention to it. (Osvalder, Ulfvengren, 2009; Bogdashina, 2003).

(Bogdashina, 2003) uses the expression that “persons with autism has different systems of communication and perceptions” and of that reason they wont at times respond in ways that neurologically typical persons expect them to. This could be called a different set of SPATS, Senses, Perception, Abilities and Thinking Systems (Morris, 1999 in Bogdashina, 2003). Sensory stimuli is for some persons easily mixed together making it hard to concentrate on input from one particular stimuli, e.g. it could be hard to sort out a voice if there is background noise. A fan in the background could demand just as much cognitive attention as the voice of the person talking to you, making it hard to concentrate on what is said. Stimuli or senses can also be enhanced and therefore in some situations become hurtful or unpleasant. This could apply to colours, words, light, sound, tactile contact etc. (Powell, Jordan, 1998; Autism och Aspergerförbundet, 2012). On the reverse, particular stimuli can have positive effects such as relaxation, motivation and sense of reward. Music, different sounds, touching and lights are common things that could be hurtful but just as well give positive effects. It depends on the individual and it is not unusual if a person for example perceives higher tones in music as disturbing and low tones as calming.

### **2.1.7 Communication and social interaction**

Social ability is a primary skill in order to keep mutual interaction between humans (Haglund, 2004). The abilities to try establishing contact and communication, keeping a conversation alive and understanding the social context and its codes are all included in social ability (Autismforum, 2012; Haglund, 2004). These areas are common to be problematic for persons with autism but social ability both can and should be trained. A typical difficulty for persons with autism is the social interaction with others and seeing the meaning with it. There are often difficulties in speech and in the ability to use and understand varying non-verbal behaviours such as eye contact, face expressions, body language and gestures in social contexts, often making it hard to communicate properly (Powell, Jordan, 1998). At times this is even involuntary, the person may in some cases know how



to behave, move or what to say but the body just won't comply, which in itself can cause big frustration or anxiety.

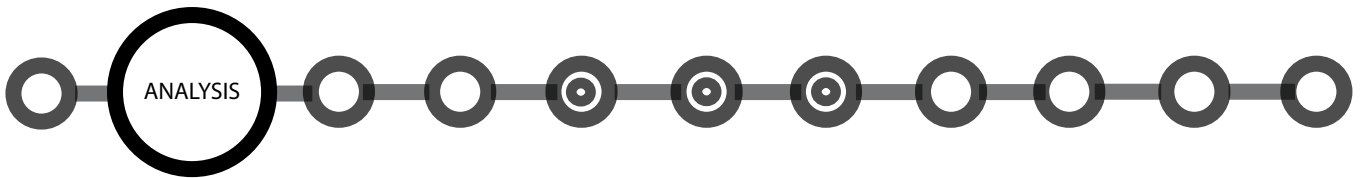
Since the range of difficulties is individual also when it comes to social interaction and communication, suitable methods differ. Training such as drama, LEGO therapy, playing music and playing with contemporaries that are neurologically typical has displayed progress for persons with autism. Another way of encouraging to social interaction is for teachers, parents and other surrounding people to reinforce good behaviours and spontaneous attempts from the child with autism (Autismforum, 2012; Haglund, 2004, Owens et.al. 2008).

There are also methods for training communication at different cognitive levels. Included in these are practicing turn-taking, (i.e. learning to include another person in a conversation or game, and to wait for a respond from him or her before proceeding.), practicing important words, exercising oral motor activity to help form right sounds, training imitation, learning signs, practicing to see from other persons perspective etc. (Autismforum, 2012). It is also beneficial to use several different training methods and to let the child train in different environments with some changes and adaptations, as well as training in structured activities (Haglund, 2004).

### **2.1.8 Flexibility**

For persons with autism it has often been detected that there might be a lack of interest in others. This also applies to what is called Theory of mind, the ability of seeing things from other perspectives (Heimann, Tjus, 1997). Imagining things such as in children's play is at times hard for some persons with autism, meaning that they often choose not to participate.

Attention might be tunnel shaped, i.e. interests are quite common to be found very narrow and persistent for a long time and structure is one of the keywords when it comes to everyday life. Structure and routines gives a sense of predictability. When structure is changed, or things act, or are done in new ways, confusion and anxiety can arise since the sense of predictability disappears (Autismforum, 2012). Flexibility is therefore often practiced in various ways. This could be done e.g. by asking questions like, "What would the world be if it was upside down", or by deliberately expose the person with autism to new situations. What is important is that flexibility is trained in small steps and an appropriate pace for the person training (Powell, Jordan, 1998).



### 2.1.9 Developing interfaces

An interface is the link between an operator and a product. The interface provides the operator with possible ways of using the product and tells what status the product currently has (Osvalder, Ulfvengren, 2009). A common way of displaying the interaction between human and machine is shown in figure 6 below.

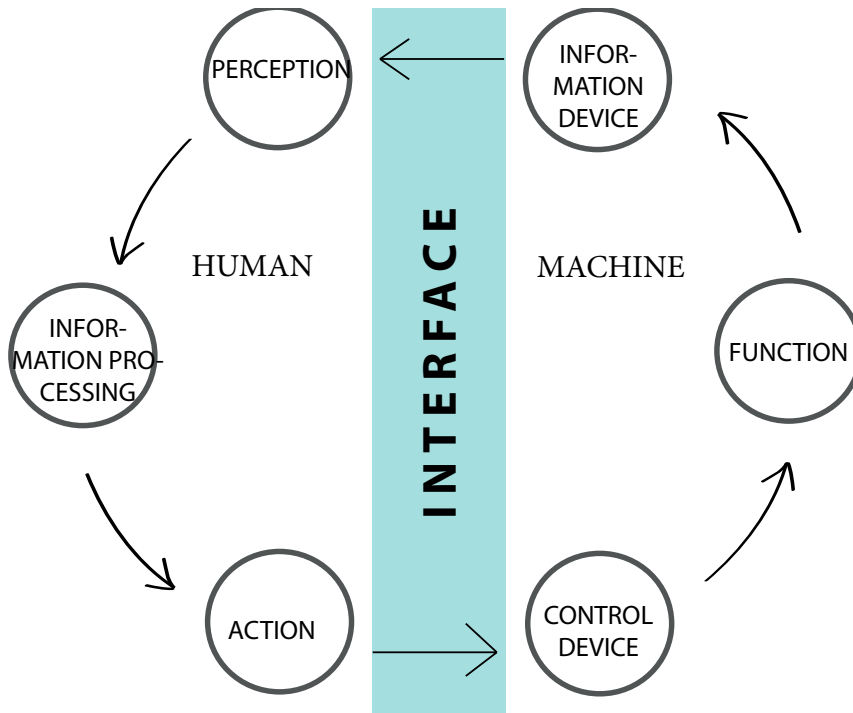
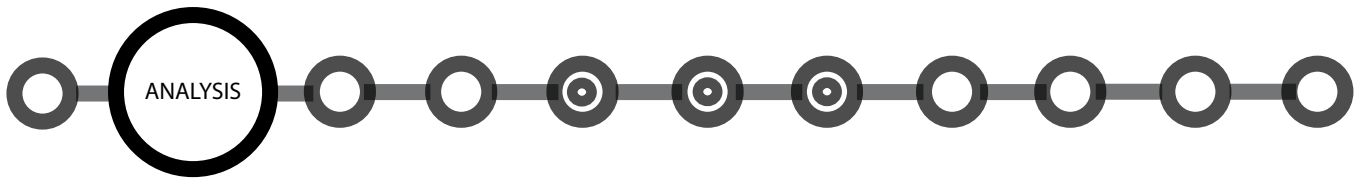


Figure 6. *Human-machine interaction*

The interaction between an operator and a product builds on constant exchange of information, feedback and actions. As the figure shows an operator perceives the interface and the information that is given about what status it has. The information is then processed and the operator prepares to take action to change the product status in desired way. The action, which in other words would be pressing a button, pulling a level, stepping on a pedal or in any other way manage a control device, will affect the status of the product which will then send new information by feedback to the user who then can perceive it and the circle is started all over. The actions that the operator decides to take depend not only on the interface but also on his or her mental model of it. A mental model is the model of how we interpret ourselves, others, the environment and objects we manage. They are formed through experiences, training and instruction (Norman, 2002; Osvalder, Ulfvengren, 2009).



A designer creates a mental model for a product, which then is implemented in the interface of it. The interface is what the end user is about to interpret and depending on how well the interface is designed, the mental model formed by the user will correspond to the one of the designer.

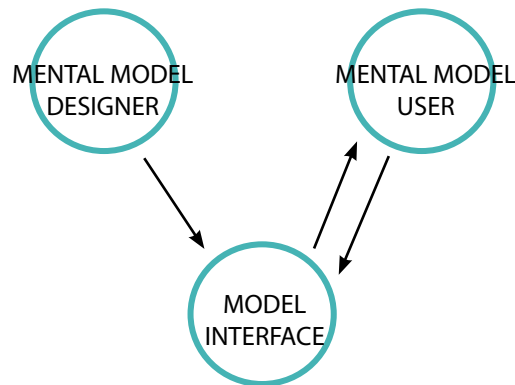


Figure 7. *Mental models and how they are affected by each other.*

Interpreting the interface and the product therefore mainly forms the mental model of how to use it, but since the models also form through experiences, a “wrong” mental model could be formed hence, the expectations of taken actions wont correspond to the result of feedback which, in turn will cause confusion. Of that reason the interface design is very important, especially if the product or machine has impact on safety. The phenomenon, where the interface provides the operator with information regarding possible actions, and from which the operator will create expectations of how to manage it, is called the gulf of execution.

The interface and the possible actions to manage the product build on affordances, constraints, mapping and feedback. A good interface combine these four in an aware way that lets the operator understand what actions are possible without needing instructions. In more complex systems instructions might be hard to avoid but then the interface should be as logical as possible, meaning that instructions are only needed few times (Norman, 2002).

Affordance in the manner of interface design means clues. These clues are really properties of an object that tells the user how it may be operated. For less complex objects there should not be any description needed in how to use it, affordances should tell solely by their presence (Norman, 2002). Figure 8 shows two different button types found in the operative system of Apple smart phones. The picture to the left indicates the user that the buttons should be pressed on, similar to a real push-button with its square shape and perceived volume, giving the user no possibility to do else. The picture to the right on the other hand shows a button that needs to be slid to the side in order unlock the phone. The affordance for this button comes firstly from the distinct track in which the button should move, together with the arrow pointing in the direction of the track and the text stating what to do.

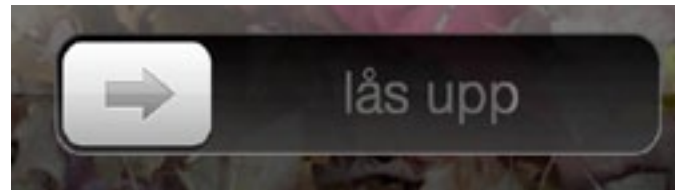
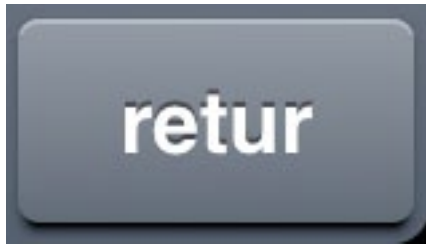
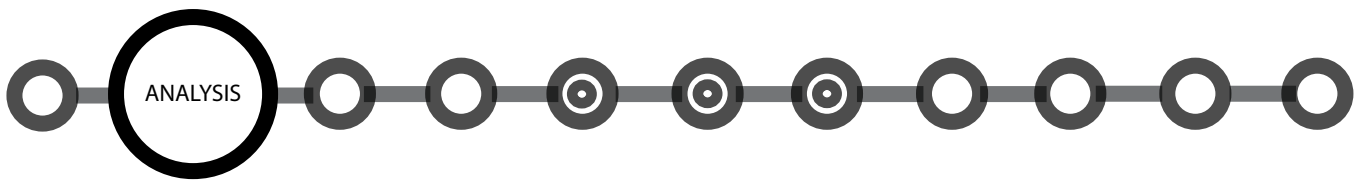
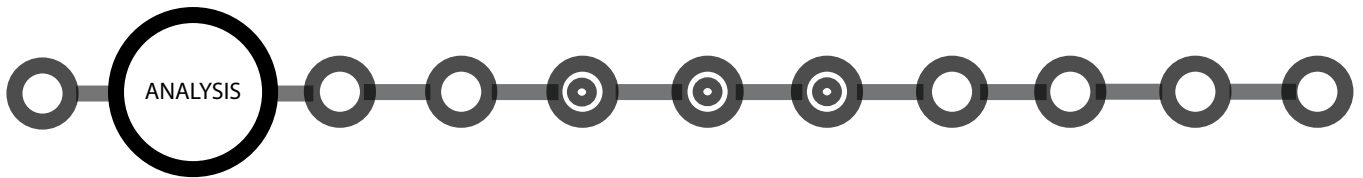


Figure 8. *Two types of buttons found in iOS*

Mapping means considering the relationship between two things (Norman, 2002). Taking controls as example mapping is done according to how the controls are to be managed in order to get the right feedback and how they are grouped/placed on the interface. In what way should a wheel be turned if having a wheel button to control the volume of a device? By experience and cultural standards at least people from Scandinavia would say clockwise to increase the volume and counter clockwise to decrease. Other examples are pedals in a car, when pressing down one of the pedals you will decrease the speed and by pressing down another you will increase speed. This could be somewhat contradictory but with the close relationship with feedback the functionality is easily learned and remembered. The mapping of pedals of cars is also standard in the whole world, which gives the operator a mental model that might be applied on different objects of the same type.



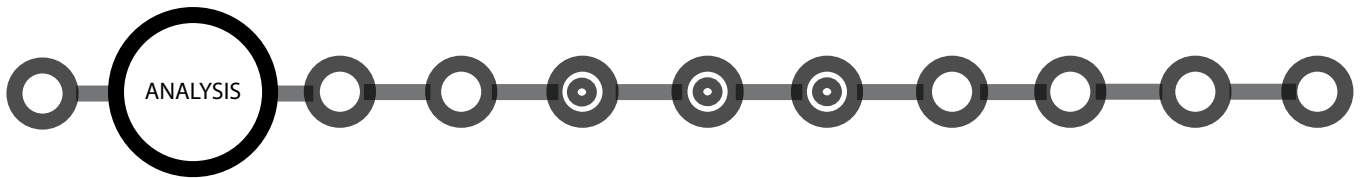
Figure 9. *Wheel button*



Feedback is the sensory information that is given the operator to indicate what action has been taken in the product or the machine and what status it currently has (Norman, 2002). Feedback might be given for example by audial, visual or haptic means such as sound when pressing a button or when completing a task, colour changings where a screen is touched, text that tells the status of the product or to inform the operator how to act, vibrations to compensate other senses etc.

Constraints are used to limit the options of actions. (Norman, 2002) suggests that there are physical, semantic, cultural and logical constraints. Physical constraints regards, as the name implies, the physical possibilities to manage a product, if there is a product that can only be held in one way, then the constraint lies in making it impossible to hold in any other way. The semantic constraint regards the meaning of the usage situation. For example, looking at a power outlet on a wall, we instinctively know that we can connect something driven by electricity in there, based on our knowledge and experience of the world. Cultural constraints are made up by cultural conventions such as understanding a red sign for stop, green signs for go and yellow for warning or wait. Since they depend on the cultural context the constraints of course might be easily understood in one culture but completely misunderstood in another. Logical constraints come from being able to understand an interface by using logical reasoning. If there is two screws and one long screw nut and the operator knows that all parts need to be attached, the most logical way is to fasten the two screws from each side of the nut. This is of course strengthen by the physical constraint that there is only two possible positions to attach the screws in.

To conclude the usage of affordance, mapping, constraints and feedback the example of buttons are brought up again. Most people would interpret a round wheel button with grooves on the circumference area, as something that is to be rotated given by the affordances. The physical constraint in not being able to push the button, together with the semantic constraints of seeing the meaning of using it guides the operator to action. If mapping is used according to the mental model of the operator, the person would most probably interpret the usage of the wheel to have something to do with a setting where more or less of something is to be set. Let us say this is a control for volume. Then clockwise should give the operator higher volume and counter clockwise should then logically be lower volume.

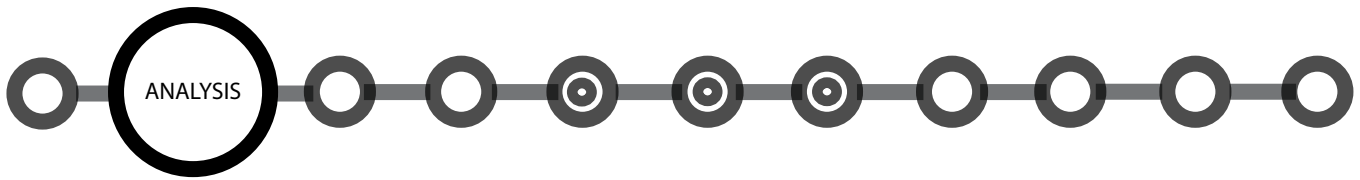


(Osvalder, Ulfvengren, 2009) suggests some general design principles for a product or technology system. It should:

- Be consistent in its design
- Be compatible with the operator's expectations
- Take the operator's mental and physical resources into consideration
- Provide clear information
- Provide clear cues
- Provide good feedback
- Be designed to minimize errors and correct faults
- Allow the operator to have control over what happens
- Prioritize functionality and information
- Involve an appropriate transfer of technology

The theory and these guidelines are found in literature that considers people in general. In other words, autism and how it may affect everything from mental models to feedback and, for example, constraints, need to be discussed. First of all the mental models; there is nothing that can either strengthen nor weaken the proposition of how mental models are formed when it comes to children with autism. Referring to the theory about learning one can say that the coagency and content dimensions help form the mental models. Since children with autism could be sensitive to the surrounding environment and also have special interests, it is possible that the mental models are formed thereafter with focus on other elements, than what the interface would tell a neurological person, disregarded if the interface is well designed or not. Therefore design guidelines of an interface should be more investigated if they are to be used generally for a target group such as for children with autism. With difficulties in relating one object to another and to categorize knowledge and understanding social contexts, semantic, logical and cultural constraints might be hard to understand. The same applies to mapping, affordance and feedback, but this does not mean that the aspects should be neglected, the other way around, the aspects should be considered far more when developing interfaces for children with autism than what is needed for neurological typical persons. In this project however, this investigation will not be possible, therefore, the general guidelines will be used and adapted to children with autism as far as the writer's ability allows.





### **2.1.10 Developing pedagogical products for autism**

Helma van Rijn and Pieter Jan Stappers, coming from the faculty of Industrial Design Engineering in Delft University of technology in The Netherlands, has done a research on what is valuable for autistic children in their interaction with the environment. The report treats the validation and testing of an interactive product. This resulted in a proposition of design guidelines that are to be used by designers, helping them consider important aspects when designing products for persons with autism.

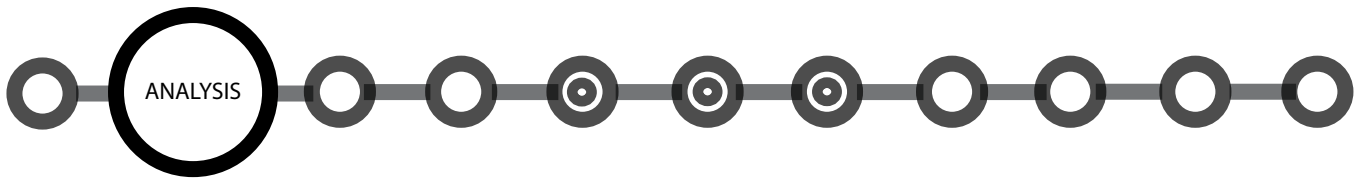
- Give them a feeling of being in control
- Provide structured situations
- Let them create a structure themselves
- Make use of their special interests
- Facilitate their excellent memory
- Reward them with sensory experiences
- Facilitate their eye for detail
- Let them use their whole body (Van Rijn, Stappers, 2008)

These guidelines are based on literature, consultations with parents, professionals and through results from testing the interactive product (Van Rijn, Stappers, 2008). They all regard the most common qualities present for persons with autism.

It is worth mentioning that the purpose of their interactive product was for the child to learn its first 100 words, which is not necessarily connected to progress in communicational skills such as socialisation. (Powell, Jordan, 1998) mentions that one of the difficulties that might occur for a person with autism is to connect what is learnt in one environment to the same thing in another environment. For example, it is fully possible that the person with autism learns that the big white box under the television at home is called “bench”, but that does not necessarily mean that he or she automatically connects that the box of wood under grandmothers television also is called “bench”. With this example in mind it becomes understandable that it is fully possible that a person with autism might easily learn a lot of words without instinctively understand when or how to use them.

One of the purposes with this project was to develop an interactive product that promotes communication and making contact with others. In other words the main aim is to practice turn taking, and in order to have progress turn taking in this sense will have to be forced. Forcing might sound harsh but it is to be interpreted as “not having a choice”. The principle is to make a system where two persons have to practice turn taking in order to reach a goal together. In a way, the two persons will have to let go of control of the whole situation but can still have con-





trol over the own actions. The proposed guidelines, such as “Give them a feeling of control”, can i.e. be adapted in different ways and will therefore be considered as help but not as the single and definitive criteria to take into account in this project.

In (Powell, Jordan, 1998), it is found that:

- Learning by playing is important for the cognitive developing progresses in any child
- It is important that the child reflects over what has been learnt
- Stimulation by playing with non-autistic children has many positive effects
- Predictability and regularity is important for learning and motivating the child
- Personal settings or adaptability in an interactive product is important, giving the child a choice in what sensory stimuli is/are to be used
- It needs to be safe to do wrong

These are not expressed as pure guidelines in the book, but as things that has proved to be important when working with persons with autism. What is mentioned above, together with important aspects found in the whole need and requirements analysis will be integrated in a criteria listing found in the end of this chapter.

### **2.1.11 Personas**

Personas were created to give a short overview of how autism may affect a child. The purpose of this was also to give the project a somewhat clearer direction even if the two personas would not cover the whole spectrum of autism.

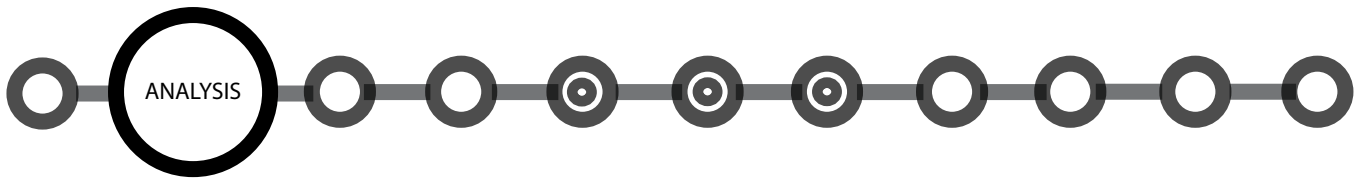


Figure 10. *Emil*  
([www.morguefile.com](http://www.morguefile.com))

This is Emil. He is 12 years old but because of his diagnoses he thinks and acts like a 6 year old person in many aspects. Every day and its chores are structured for Emil and he has a big scheme at the wall so that he will know what to do next. Emil only speaks a little but only when he really wants to himself, and he likes to play with other kids but often draws back when there is too much noise and movements in the room. Often Emil thinks it is hard to play with others since he does not really know what to do; it is hard to imagine things that are not real. Colors and lines are some things Emil loves to play with. He often puts things with the same color in a straight line or sees lines in objects and connects them into a bigger one. Sometimes mom needs one piece of Emil's line for cooking and this can really make him angry, she is destroying his structured and nice line!

This is Emily. She is five years old and loves to look at things that are twinkling. She has quite low vision but can sit down for hours just contemplating the light. She does not like high tones or other sounds that hurts but on the other hand she loves listening to songs that she recognizes. At school Emily likes to be left alone but at home she prefer keeping close to her siblings. Her brother and sister are a little bit older and they often play in a way that let Emily participate. Since she does not speak, her family uses signs to show her what they want to say, which works good because Emily understands but needs to practice on taking contact with others herself. Emily also likes to feel at different materials with her hands and she is better in mathematics than her older siblings if she is shown clear pictures of what she should do. One of Emily's favorite things to do is when daddy gives her feet a massage, these times she laughs out loud and for a long time.

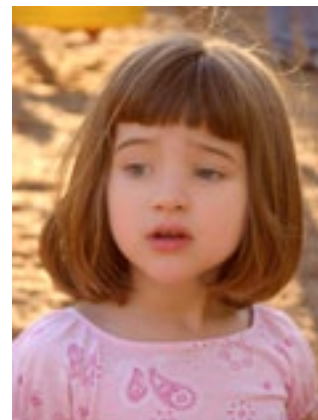


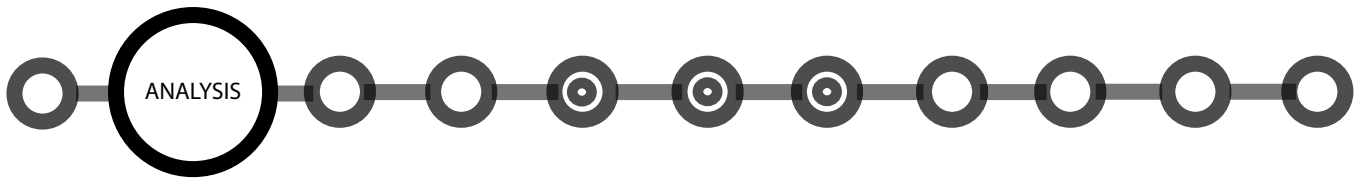
Figure 11. *Emily*  
([www.morguefile.com](http://www.morguefile.com))

## 2.2 MARKET ANALYSIS

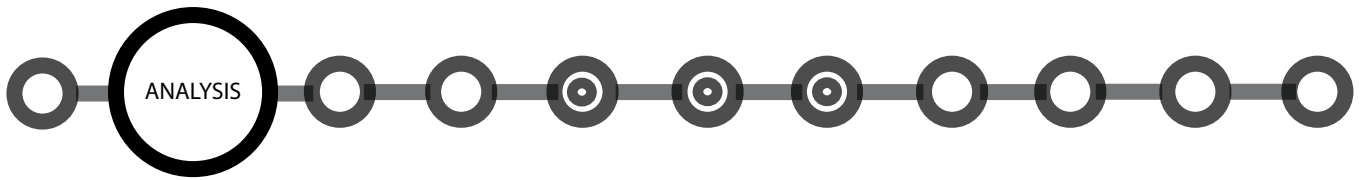
Looking at the available aids for persons with autism today, one finds a variety of toys for sensory stimulation, balance and motor skills, oral motor development, play stations for climbing, activity mats etc. Different schedules helping to structure the day are very common, as well as many ways of using voice output, symbols and pictures for communicating and understanding. Music and instruments being a natural way of communication are used in e.g. exercising time perception, motor skills and creativity. Together with dance it could even help exercising co-ordination skills. Working with flexibility and seeing other perspectives one might use drama, role-play and interactive books, where the person reading can choose different possible endings (Autismspeaks.org; autism.lovetoknow.com; toysforautism.com; toysrus.com).



Figure 12. Toys from [www.toysforautism.com](http://www.toysforautism.com)



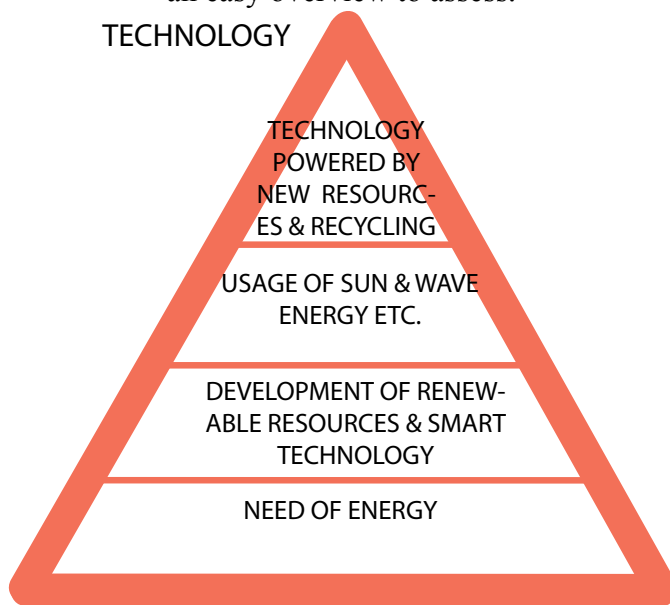
There is computer software, hand held computers with voice synthesis and even more prominent; there are a lot of applications for smartphones and tablets. There is an utter abundance of applications on the market today and taking look at the trends indicates that there will for sure be many more added. Applications for persons with autism do exist in a variety. There is for example support for structuring the every-day-life by having a scheme combined with symbols and pictures to enhance associations, symbols combined with words and digital voices to help communicating through the device, games where turn-taking is practiced, voice imitations, practicing eye contact and face expression and many more (Autism-speaks.org; itunes.apple.com). The main advantages of applications are their good accessibility being easy to download, they are often not very expensive and the device is common to already been introduced in the family for other reasons. Since the device, a tablet or smartphone, is a popular product in general, applications also have the advantage that they not necessarily have to be interpreted as special aids by others, possibly creating a sense of easier fitting in to the society.



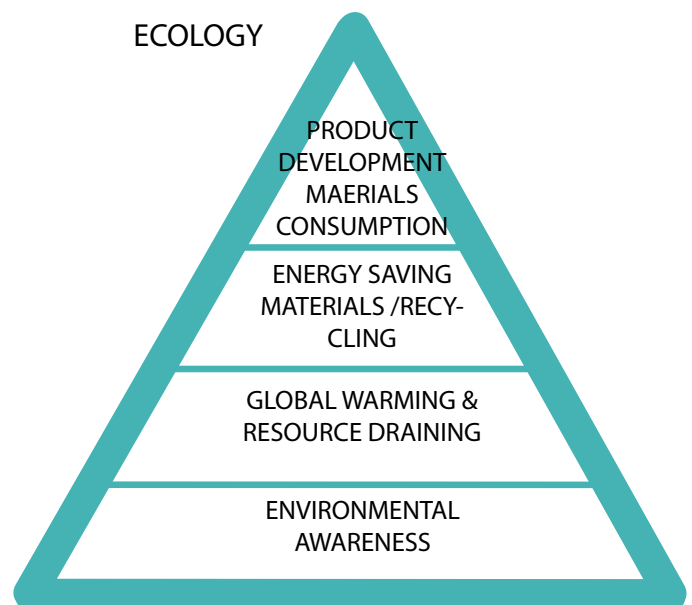
## 2.3 TRENDANALYSIS

A trend analysis was made with aim to find important design aspects, and areas of focus, to consider when developing the concept. The analysis considered three main trends; The Technological, Ecological and Social trend. The technological and ecological trends were chosen because of their affect on product development. Even the social trend affects product development and was extra important to analyze in this project because of the special needs of the actual target group. Mega-, maxi-, midi- and micro trends were structured in a trend pyramid thought to give an easy overview to assess.

### TECHNOLOGY



### ECOLOGY



### SOCIETY

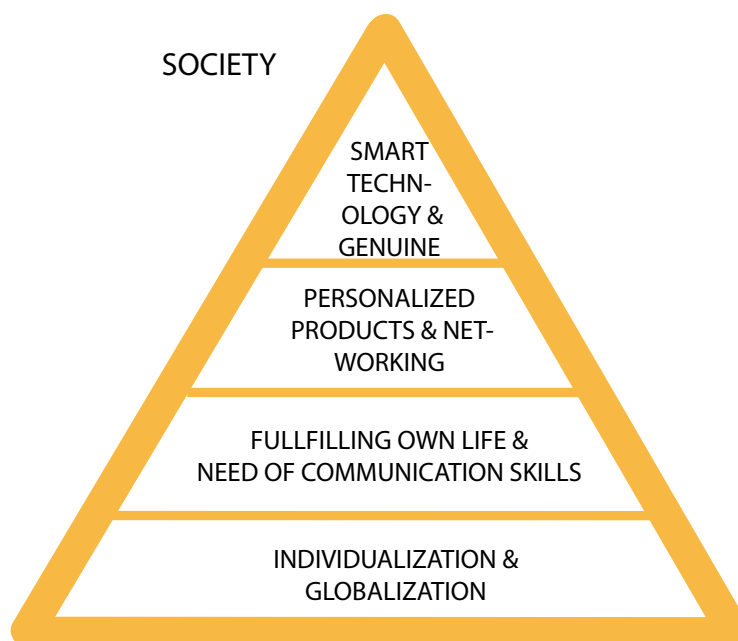
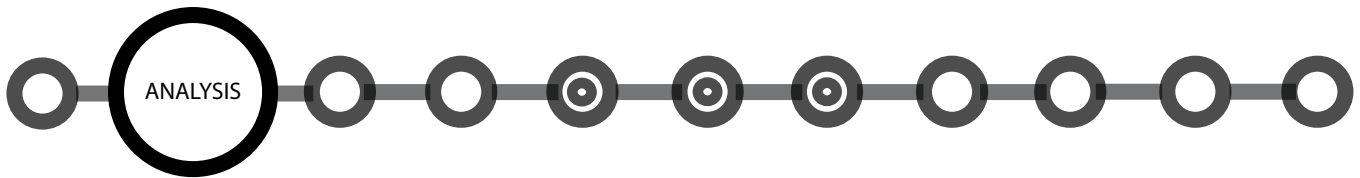


Figure 13. *Pyramids of mega-, maxi- and midi trends in Technology, Ecology and Society*



One social trend is the becoming need of higher ability to communicate and need of social skills. This is deriving from the individualization that is increasing in the world (Samhällsutvecklingen, Andersson J. and Litzén E, 2012). The modern human is seeking to fulfil her life in a more individualistic way than earlier in history. We have more opportunities to climb in social hierarchies and it is more accepted for all groups and types of people than before. We change jobs more frequently and this also tends to become expected by employers and the labour market.

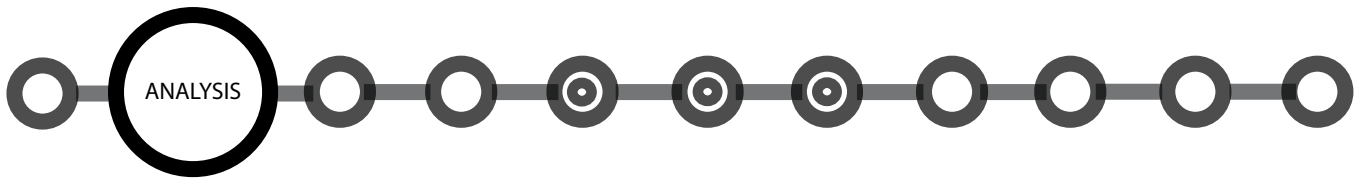
Networking is already important in many people's lives, and the enquiry of personalized products is increasing. This is apparent in today's blooming industry of smartphones, tablets, and Internet services where personal settings are primary.

There is also a higher demand on more unique and genuinely made products in terms of sustainability (Dagens handel, 2012; Market, 2012), which is the direct contrary to the mass-produced products such as smart phones. Taking a look at the ecological trends, it becomes apparent that environmental awareness and products that helps us consume less energy are increasing in popularity. This also regards the materials that are used in our products.

The technological trend shows a strong development of technology deriving from the increasing need of energy resources in our world of globalisation (Samhällsutvecklingen, Andersson J. and Litzén E, 2012). The development of renewable energy is showing in e.g. the car industry, smart technology powered by sun- or wind energy and usage of fully recyclable materials.

The trends are somewhat contradictory. It is commonly known that the need of energy will increase in the future in order to satisfy the market, due to a higher living standard in greater populations. At the same time, it is just as commonly known that we all need to consume less energy. A smart phone for example, could help spreading the knowledge of environmental friendly acts by providing applications for energy consumption etc. However, the number of smart phones is huge and the technology behind the device is far from environmental friendly with its circuit boards and electrical components. Only the waste of all gadgets will in itself have big impact on the environment, meaning that the positive effects from spreading the knowledge by technology could be discussed. However, the trend of developing new innovative products will go on and so will probably the use of these kinds of interactive devices. The ecological trend will on the other hand give a chance to increase products on the market that are produced in a sustainable way, with environmental friendly materials and that are less energy consuming.

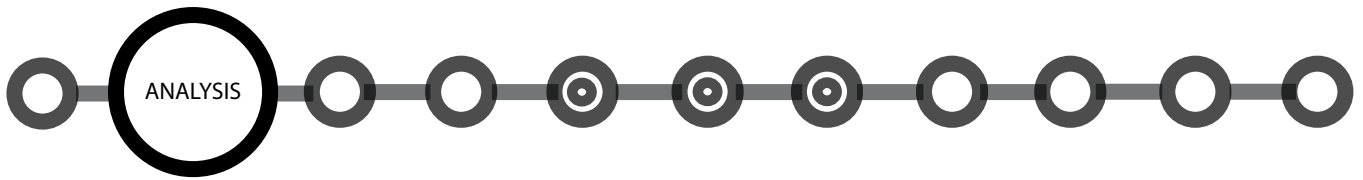
With the increased need of social skills and ability to communicate one can easily understand the challenge that might emerge for persons with difficulties in com-



munication, something that is one of the main issues with having autism. The technological development and innovations can clearly help develop communication skills in ways that could not be done before.

When reading some literature, computer aid came up as a method that is to be developed (See References - (Heimann, Tjus, 1997)). The literature is however a few years old and as commonly known, applications have flourished for just a short period yet. When interviewing parents to children with autism, the use of applications and ideas of new ones are the most frequently aids mentioned. At times when the question has been put; “If not thinking about applications, what aids for autism do you and your family use?” the answer is often schedules, keeping every day structured, movies, puzzles and computers. These things can all be integrated in an application and soon the discussion is brought back to applications. The same phenomena arise when talking to professionals, looking at Internet forums, blogs and videos on the Internet sites such as youtube.com. In other words, applications seems to be in the hot spot at the moment and as mentioned earlier, with the rapid development of technology, nothing indicates that the development of applications for autism will decrease yet for a while.

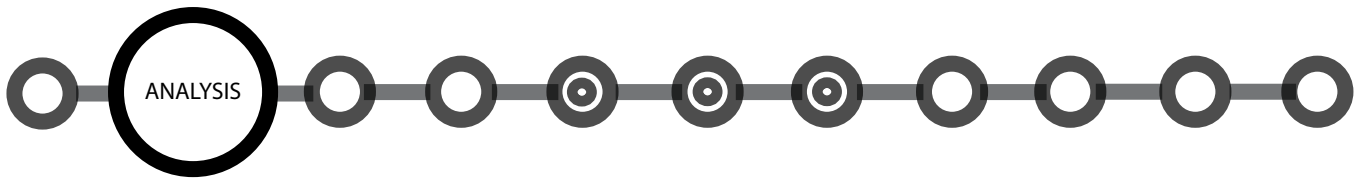
A look at interactive toys gives a different picture. There are many toys for persons with autism but there are not many interactive toys that seem to include sound, light, vibration etc. in a very pedagogical conscious way. Referring to Helma van Rijn and Pieter Jan Stappers, (Van Rijn, Stappers, 2008), and their project “LINKX” again, this is the type of product that this project relates to as an interactive product. In “LINKX” sound, light and the actual use of the product are integrated in a pedagogical aware way, aiming to help a certain area in cognitive development for children with autism. Typical toys on the market are focused at only few basic needs at a time if it is not computer software. There are e.g. plain board games, chewing sticks, light sensations, typical children’s toys with sound and hand held games. These toys are not to be neglected, they have their certain advantages but the trend analysis clearly shows that there is great potential in developing interactive toys with high pedagogical awareness since there is not too many of this particular type available on the market.



## 2.4 CRITERIA LISTING

Important aspects found during the whole Needs and requirements analysis, was gathered and make up the foundation of the criteria list found on the next page (Figure 14). The criteria in the category Product aspects are made up by the aspects that are necessary in order to reach the goal of practicing communication skills as it was stated in the Introduction chapter, section 1.2 and 1.3. These criteria are noted with a N as in necessary. There are also aspects that are seen to be important to fulfill as far as possible because of their contribution to the final result but, which however, do not affect the needed functionality of the concept to the same extent as the necessary ones. These have the notion DP as in desirable properties. Also in the categories Stakeholder aspects and Lifecycle aspects the notions N and DP are found.





#### PRODUCT ASPECTS

- |  |    |
|--|----|
| 1. Encourage interplaying and having fun with others, at least one other individual included     | N  |
| 2. Provide understanding of users mutual dependency of each other by taking turns                | N  |
| 3. Provide possibility to practice flexibility, at least two options in how to use the product   | N  |
| 4. Provide predictability of the usage situation by consistency in product and feedback          | N  |
| 5. Offer error reduction, user errors should not affect the turn taking negatively               | N  |
| 6. Offer the user ability to play in own pace  | N  |
| 7. Offer sensory stimuli, perceived by at least two senses                                       | N  |
| 8. Offer personal settings for controlling the sensory stimuli given by the product              | N  |
| 9. Offer the user a sense of control, no unpredictable actions made by product                   | DP |
| 10. Offer a structured usage situation, structure in product appearance and how to use it        | DP |
| 11. Offer the user an ability to create visual structure with product                            | DP |
| 12. Offer possibility for the user to use memory   | DP |
| 13. Support the users ability to note details  | DP |
| 14. Offer the user an ability to practice gross motor skills                                     | DP |
| 15. Encourage the user to reflect over the result  | DP |
| 16. Offer the user a limited area of focus   | DP |
| 17. Offer an easy set up of the product, should only require one (neurologically typical) person | DP |
| 18. Offer easy understanding of how to use the product   | DP |

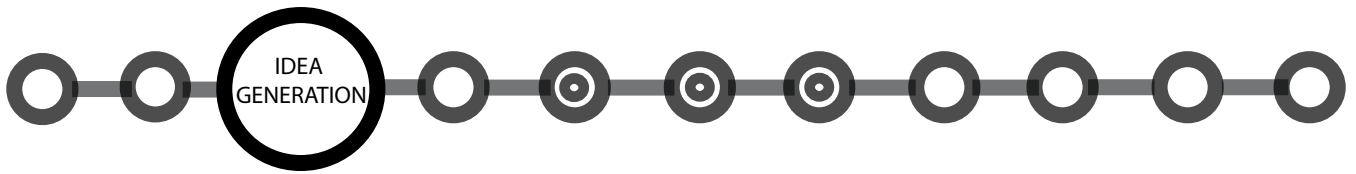
#### STAKEHOLDER ASPECTS

- |                                     |   |
|-------------------------------------|---|
| 19. Offer a relevant estimated cost | N |
|-------------------------------------|---|

#### LIFECYCLE ASPECTS

- |   |    |
|---|----|
| 20. Consist of sustainable materials in as far extent as possible           | N  |
| 21. Offer material quality level for normal usage during at least two years | DP |
| 22. Offer possibility to repair easily                                      | N  |
| 23. Offer easily separable materials for recycling                          | DP |

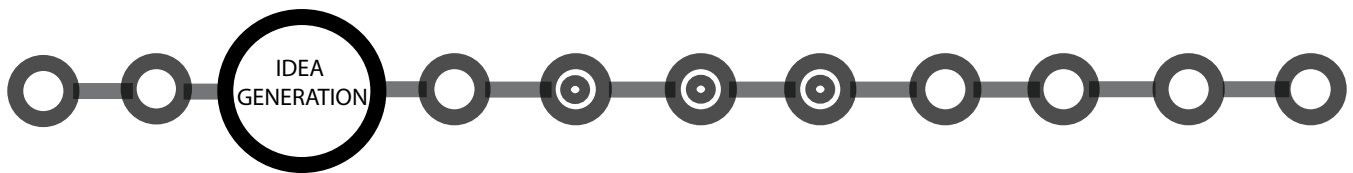
Figure 14. *Criteria list*



### 3. Idea generation

An idea generation divided into two parts was started after establishing a good picture of what needs and requirements were present for the project. The first part aimed to find ideas of how to work with turn taking and taking contact with others under fun circumstances. The idea generation was an iteration of using modified brainstorm methods and “Theme x-ing”, turning to literature, analyzing available games and toys, having focus groups, personal interviews and study visits. The result was a number of principles that were categorized and reduced to only five that were to be further developed (Section 3.1.5-3.2.2).

The second part was aimed to connect each of the principles to certain product types. This was done by a mind-mapping session using the product criteria as aspects to develop upon. The modified brainstorm was done individually and for each of the five principles. When having further developed a principle with the criteria in mind, it became quite clear what product type would serve it the best. The five concepts were then visualized and presented to professionals and parents to children with autism in order to receive a brief evaluation of the most accepted and engaging ones.



### 3.1 IDEA GENERATION PART 1

#### 3.1.1 Interviewing

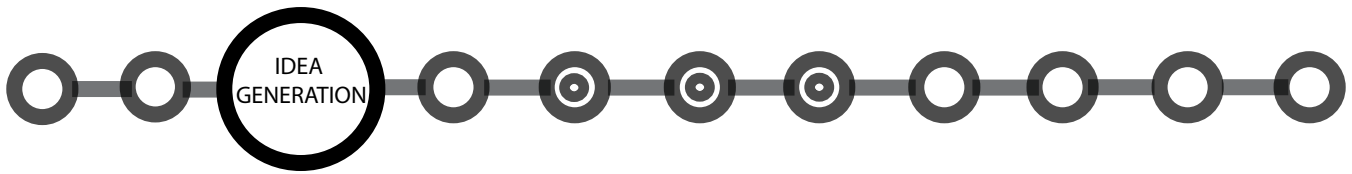
Interviews (Method 1.5.1.1, Appendix 1) have been done both by personal meetings and by phone or computer. Evaluation of concepts, questions regarding autism and understanding of how to work with autism has been the main reasons to have personal contact with parents and professional. Interviews have given more information to the project than would have a questionnaire because of the ability to probate and associate important aspects to each other. It has created a dialogue very much beneficial and crucial for this thesis and it has brought up important aspects that the writer did not initially think of or knew about. Many ideas emanated from these conversations and they were either sketched or written down through the whole process. They were then stored to be used in a coming evaluation.

#### 3.1.2 Focus group

Parents and persons being in daily contact with autism were invited to the focus group (Method 1.5.1.2) where ideas regarding toys, games and every day situations were to be found. It was started with an introduction to the project and the background in order to create a brief understanding for the participants. A brainstorming session (Method 1.5.3.1) was thereafter begun where inspiration could be gathered from a prepared table. The table had pictures of different team sports and professions where teamwork is needed. There were applications for smart-phones, music instruments, interactive books, toys and board games. Everything was chosen because of its potential to practice turn taking and to bring associations to it.



Figure 15. *Parts of the table used in the focus group, on the pictures from the left: Music instruments, Games, Sports and things to potter with*

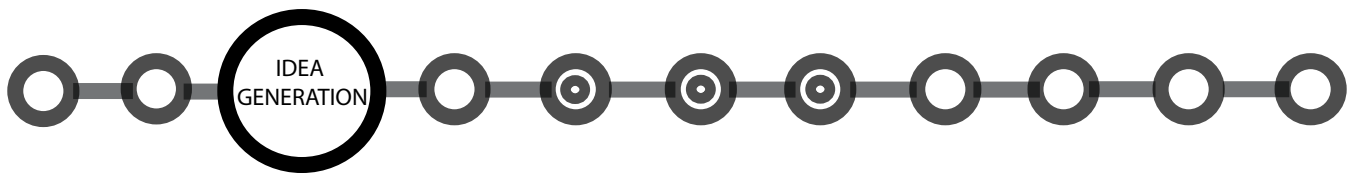


The brainstorm session was not generating many ideas, possibly because of the participants' inexperience of generating ideas in a manner that is common in product development. The prepared table was not really helping their creativity; actually, it seemed to restrict their thoughts to the objects on the table and confusion aroused. Instead, the method Theme x-ing was introduced (Method 1.5.3.2). In this thesis the themes used were sports, professions and games because of their natural elements of cooperation and teamwork, this because the method was used to find ways to work with turn taking.



Figure 16. *Theme x-ing with three categories*

The method was created specially for this project and was to be tested on the focus group. As it turned out, the method proved to work excellent after having a quite dry brainstorm session preceding. The creativity was increased very fast even if the participants tended to choose words that would fit together rather than being inspired by totally new combinations. Because of time limitations of the focus group there was also not time enough to evaluate whether the creativity would result in relevant ideas. However, the session was continued individually and many ideas were generated and added to the idea pool. The method also seemed to be especially suitable for finding ideas for fun smart phone applications since much more of the ideas could be developed for this use than for physical products.



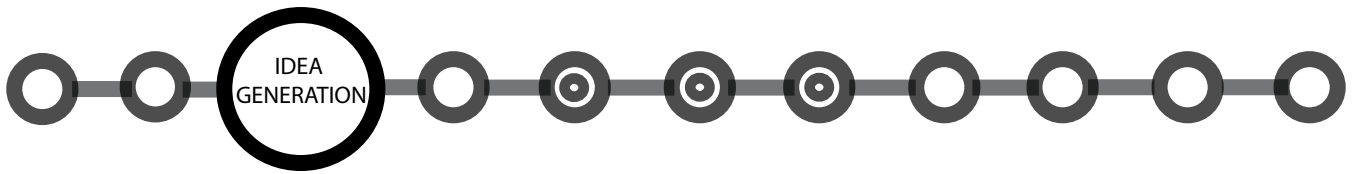
### **3.1.3 Brainstorm**

In part 1 of the idea generation, brainstorming was performed in a focus group where parents and professionals were invited. As mentioned, the participants did not seem to be much inspired when it came to brainstorming and little ideas were generated. It was therefore necessary to have an additional brainstorming session, but this time done together with persons who had experience in creative work and who were already familiar with the method. This time much more ideas were generated, and with wider variety than what the parents and professionals had. Although more ideas were generated now, even more were needed so next step was to use a modified version of brainstorming. This time it was performed individually where all ideas were written down or sketched in order to later be compared and evolved by combining ideas.

### **3.1.4 Study visits**

The thesis has required a thorough understanding of autism and study visits have been very contributive. At Autism- and Aspergerförbundet in Gothenburg two study visits were done. The first time was before starting to work with the thesis. At that time, the need of getting contacts and help with setting limitations for the project was high. At Autism and Aspergerförbundet much of this need was fulfilled and the project was invited to use their library full with literature regarding autism. The next study visit was therefore used for reading and interviewing at their office.

Other helpful organizations have been DART (Communication- and computer resource center) and SPSM (Special pedagogics education authority). Also here one study visit was done before the thesis work was started with aim to inform them about the thought project. At DART they contributed with their knowledge about autism, literature and their special area, computer- and other interactive aids. At SPSM they contributed with new contacts and expertise when it came to working with autism and different methods. The need of talking with special pedagogues was met by having a study visit at Eldorado, a sort of day care in Gothenburg where persons with different dysfunctions can come and try a variety of methods and sensory experiences that are suitable for them.



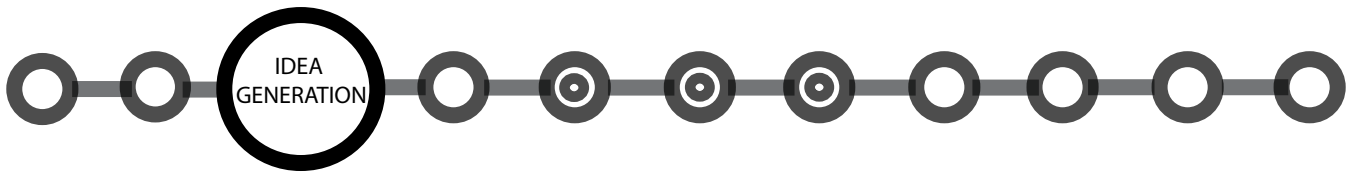
### ***3.1.5 Categorization and selection of working with turn taking and taking contact with others***

All ideas that had been generated through the interviews, focus group, brainstorming sessions and the study visits, was written down on post-it notes and categorized into four mayor principles of playing and games. First category was “Memory”, where the ideas were built on using and training memory such as in puzzles. Next category was “Strategy”. Ideas in this category had to do with strategic thinking as in taking decisions and valuating the best way to a goal. The third category was “Pure turn taking” and ideas were related to the topic name. The last category was named “Double command” and ideas were dependent on two persons collaborating in order to reach a goal.

When the categories were settled, and the ideas more structured, it became evident that another categorization was needed. This time the already existing categories were divided into three levels of complicatedness; Easy, Adequate and Hard. The levels were created based on literature stating basic knowledge and skills of children between 4-7 years old (Literature review 2.1.1).



Figure 17. *Categorization of ideas*



When the level of complicatedness was determined it became natural to take away the ideas from the categories “Hard” and “Easy” since they would not be as suitable as the ideas of category “Adequate”. In this way, the many ideas were now reduced in amount and it was possible to evaluate and further narrow down the number. This was done by usage of the criteria and guidelines list without weighing the criteria or guidelines.

The reason why weights were not used was because the ideas were not very far developed, and at this stage one criteria or guideline could not be seen as more important than another since the ideas all had possible and similar potential to increase and fulfill the criteria after further development. Instead all ideas were evaluated with regard to how much they would fulfill criteria/guidelines. Ideas that clearly would fulfill a criteria/guideline was noted with a Y as in Yes, if not, N as in No. If the idea had potential to fulfill the criteria/guideline or, did to a certain extent, it was noted with DP, Development Potential respectively S as in Somewhat. The amount of Y, N, DP and S was then put together and compared for each concept, showing five of them that clearly was the most beneficial ones to proceed with for further development. The complete evaluation is found in Appendix 2.

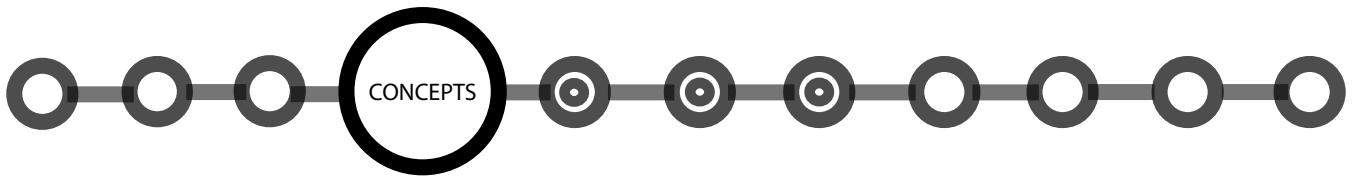
## **3.2 IDEA GENERATION PART 2**

### ***3.2.1 Connecting concepts to product types***

The criteria list was used when developing the five concepts further. The question “How to solve this to enhance the concept and to fulfill the criteria?” was asked for the five concepts and each criteria. The ideas were written down in a simple mind-map (Method 1.5.3.3, Appendix 3), and up until here, the ideas had been only principles without any particular product type in mind, but with the mind map session and the ideas regarding possibilities to fulfill the criteria/guidelines it soon became clear what concept would be suitable for what type of product.

### ***3.2.2 Visualization***

When having the five concepts connected to suitable product types it was time to move to the next stage; Visualization of them. This was needed because an evaluation of the concepts was to be done by parents and professionals. The aim with the evaluation was to be able to choose only one of the concepts for final development and therefore sketch-models would make the understanding of the concepts much easier. A plan for how to build and visualize the concepts was made up in an attempt to be able to present them with equal degree of readiness. This is an important aspect when trying to avoid bias for the persons evaluating.



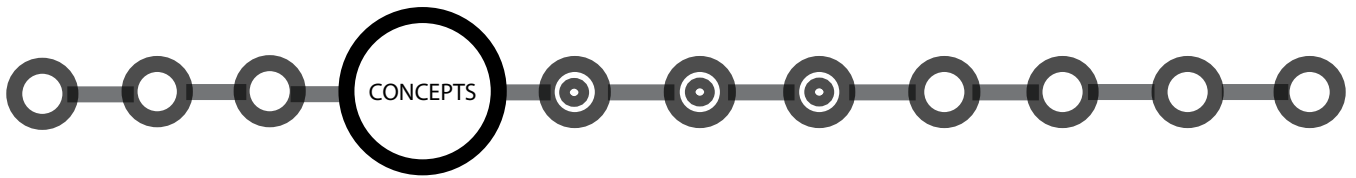
## 4. Concepts

As described in previous chapter, section 3.2.2, there were now five concepts ready to be evaluated by parents and professionals. Those concepts are presented in this chapter together with the evaluation.

All of the concepts have a main function of exercising turn taking and there are two main product types, either a physical 3D-puzzle with interactive properties such as light and sound, or, an application for smart phones.

The main idea is that there will have to be two players and it wont be possible to make a move before the other person has done his/her. In that way it is thought that one will be “forced” to wait and give turns to each other. I.e. the players are dependent on each other in order to reach a goal.



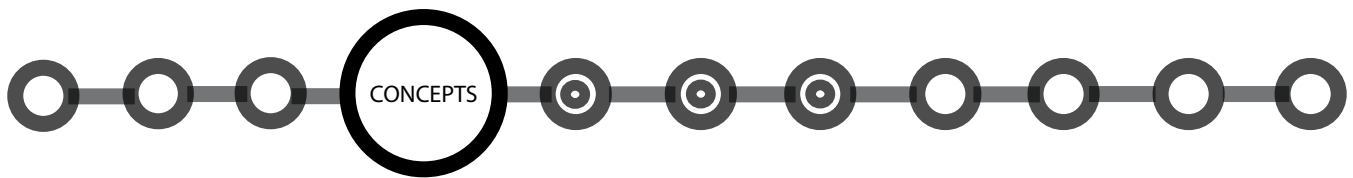


## 4.1 BUILD A CAR

This concept is thought to work as an application for a tablet. The idea is to build a car together with another player by taking turns in choosing parts for it. Each player has its own side of the tablet where parts are shown. The first player gets to choose the first parts, e.g. the tires and will on his/her side of the tablet have different kinds of tires to choose between. When a set of tires is chosen, the turn automatically goes over to player two. This will be apparent on the screen by disabling the first player's side. Player two chooses the chassis, and then the turn goes back to player one and so on. In which order the parts are to be chosen, is visualized with a scheme on the screen that also shows how many more parts are to be added to the car before it is complete. When the car is complete an animation or something similar is shown on the screen.



Figure 18. Application 1- Picture 1: Choice of parts, Picture 2: Animation of car



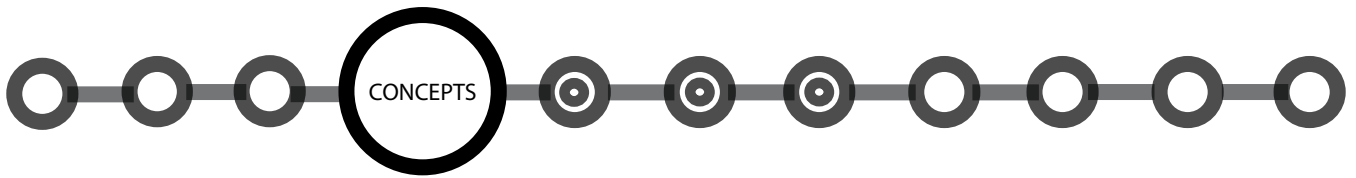
## 4.2 CONTINUE A SONG

Also this concept is to be implemented in an application for tablets. The basic idea is that of using songs and turn taking by letting the player fill in words. First the two players will have to choose a song that both know well. The song will start playing until a certain word is sought for, then the music stops. Both players have his/her own side of the tablet with different symbols that resembles the word and other similar words. In order to make the music continue playing both persons will have to press the right symbol.

Wrong symbols may be chosen without anything happens. When the song has been completed there is a choice to listen to the song while watching a fun video playing on the screen. Turn taking is here practiced with the tablet and the application, while actually doing something together practices the social skills.



Figure 19. Application 2 - Picture1: Choice of song, Picture 2: Placing symbols, Picture 3 :Play song

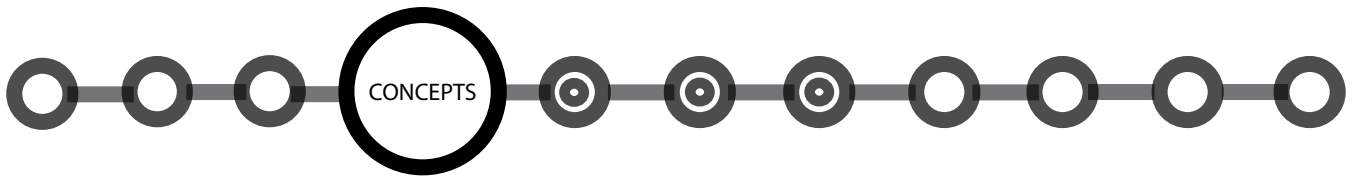


### 4.3 PUZZLE

The third concept is a puzzle in an application. The two players have to work together in order to start the game e.g. by pressing a symbol from both sides. A picture is either chosen or taken with the camera and will form the actual puzzle. The application will automatically divide the picture into pieces and place half of them on each player's side. In order to build in turn taking into the application only one side of the tablet will be enabled at a time. This makes it impossible for one of the player to place any piece while it is the other player's turn.



Figure 20. Application 3 - Picture 1: Lock up together, Picture 2: Choose picture, Picture 3: Place pieces on picture

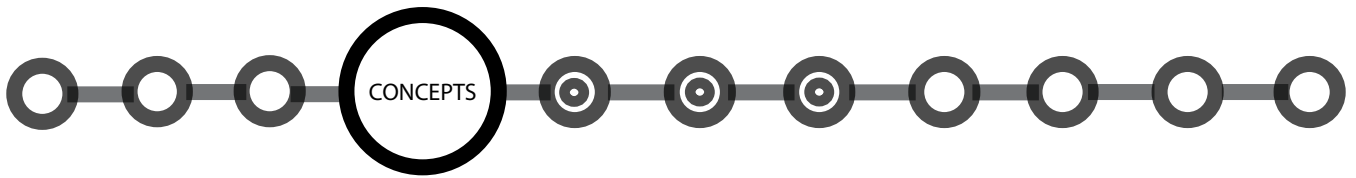


#### 4.4 TREASURE HUNT

This concept combines an application with a physical product in what is called the “treasure hunt”. The basic idea is to create a physical toy that can be connected to a smart phone; in this case it is a treasure-chest that has to be opened by putting three hands in a certain combination that is highlighted on the lid. When the combination is right the lid is mechanically opened and this is connected to the application that will start playing or showing something fun. The thought is to make two persons cooperate in order to open the box and then discover what is in it, something that could act as a help in reciprocal games and as a support for creativity.



Figure 21. *Sketch model of treasure-chest*

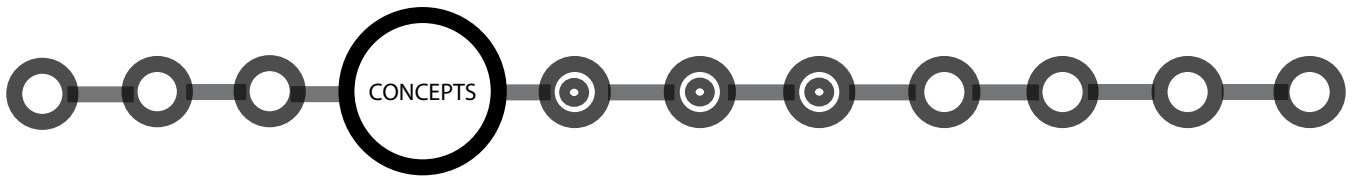


## 4.5 3D-PUZZLE

The 3D-puzzle is a physical and interactive product. Blocks are divided between the two players who will build an object together by following a scheme or picture of the result. One block can only be connected to one other, i.e. block number one can only fit together with block number two, block number three on block number two and so on. If the blocks are divided in a proper way, turn taking will happen naturally since that is the only way of reaching the goal. The blocks are interactive and may for example give a sound, light or vibration as feedback when it is connected correctly. This concept has the benefit of using close interaction of two persons and could possibly tempt the persons playing to try communicating by gestures and so on.



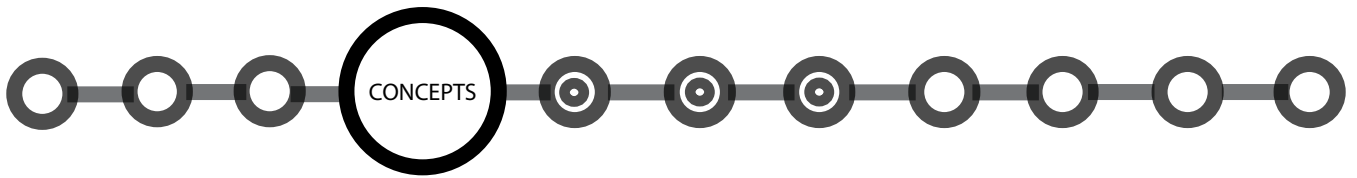
Figure 22. *Sketch model of 3D-puzzle*



## 4.6 EVALUATION OF CONCEPTS

The evaluation was done by interviews, both by telephone and in person. The reason why telephone was used was because many of the interviewees had little or no time to meet. Instead the concepts were described and discussed. Already from the first interview concept number one, build a car, was the outmost popular. On second place came number two continue a song. As a good third came the puzzle and after realizing that the applications for tablets were the only options that were considered, the author started to analyze how come no one mentioned the benefits with physical toys. During the coming interviews, the writer instead intentionally asked about the benefits with all concepts and now got much more positive statements about the 3D-puzzle. After while it was also realized that when explaining the applications and the 3D-puzzle by telephone; applications was interpreted as much more developed than the 3D-puzzle and this was probably because the ideas for applications seemed more detailed and easy to grasp than the physical toy. When telling the interviewees that the 3D-puzzle was going to be interactive with light and sound, many even seemed to believe it would be hard to construct. I.e. even if the sketch-models were made with attempt to not differentiate too much, bias occurred because of the description of them. On the other hand, when presenting the sketch-models in person, the 3D-puzzle was much more popular, maybe because then it was easier to see how to use it.

In the end there were three concepts that were the most popular. The “build a car” application, The “continue a song” application and the 3D-puzzle. They all had their benefits, mainly regarding the applications’ availability and potential to attract attention. The 3D-puzzle was beneficial because of its resemblance to LEGO and other construction games that often are popular within this target group.



## 4.7 SELECTION OF CONCEPT

When selecting between the three concepts a few keywords were chosen. The keywords worked as help in clarify what the five most important properties that the final product should have.

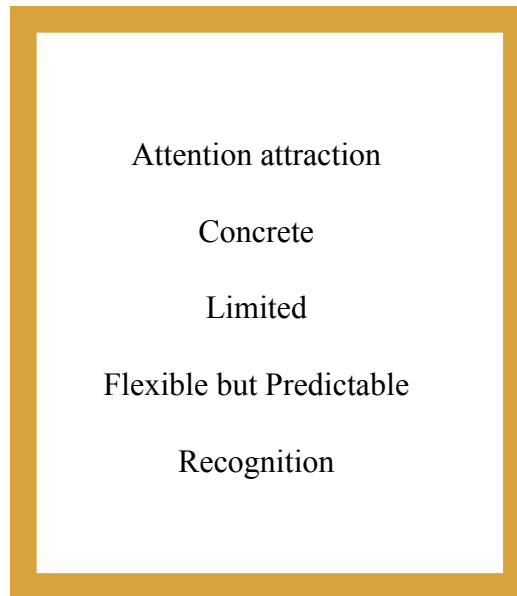
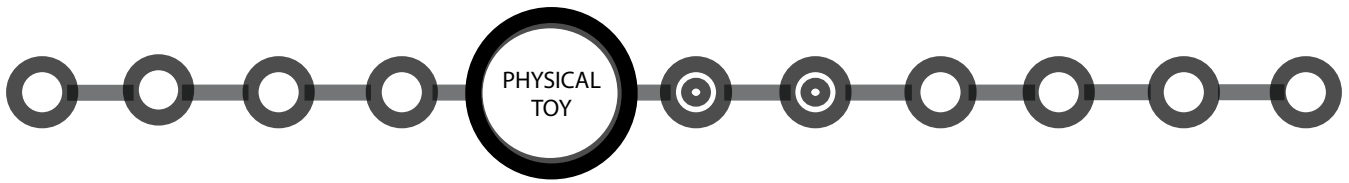


Figure 23. *Five key words*

As a final choice was at last two of the concepts chosen. The “build a car” application and the 3D-puzzle would relate most to the five keywords and the decision was partly based on the interview results and partly on a new idea that had come up during the concept evaluation.



## 5. Development

The concept had now changed into a two-part concept. The main idea was to combine an application with a physical toy with the motivation that; benefits from both would complete the learning aspects of the total product. The application was up until now based on taking turns in building a car and at least the basic principle of that was kept. The physical toy would consist of the same parts that would be available in the application so that the built up object in the application was possible to build also in real life. I.e. the application would let the two players build their own draught that could be used for the physical toy. The question was what type of object was to be built, was really a car the best option?

In order to see if there were any special interests that would be mentioned more often than other, and therefore to see if there were any type of product that would be potentially more appealing for the project to concentrate on, a survey on Facebook was made. The survey was made in three groups where persons with Asperger's syndrome, autism, parents to children with autism and professionals are members. The question that was posted asked for any special interests that their child with autism or a child they might now of, (four to seven years old) have. This could be colors, toys, machines, lights etc. The same question was also asked to the personal contacts that were already introduced to the project.

As a total, around 80 answers were received (Appendix 4). There were four interests that were mentioned far more often than others and these were Lego, Computer games and Internet, Music and Trains. On second place not far from the four in top came Cars, Ambulances, Police and Police cars and Dinosaurs.



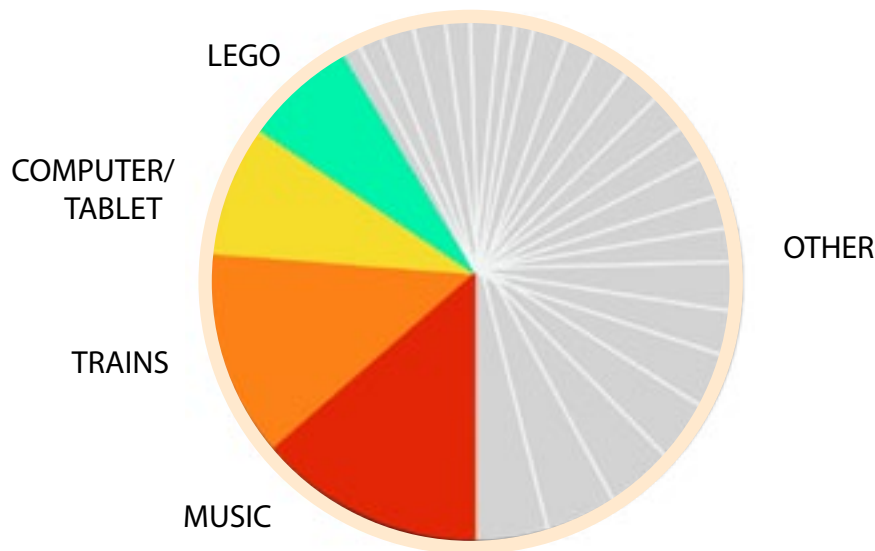
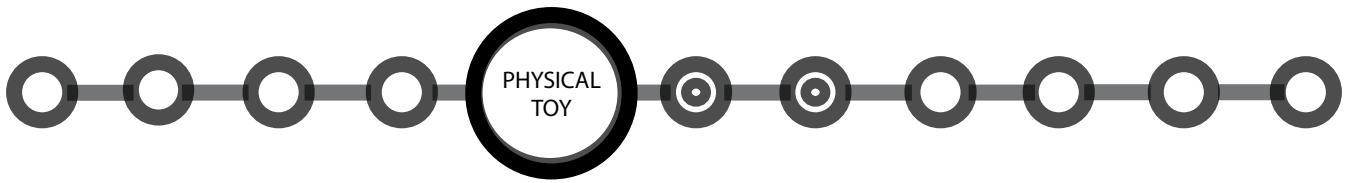
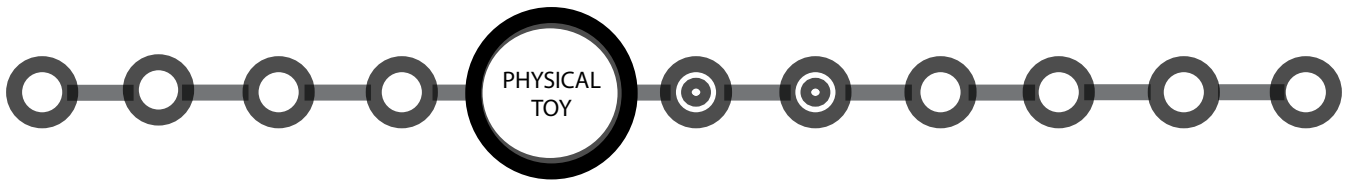


Figure 24. *Survey result. Four main special interests found*

The model above shows the result from the survey made on Facebook. As one can see trains were popular within the target group. Of that reason it was decided to use trains instead of cars as object in both application and physical toy. An option would of course be to offer many different objects such as cars or buildings, but for this project, focus was decided to be put on only one object, leaving others for future development, this in order to keep down the number of directions of the development phase, given that there was already two, the physical toy and the application. The fact that Lego was one of the top interests in this survey gave a positive indication that the assumptions and arguments for a physical toy such as the 3D-puzzle actually should be valid. In the same way, computer games being a top interest, indicates that the application might be just as interesting as the physical toy. Together they offer possibilities for a larger range of users.

Music was also one of the most popular special interest that was brought up in the survey results. As implied in the theory chapter, music can be a possible channel for communication to some persons. The sense of rhythm as something we naturally carry with us is therefore an interesting subject to elaborate with. For rhythm there is no need of words and it is independent of other rhythms as long as it has the same beat. Furthermore, different rhythms can together create interesting music. Various rhythms are found in all music, and they are easy to put together and



loop. To give the total product an added value and an increased possibility for practicing creativity, music will make up some of the audial feedback, as it is naturally continuous. Therefore, building the train will mean that the user is also “building” music.

Light will be used to draw attention to the product, especially for those who do not like sound but are interested in lights and details. Both audial and visual feedback such as lights should be possible to switch off because of the sensitivity and preferences for some persons in the target group.

The development was from here divided into two parts. The physical train, and the application. The physical train set was developed by a synthesis of functions (Section 5.1.1), followed by discussion regarding the turn taking function and number of possible combinations of parts and music. Thereafter the ulterior design (Section 5.1.2) was begun, where sketches and clay models with inspiration of dinosaurs developed form and shape. When the form development was done, colors and details were decided (Section 5.1.2.4) and then an ergonomic and safety analysis of the toy was performed (Section 5.1.4). The functionality of music (Section 5.1.3) was also developed further before interior design and choosing material was finished.

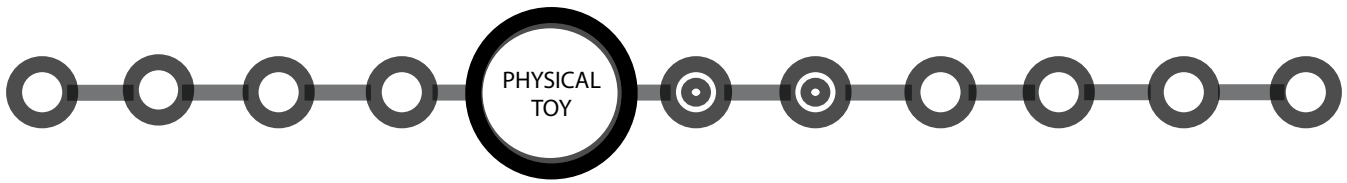
From here the development of the application was started, also this with a function analysis (Section 5.2.1). Quick sketches (Appendix 6), which were refined and developed with computer software, helped deciding the basic layout of the interface. A storyboard with the final graphic elements and functionalities was then created from the layout (Section 5.2.2 and 5.2.3).

When the first draft of the interface was completed an evaluation (Section 5.2.4) was done by usage of methods HTA, Cognitive walkthrough and Predictive Human Error Analysis.

## **5.1 PHYSICAL TOY**

### ***5.1.1 Synthesis of functions***

A synthesis of functions had to be done for the physical toy, something that could not be done completely without considering the functionality in the application. However focus was initially set on the toy and as described earlier, the main principle of the whole product is to practice turn taking by first playing in an application and then replicate the image with physical and identical parts.



The functions were divided in Main function, part functions and support functions:

**Main function toy**

Practicing turn taking, creativity and replication

**Part functions**

Allow for different options of parts

Allow mounting of parts independently

Allow visual and audial feedback

**Support functions**

Enable audial feedback according to what type of part is chosen and where it is placed on the train

Allow shut off visual and/or audial feedback

Allow the wheels to spin

Figure 25. *Synthesis of functions for physical toy*

The first question in how to realize the physical toy was how many turns were to be taken. Initially the thought was to have one train with about four wagons and ability to choose color in wheels, chase and top parts. This would require at least 6 turns each. The amount of parts would on the other hand be large if all parts were to come in different colors. Instead the idea changed to having the same color for all wheels and chasses and different colors only for the top parts. A visual explanation is found in figure 26 on the next page.

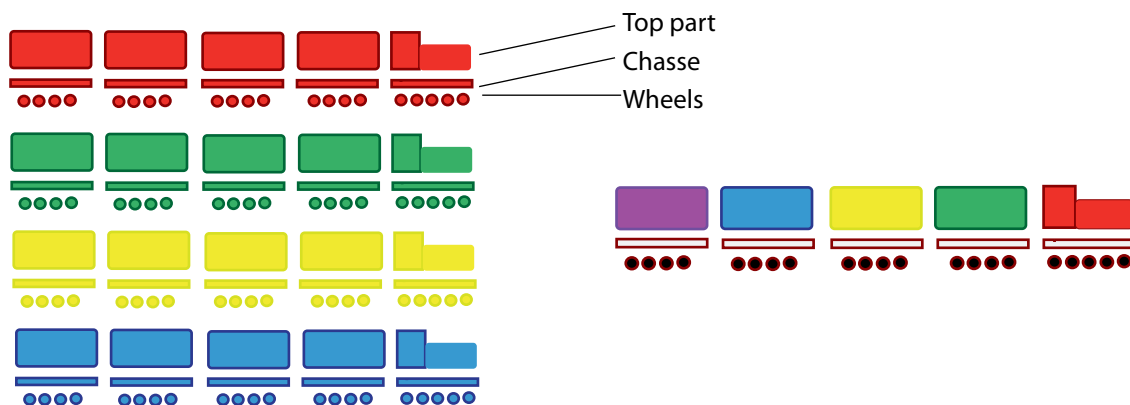
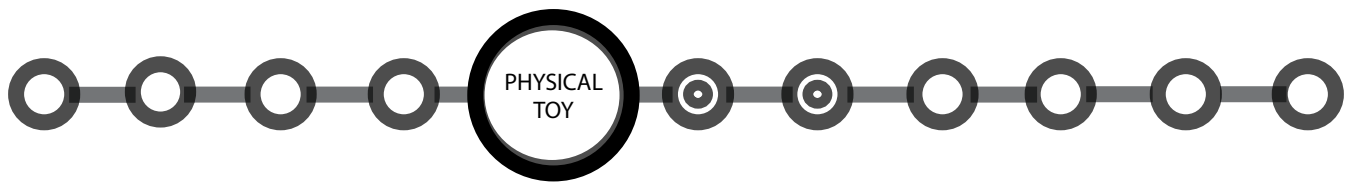


Figure 26. *To the left: Four colors for all types of parts, To the right: Five colors for top parts, one color for chasse and one color for wheels.*

The amount of turns would now decrease and become quite limited since there would only be five different top parts to choose between (Shown in figure 26 to the right). To increase the abilities in taking turns three complete trains were added so that it would be possible to build a complete train of only one type of color or wagons. In this way all four complete trains would have one of each type of wagons, and to extend the game further, each locomotive was divided in a nose and a cabin. In this way 16 variants of locomotives could be chosen. As a total, there would be 16 combinations of locomotives and 16 wagons with added rhythms to choose between.

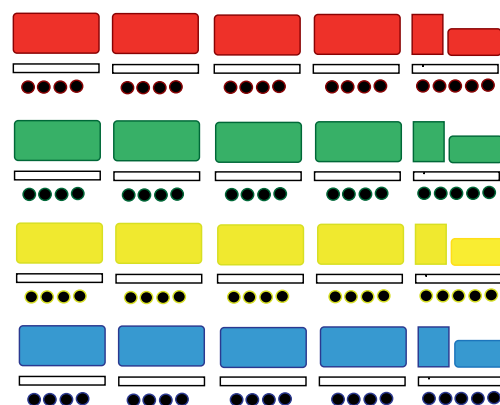
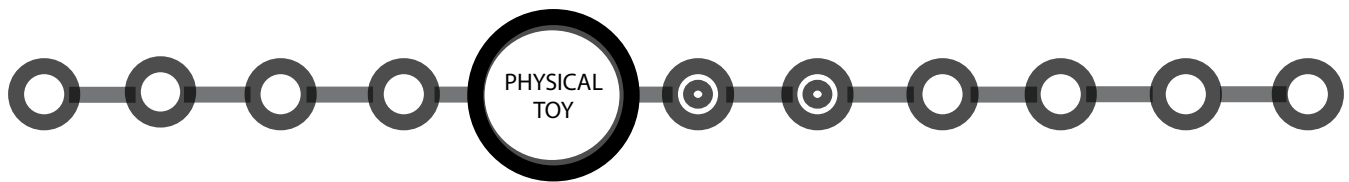


Figure 27. *Four colors for top parts, one color for chasse respectively wheels.*



At this point it became quite clear that the train would have to be platform based. I.e. the different parts of the train would have to be mounted on a platform (the chasse), where the wheels were pre-mounted. The choices to make in the application as well as in the physical toy would then be between different top parts such as the nose- and cabin parts of the locomotive as well as the type of wagons. Type of wagons was decided and inspired by cargo wagon on real trains.

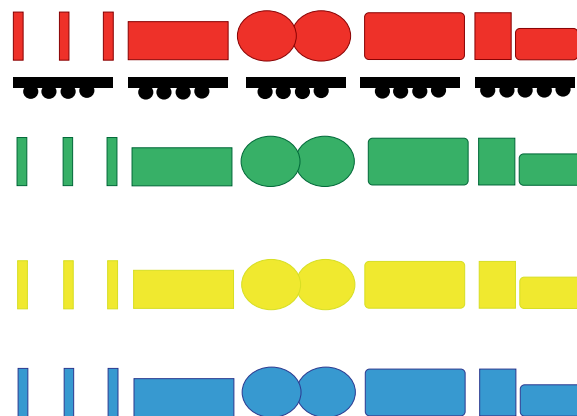
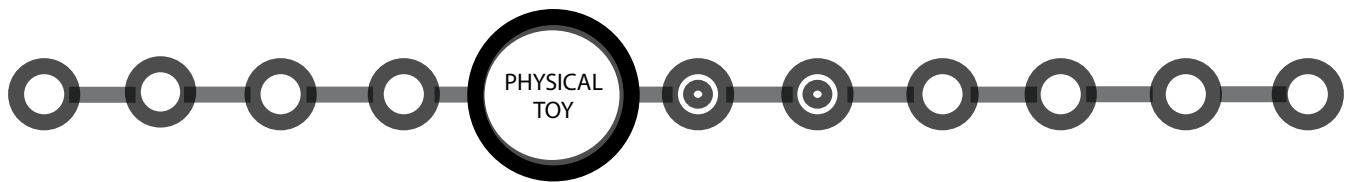


Figure 28. *Four types of cargo wagons, four colors and one platform to mount on.*

This was to hold down the number of turns since a train has a lot of wheels and mounting one axis at a time would require at least 4x4 mounts and highly increased amount of turns, which also could cause the game to be a bit long-drawn. The option would be to make some sets of wheels with four to five pairs on each, ready to mount on the platform. In that case the amount of turns decreases, but the wheels should then have different colors so that the choice itself would not only be to pick a simple set of wheels because that might take away some fun of the game. The same applies to the chasse platform, if this is to be chosen by the players it should have different colors, other wise every second choice would be either a platform or a set of wheels with one color, or the different types of top parts, which really would be the only parts with multiple choices. However if the wheels and the platform would have different colors to choose between, the mix of colors in the complete train would be extensive. Thinking about persons with autism that want structure and maybe have colors that they do not like, the usage of too many colors in the toy seemed wrong. Of that reason the platform idea with pre-mounted wheels was preferred. Since music and light were to be built into the functionality some components for electronics were needed as well. With the platform idea, a natural place for these components was created. Another benefit with using the chasse platform with pre-mounted wheels was that the amount of small and loose parts would be minimized and the risk for swallowing would be decreased, taken



that the toy is intact.

After evaluating the last idea the functionality in the application seemed to be much better than the physical toy. In the application it is more beneficial to have many choices than in the physical toy. This because one will have to buy the set of trains, which means that if there is four complete trains with four types of noses, four cabins, and four wagons plus the five platforms, one would end up with 29 physical pieces. Thinking about sustainability and the value of having these possibilities in combining parts, it did not feel relevant. Instead a final choice was taken to keep the platform idea, and the two-part locomotive but now there would only be two complete trains to choose parts from. The maximum amount of turns would then be six and then the game may be restarted. Six turns would also mean six rhythms and that is enough for creating music on a basic level. Different combinations of wagons and locomotives will accordingly give different combinations of rhythms so the variety in the end result will be quite large. If the turns taken are perceived too few in the application, one may simply restart the game and try another combination, making the turn taking infinite. On the other hand, if the amount of turns is too large one may simply stop building where it is enough, something that might require a co-player that is aware of the limits of the person with autism.

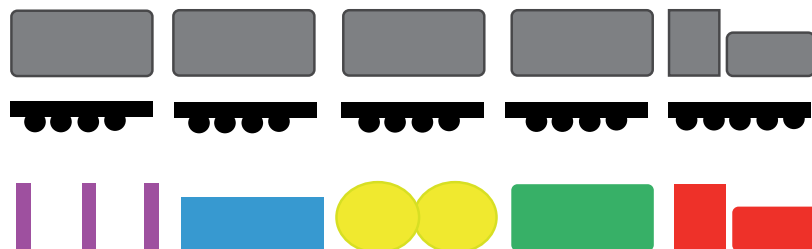
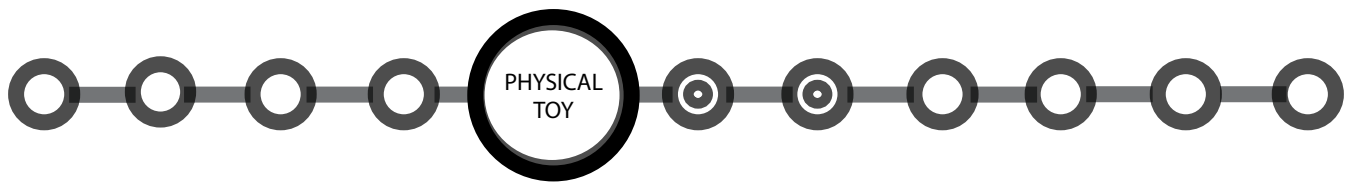


Figure 29. *Final amount of parts, five platforms and 12 top parts, of which four wagon parts make up a passenger train.*

One of the trains was to be a complete passenger train, and the other would be a cargo train with four types of wagons. This to give the child an option to only use one type of top parts if there would be a need of structure present. The same numbers of platforms were kept, i.e. five, and totally that would make up a set of 15 parts which seemed much more motivated.



### 5.1.2 Ulterior design

#### 5.1.2.1 Brand positioning

When the main idea for the physical toy was decided it was possible to begin the aesthetical design. The reason why the physical toy was chosen to begin with was because the train parts would be needed in the application. The decision to use pictures of the physical train parts in the application was decided early in the development phase. This decision was taken with the argument that a person with autism might benefit from having the exact replication when it comes to understanding the connection between the physical toy and the application. Furthermore, it should be beneficial to keep the total design of both as similar as possible to strengthen the users understanding of playing the same game in different ways.

To start the aesthetical design, a smaller analysis was made of other toy brands trains. The aim was to find certain design cues that distinguish these brands in order to differentiate from them.

It was found that certain brands such as BRIO, who would also be one of the most well established brands, had focus on quite simple shapes and forms but with quite lot details that gives their products a sense of real trains. Other brands would instead focus on toys that really were scale models of real trains. In the other end of the scale, brands like LEGO and Duplo offer the possibility to build trains with basic shapes such as cubes and rectangular parallelepipeds.

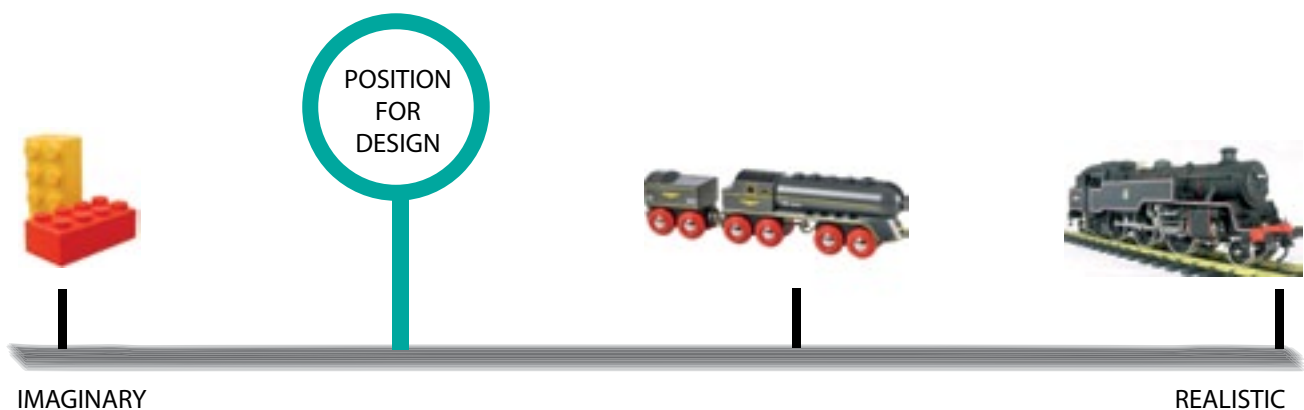


Figure 30. Scale of brands position in realistic vs. imaginary expression of aesthetics ([www.brio.se](http://www.brio.se), [www.modeltrainshq.org](http://www.modeltrainshq.org))

Of that reason the aesthetical design for this product was positioned to the left of the middle in the scale. Shapes and forms of the parts should not be too much like real trains and not too far from it.

When it came to details it was decided that these should be kept simple and restricted in amount. The decision was quite hard to take since it relates to the user. On one hand, many details could be beneficial for the person with autism since it has been noticed that many have a very good sense for details and therefore would have more to put attention on. On the other hand, many details might just as well be confusing and lead some of the attention away from usage of the toy.

Taking this into account just like the the positioning of the aesthetical design, it was at last decided that the level of details should be kept simple since the main usage of the toy, except for taking turns in building it, is to explore music. The total visual impression of the toy should be clean shapes and few details relevant to usage.

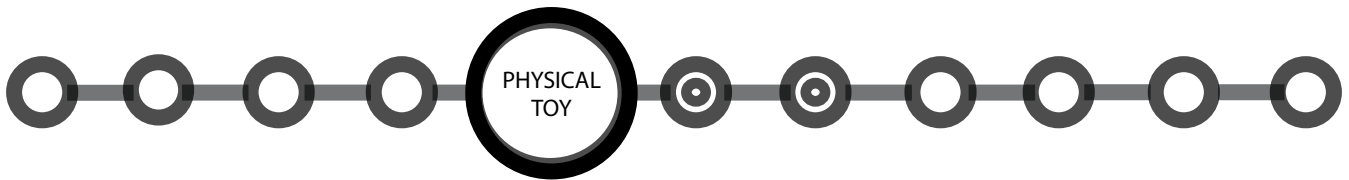
#### 5.1.2.2 Inspiration

To elaborate with the form design given the positioning of it, something to help creativity was needed. As the earlier mentioned survey regarding special interests implied, dinosaurs is a recurring interest for some in the target group. Also the form of dinosaurs is often streamlined and robust, similar to important design aspects of a train. As inspiration for the form expression these were therefore used. The figure below shows what kind of dinosaurs that were used.



Figure 31. *Dinosaurs used as inspiration for form*





### 5.1.2.3 Sketching and Clay modeling

“Quick and dirty” sketching became a natural method to develop the form further with the possibility to try many different forms in short time but it never gave a sense of how the different train parts would actually feel to hold.

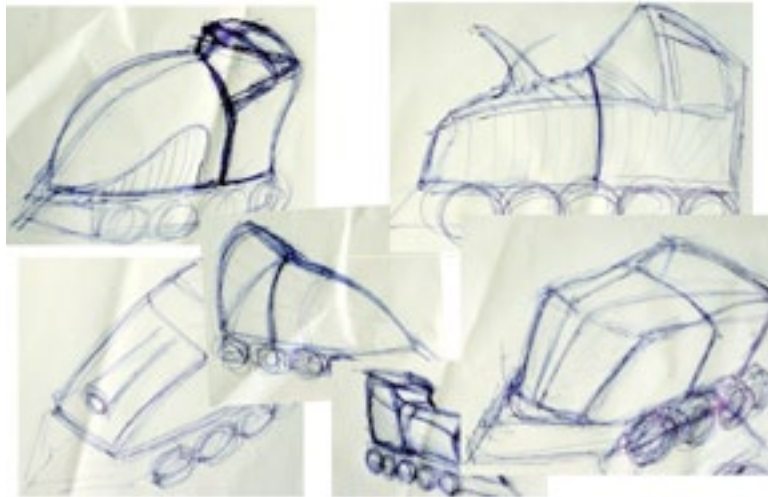


Figure 32. *Quick sketches*

Clay was therefore used to explore the physical expression in the form language. The aim was to create shapes and forms that felt good in the hand and that were continuous so that they maybe would be more appealing to a person with increased perception in the haptic sense. The last proposition was of course only a speculation, there is no evidence that this would apply at all in real life, but the thought of it helped develop the form further. Thanks to the clay models, an initial sizing of the product could also be done. The size was at this stage a rough approximation and accommodation between children’s hand size and pure aesthetics.



Figure 33. *Clay modeling. Shaping and fitting*



Furthermore, since the application and the toy would consist of many different parts that could be combined, the clay models helped finding ways for fitting pieces together independently of each other. When the fitting was done and the basic form was decided, another session of sketching was performed to refine it.

#### *5.1.2.4 Coloring and details*

The form development had now come to deciding colors and detail placement on the train parts. In the FaceBook survey, some parents had pointed out that clear colors and contrast seemed to appeal their children. Of that reason, not knowing of any other preferences regarding colors, contrast was seen as a guideline when selecting for this project. To find inspiration for colors other than using contrast, there were a few photo sessions in different places where colors and color combinations were explored.

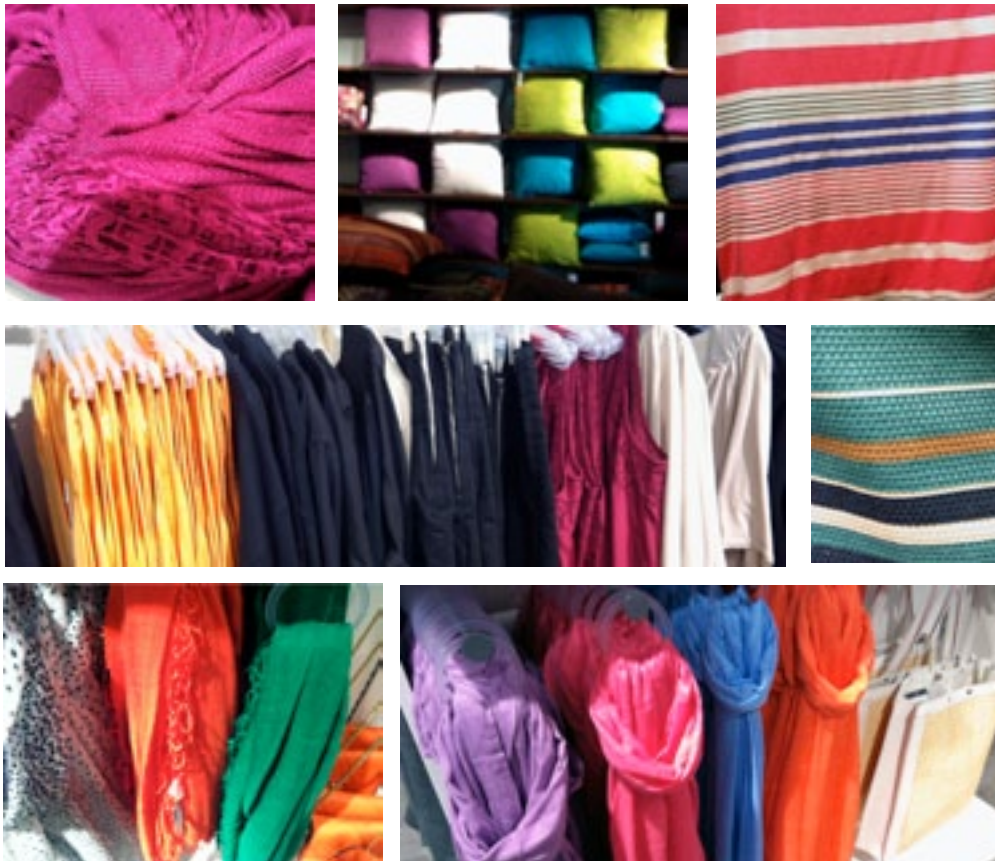
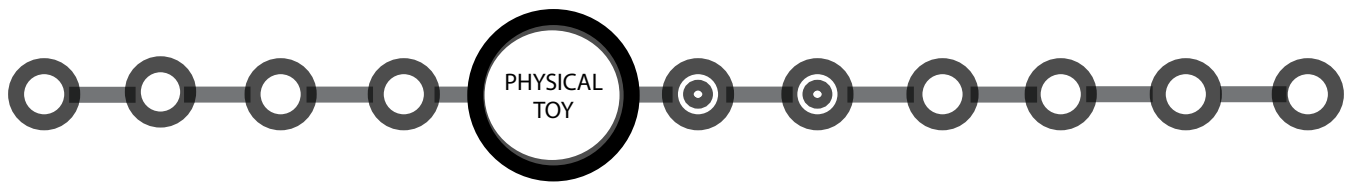


Figure 34. *Color combinations from photo sessions*



Also, in the same way as earlier, a smaller analysis of other brands and their typical colors was made. Taking BRIO as example again, one can see that they also focus on contrasts and strong, clear colors. In general really, toys tend to have bright and clear colors or pastels. Since this is a new product, and possibly brand, it should be differentiated even in this manner, therefore elaboration with colors was done partly with focus on not using other well-known brands' colors. To get an idea of how or whether the colors would fit the train, the simple train illustrations were used to visualize the combinations. Many examples were produced and developed (Appendix 5) until one final decision was reached.

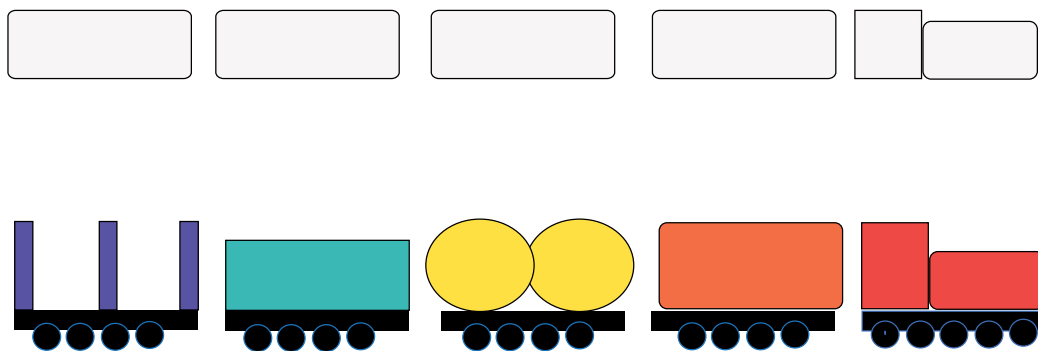
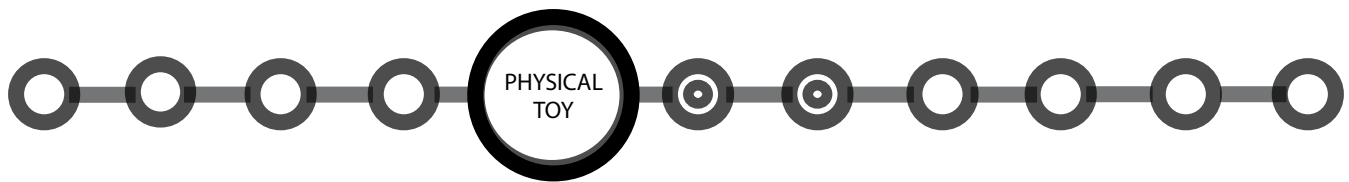


Figure 35. *Final colors for train parts*

As figure 35 shows, the passenger train would be all white and the cargo train would consist of nuances from the color circle (CMYK color codes are given in figure 36) . The nuances were selected with aim to create an expression of lightness, freshness and kindness. Prejudices regarding gender and typical colors were carefully avoided trying to use colors that had no “label”. Even if this particular target group might not perceive colors and genders as something that is connected, it felt important to at least consider the aspect. Why the passenger train was supposed to be white was of the same reason why there should be a complete passenger train at all; if one player do not like colors or need structure, this will be a possible choice. All chase platforms and wheels were kept black because it gave the most calm impression and contrast.

When it came to details it was relatively fast decided that there should be at least one line with the same color that would continue over all top parts. The first point with that was to connect all top parts regardless color or type; the second point of it was to provide a detail that could work as a positive feedback for knowing that the parts were connected right, especially for a person with autism that appreciates lines and structure. The color of the line was changed until there was a color that would harmonize with all the different parts without requiring too much attention.



Next details to consider were lights and windows. The lights were placed either on the side of the parts or in the top depending on both aesthetic aspects and according to the real life usage situations. The same applies to the windows and figure 36 shows the result.

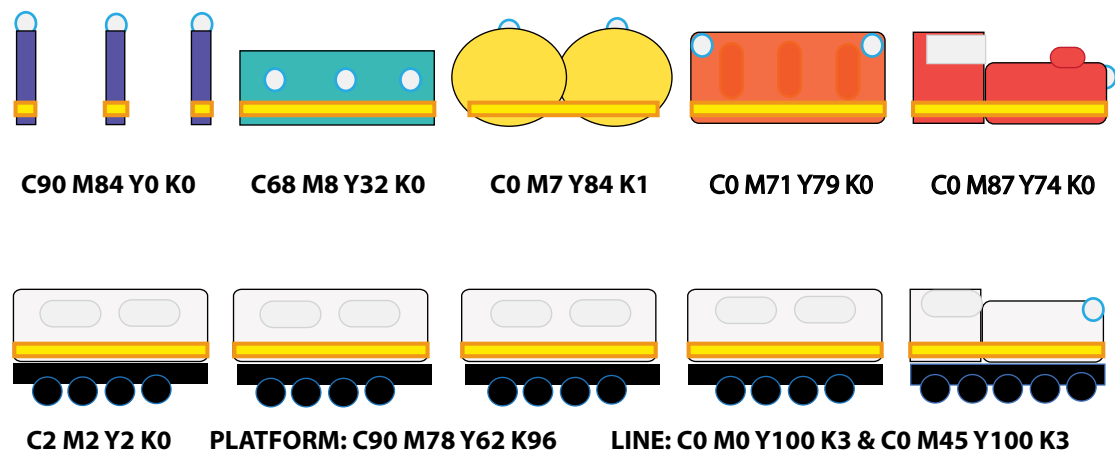


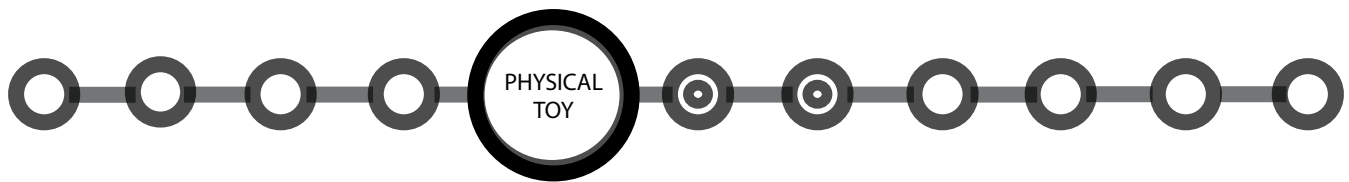
Figure 36. *Final details added to train parts and CMYK color codes*

### 5.1.3 Music functionality

Deciding the functionality of music was done by relating it to the amount of top parts of the train.

In the cargo train there are four different top parts to choose between except for the locomotive parts, the nose and the cabin. If each part would have one rhythm the total would be 6 rhythms in a complete cargo train. The same amount of rhythms would then logically apply for the passenger train.

Since all passenger wagons are identical, it would however be potentially confusing if they had different rhythms, especially since the different cargo wagons should give different rhythms as well. Of this reason it was first decided that all passenger wagons should have the same audial feedback. Using the same argument as for both color and form development, it could be beneficial to offer the child with autism an option to keep the train simple. In other words, it will be possible to choose a one colored train with continuous shape and basic rhythms if other options are felt to be too complex. If the players on the other hand want to use many different sounds the top parts of the cargo train should be used, but, if these four top parts only have one sound each, the same music would always play in a complete cargo train. Of this reason a higher level of functionality was needed and therefore also some basic knowledge of music.



All music is built up by beats. One basic beat is called common time, which consists of four beats in one time. By adding four beats, or times, on each other, music is logically built up. The tempo of music is decided by the amounts of beats per minute (BPM). Knowing how many beats that should be evenly distributed on one-minute periods, one can also find the time it takes to make four beats with the same distribution, i.e. how long one time should take to play.

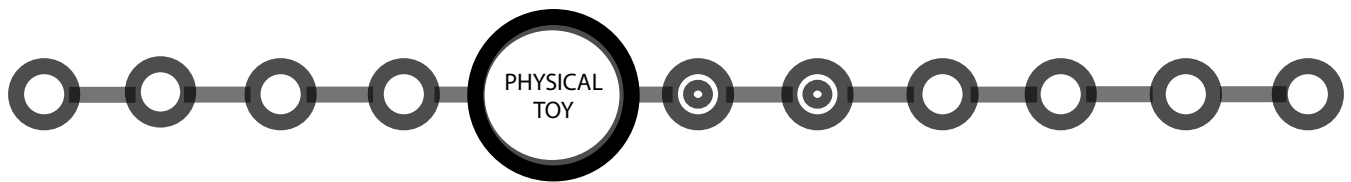
There are for example other basic beats such as two-, three-, five-, six-, seven- and 6/8-beats, in which one counts to two, three, five, six, seven and 6/8 beats respectively in each time. Adding different rhythms in an efficient and simple way for this project would then be to create loops with the same tempo and time (Ödling-P, 2012). Therefore all rhythms should be made in common time, looping the music over and over.

Since the beat is the foundation of the music and the “motor” of tempo, it seems logical and therefore most pedagogical to apply instruments that emphasize these parts of music to the locomotive, which is the corresponding motor of the train.

As commonly known, music may be built up by different instruments and rhythms and to increase the possibilities for creativity, this is what the top parts of the wagons will consist of. In order to create many combinations of instruments and rhythms, each wagon top part will have four different instruments of the same type. Which type of instrument playing will be decided by the position in the line of platforms.

Common instruments in music are as mentioned, the basic beat made up by drums and e.g. shakers, maracas or other instruments belonging to the percussion family and adding to this, bass and acoustic or electrical instruments to emphasize a melody. Of course music is not done in only one way but this is a basic way of building music. Therefore, these instruments were to be used in the train.

In the passenger train that was to be kept simple, a horn sound from a train was to be used, which then could work both as a fun supplementary sound in music or just as it is in a complete passenger train. This type of train would then get three different sounds as a total, one from the nose, one from the cabin and one for the four identical top parts on the wagons.



To conclude the music functionality of the train figure 37 below demonstrates type of instruments attached to each top part:

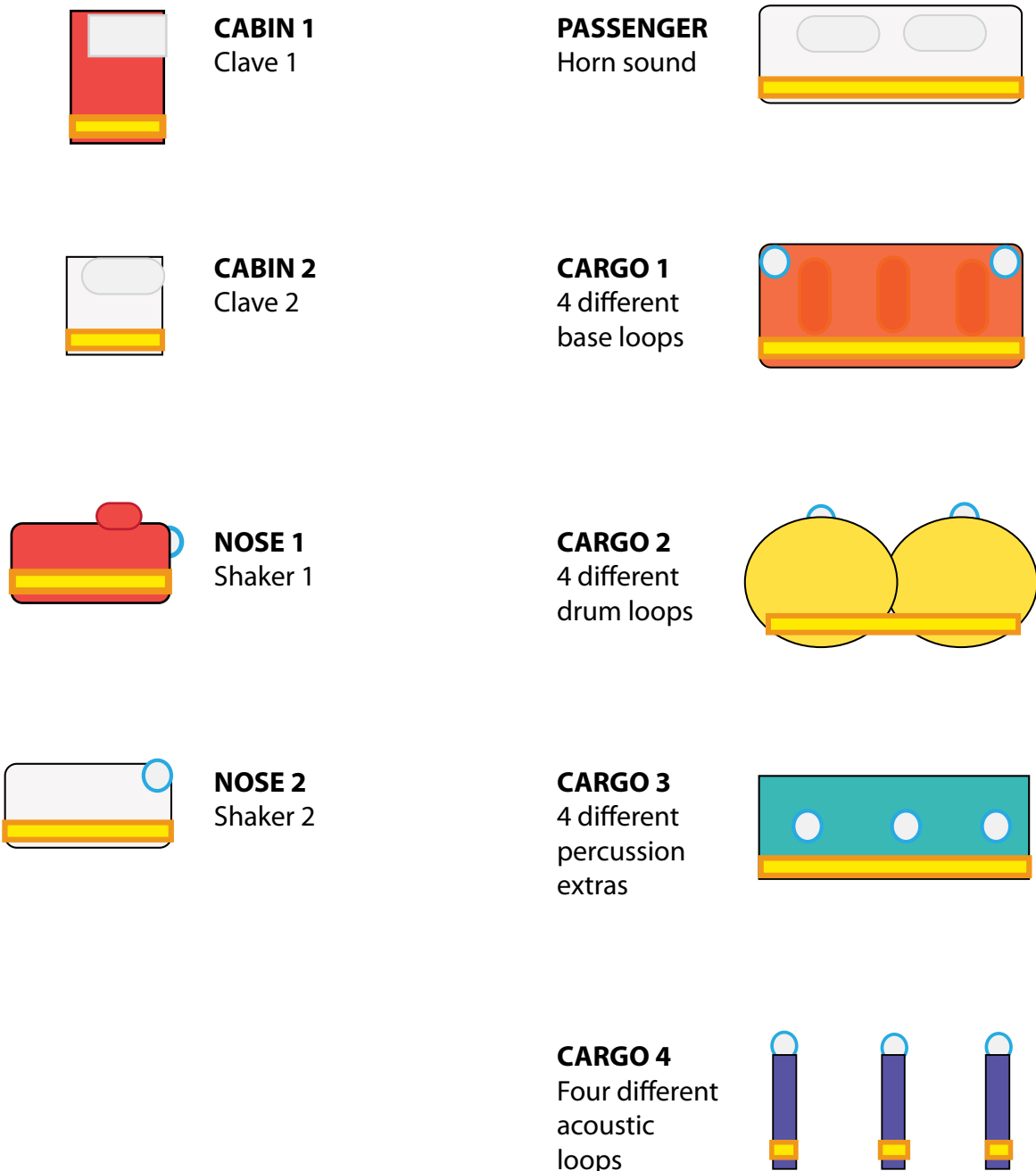


Figure 37. *Music functionality. Shows what type of rhythms that are attached to each part*



### 5.1.4 Ergonomy and safety

To ensure that the train parts were to be properly sized and safe to play with, an anthropometric study and safety analysis was done. To start with, some anthropometric data was gathered from literature. The length of hands and fingers as well as the width of the hand was collected for children between four to seven years old.

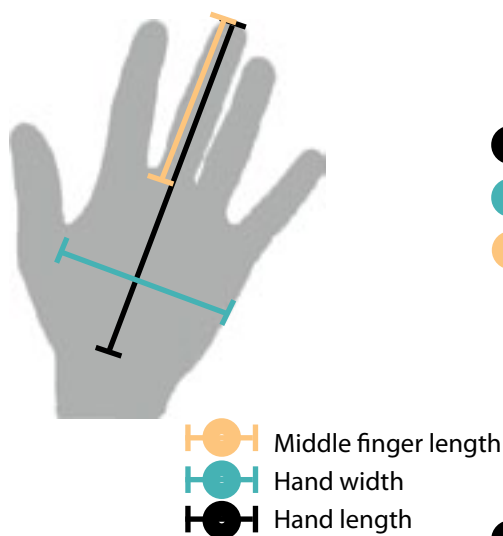


Figure 38. Taken measures

Anthropometrics Girls 4, 7 (mm)		
5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile
105,120	120,135	135,150
50,55	55,60	60,65
	48,56	

Table 1. Hand measures girls, (Pheasant, Haslegrave, (2005), Humanscale)

Anthropometrics Boys 4, 7 (mm)		
5 <sup>th</sup> percentile	50 <sup>th</sup> percentile	95 <sup>th</sup> percentile
100,120	115,135	130,150
50, 60	55,65	60,70
	48, 56	

Table 2. Hand measures boys, (Pheasant, Haslegrave, (2005), Humanscale)

Given by literature that a bent hand makes the hand length of the inside decrease with 8,8 percent (Humanscale), it was possible to calculate a proper circumference of a circular train part (Appendix 6). The circumference was then divided in two since the grip of the part would not be necessary around the whole part.

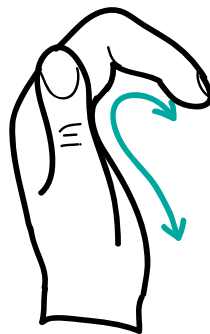
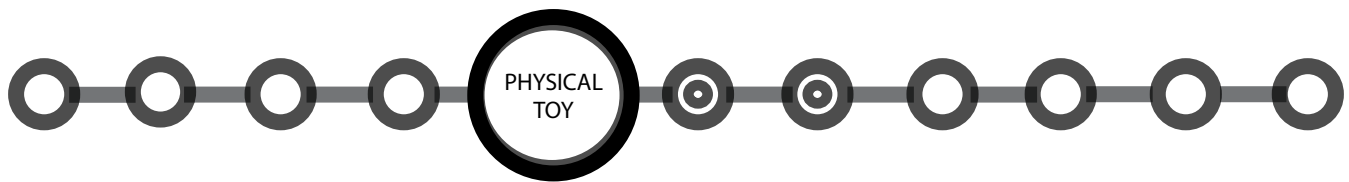


Figure 39. Bent hand, inner length decrease with 8,8 percent



Using the anthropometric measures as guideline one could see that the minimum inner grip length of the 5th percentile of boys and girls of age four was 91.2 mm. By testing the diameters 50, 60 and 70 mm in the equation, it was apparent which one of them that would meet the minimum grip length best. 60 mm diameter gave a grip length of 94.2 mm, i.e. slightly above the minimum of 91.2 mm but was considered the most proper since it corresponded to the initial sizing of the train parts made in clay. It was also considered important to make as big train parts as possible, firstly because of the contrast of details in the parts and the experience in using the toy, secondly because of the usability and clearness of how to use the toy. Adding to this that the train parts should have low weight and placing them should not need much force, the difference in grip length was estimated not to be of any disadvantage for the physical ergonomics.

However, the data above does not really tell whether the size of diameter 60 mm is *ergonomic* for a train part to play with and not all parts were going to be circular, therefore some further investigation was needed.

Measures were taken on children with the age of four and five. The reason why measures were taken only on these children was because of the assumption that if the size of the train parts fits a four year old, it will also fit a seven year old person. The measuring was done on three persons, one girl with the age of four and two boys with the age of five.

First the children hand length, width, and middle finger length was measured.

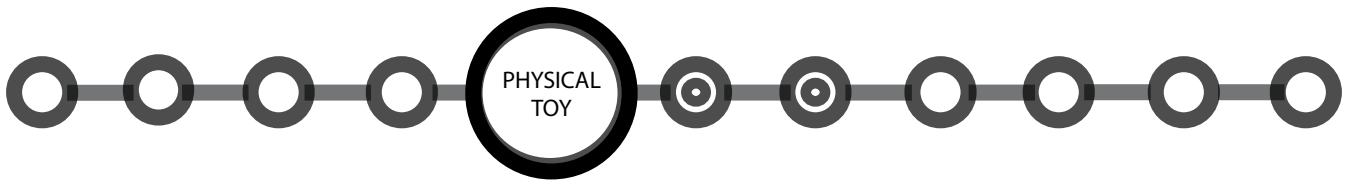
		BOY 5, nr 1	BOY 5, nr 1	GIRL 4
Hand length	●	120	110	115
Hand width	●	60	60	60
Middle finger length	●	50	50	50

Table 3. *Measures taken on children of age four to five*

As one can see, the anthropometric data from literature are similar to today's reality, which then could confirm that the given data was accurate enough to use even if it originated from old studies.

After taking hand measures the children were asked to hold two different objects. First they got to hold a rectangular parallelepiped with the measures 125x60x25 mm. They were asked to grip the object over the 60 mm side and then to move the wrist around. This was done to make sure that the breadth of 60 mm of a train part would not be too broad and that the child playing with it would be able to rotate





the piece in order to place it on the platform from different angles. This was easily done by all of the children.



Figure 40. *Test of holding the rectangular parallelepiped*

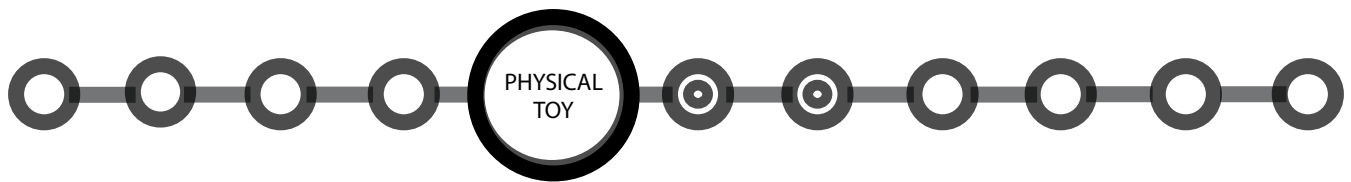
Next object to test was a cone with a bottom diameter of 80 mm and a height of 180 mm (Figure 41). The children were now asked to grip the cone from the narrowest part, the top, and then move the grip further down towards the bottom until the grip became uncomfortable.



Figure 41. *Test of gripping the cone*

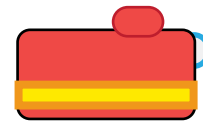
Since all the children had such range of grip, none of them had problems to grip around the widest part and all of them could easily even grip across the bottom even if their hands were stretched. The cone helped to find out what capacity in grip these children really have and did also confirm that the calculated diameter of 60 mm was adequate.

After gathering anthropometric data, calculating suitable grip length and then confirming the sizing, the final maximum measures were decided for each part. As shown at next page, at least one measure out of three on each part was set to 60 mm or less to provide good ergonomic grips.



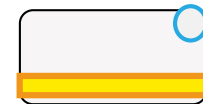
**NOSE 1 (mm)**

Width: 55  
Height: 50  
Length: 80



**NOSE 2 (mm)**

Width: 55  
Height: 50  
Length: 80



**CABIN 1 (mm)**

Width: 55  
Height: 65  
Length: 50



**CABIN 2 (mm)**

Width: 55  
Height: 70  
Length: 50



**PASSENGER WAGON (mm)**

Width: 55  
Height: 65  
Length: 115



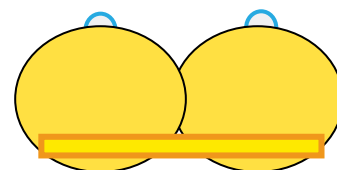
**CARGO 1**

Width: 55  
Height: 70  
Length: 115



**CARGO 2**

Width: 55  
Height: 75  
Length: 115



**CARGO 3**

Width: 65  
Height: 70  
Length: 115



**CARGO 4**

Width: 55  
Height: 70  
Length: 115

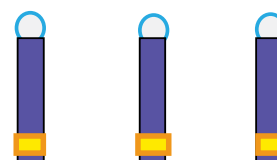
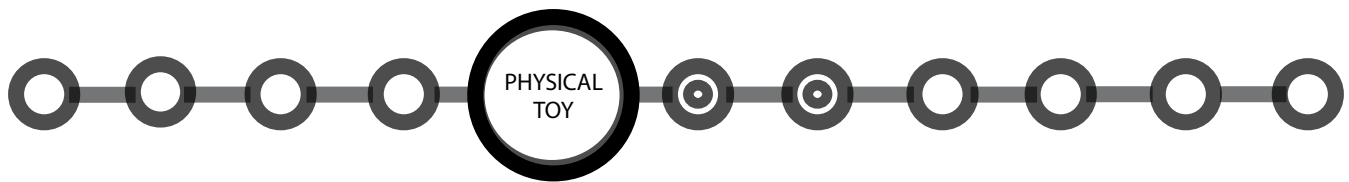


Figure 42. Maximum measures for train parts



After the anthropometric study the safety analysis was done starting with collecting safety standards for toys. These standards are open to find at the Swedish consumer agency (Konsumentverket.se) and regards toys in general as well as toys with built in electronics.

For toys in general a CE-marking or approval is required if the toy is to be sold within the European Union. CE marking is a certification that the toy is safe to use, and regulations regards e.g. health, hygiene, electrical safety and size of loose parts. In appendix 7 a short review of the requirements is found.

With time limits in the project, the CE-requirements could not be further investigated or implemented, therefore the safety analysis was kept on a basic level where the aspects of health, hygiene, electrical safety and loose parts were discussed in general terms.

Talking about safety in playing with a toy, much of the issues originate from the material. The material will affect the possibility to keep the toy hygienic, electrical safe and it will affect health and durability, all depending of the complex of substances and the structure of them.

Durability and hygiene will also be affected by the shape and construction of the toy. Of that reason, the final form of the physical train was analyzed in order to see that the shapes would have as few recesses as possible. Recesses were avoided because of their potential to capture dirt and germs that also would be hard to clean.

As indicated, choosing material and construction were the two main issues in order to make the toy safe, therefore the safety analysis was continued and finished in the two mentioned sections later in the process.

### **5.1.5 Construction**

Even if the goal for this thesis was not to design a complete construction for the physical toy, some simpler construction was necessary anyway. Since the goal was to create a prototype with some functionality, the placement of electronic components would need to be considered.

The placement of electronics depends on the functionality of them and the functionality depends on the programming. Since programming is a knowledge area beyond the writer's experience, consultation was needed. Interviews and elaboration with programming was done together with an electronics engineer. The concept was presented to the engineer who also agreed with the idea of using the platform as a base for the electronics to be the most suitable. The functionality of



using rhythms to respective type of top parts was thoroughly discussed and from here the engineer took over to write some codes to program the toy. After while he returned with a simple model consisting of a small circuit board with a microprocessor, usb-port, some connecting pins, and resistors.

The easiest and most efficient use of components, therefore also the cheapest way of making a functional prototype of this level, was to build the circuit board with the microprocessor in the first chasse platform in line. This platform would therefore be the head platform of the complete train and would have to be used for the locomotive. Two connections had to be placed on the head platform, one for the nose part of the locomotive, and one for the cabin part.

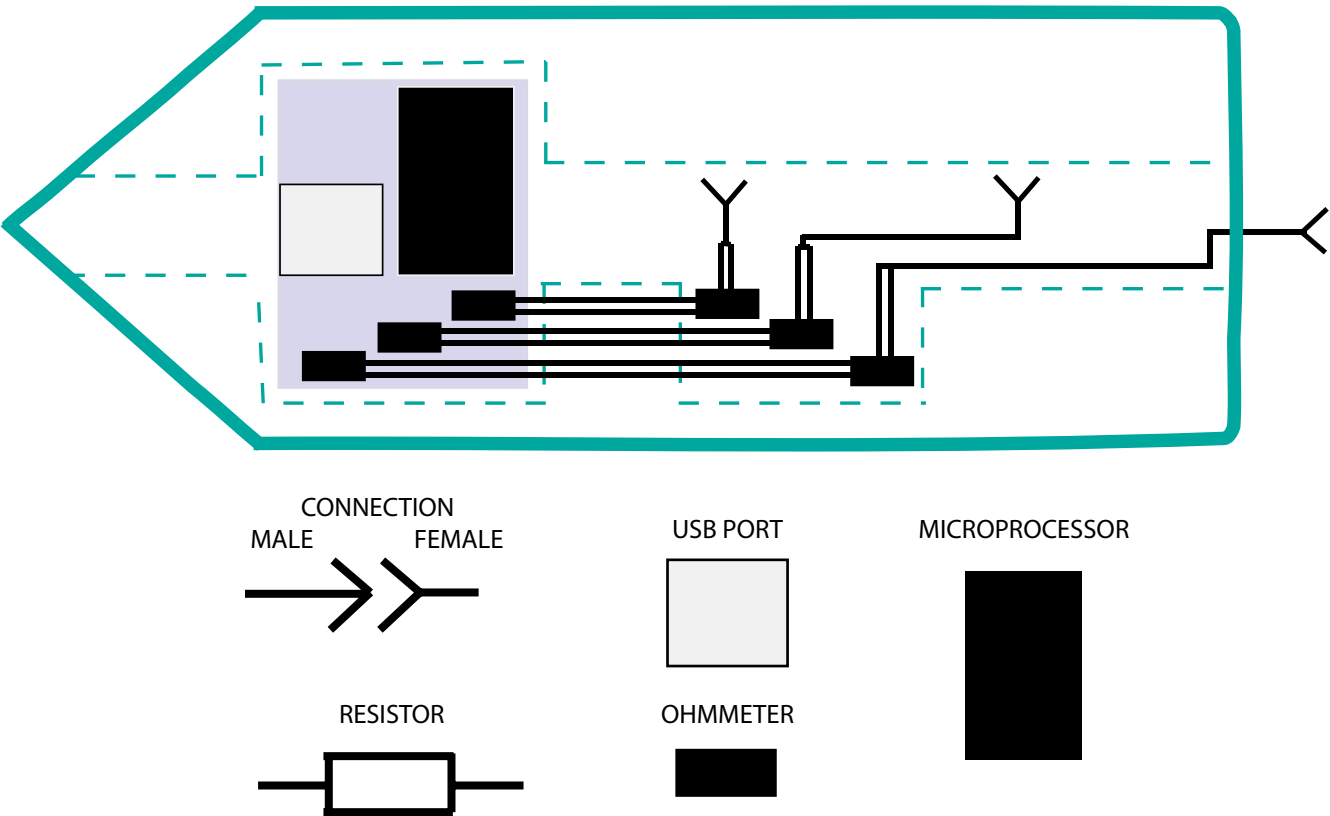


Figure 43. Top view, circuit description for head platform.

In the same way, one connection for the top part of the wagons would be placed on each following platform. For all of the platforms including the head platform, connections between them had to be mounted in order to create a circuit (figure 44).

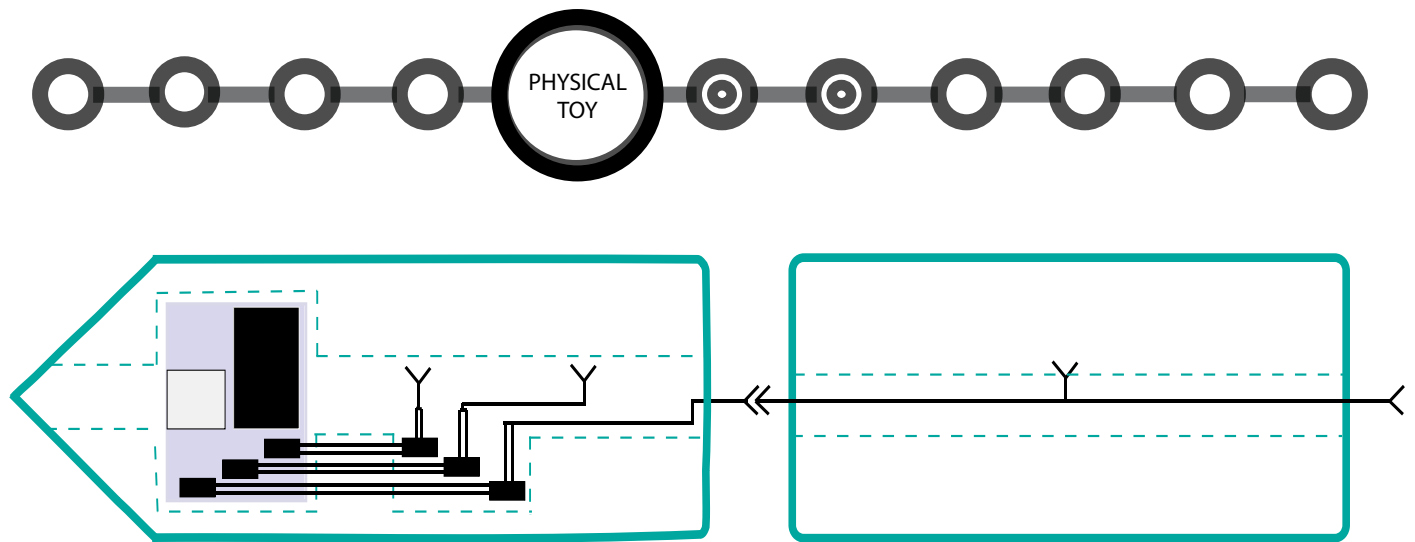


Figure 44. *Top view, circuit description of connection between head platform and regular platform, three more regular platforms may be attached*

The circuit was needed so that all top parts of the complete train would have functionality. The basic idea of this functionality was to calculate electrical resistance of the top parts. To do this, resistors with different resistivity were mounted in the top parts together with the meeting part of the connection.

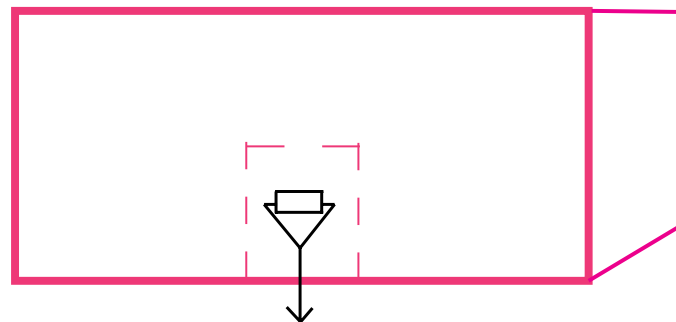
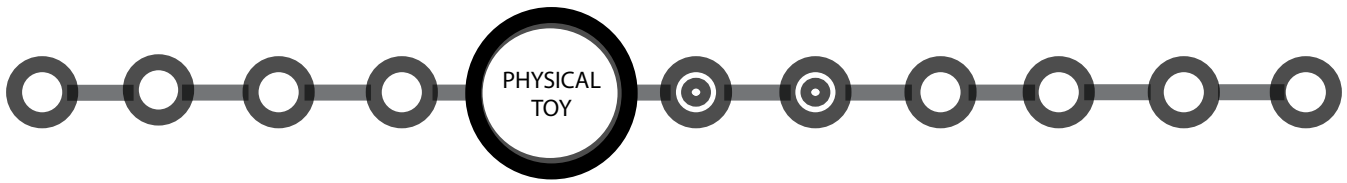


Figure 45. *Side view of top part with resistor and male connection*

To solve the functionality of rhythms, programming was now needed. There was a great complexity in programming this functionality since the many top parts would make up a great variation of combinations of resistance sum. Because of the complexity, the engineer would not have time to complete the prototype. It was therefore decided that the program would be written in a computer and the physical toy would be connected via USB to the program. In that way, a lot of time was saved which allowed this project to have a prototype with at least some functionality, even if it would not be perfectly working as the final product. Lights were added in own circuits by placing a R03 battery, a resistor, light emitting diodes and a button at each platform. Furthermore, this prototype would have a different interior design from that of the final product since some components would not be used at this point. These components include battery holder and connections for the main functions, and light solutions would be possible to integrate in a more



efficient manner at a later stage. These aspects were not taken into consideration in this project other than recognizing what would have to be further developed before having a proper prototype.

As mentioned earlier, construction of the toy also regards safety. When it came to loose parts in the physical train it was quite evident that the wheels on it make up a potential risk. It is therefore important at a later stage to consider the construction of wheel axes or even possibilities to build in the wheels in the platforms to prevent them from coming off. Usage of thin materials should also be avoided to prevent the toy from breaking under high pressure or hits, something that really applies for the whole form development and construction.

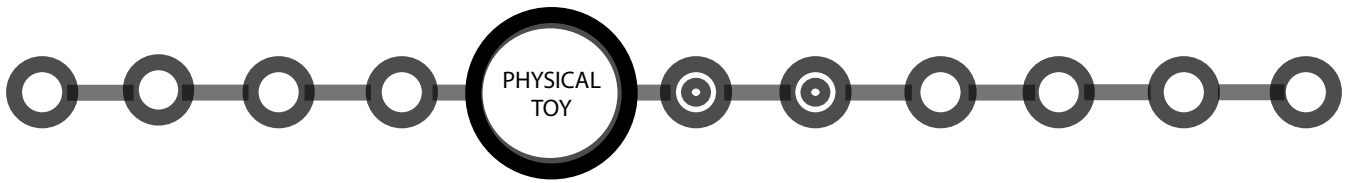
Components for electronics should also be well isolated and at the same time it has to be evident where and how to connect the different parts. I.e. there must be physical constraints that prevents the user from connecting parts in a wrong way but there must also be great affordance that gives the user a clue of how to connect in the right way.

The last mentioned aspects were however not implemented on the prototype at this stage because of financial and time limits, but were documented and kept for future development.

### **5.1.6 Material**

When choosing material for the toy, the safety analysis (Section 5.1.4) was considered first. As found, the material will affect the health and hygiene issues as well as durability, which in turn will affect the risk for loose parts. The CE-requirements states a number of maximum limits allowed for different substances in materials. The substances are used to give the materials different properties such as viscosity, strength, hardness, flameproof ability, electrical isolation etc.

The material for the physical train would have to have high strength and be a bit viscose to prevent small pieces to come off if the toy is smashed against something, on the other hand it could not be too viscose because it needs to be form stable to protect the electronics from pressure, and also of aesthetical reasons. Since there are electronics within the parts, the material needs to have good electrical resistivity and has to be flameproof. Above this, the child with autism might get anxious and maybe even angry if the toy would break, therefore the material have to be easy to fix and the train to repair if something would happen.



With no limits or data of any of the properties it was hard to search for materials. Instead materials used in similar toys that had both sound and light built in was sought for.



Figure 46. *Example of toy with built in electronics ([www.br-leksaker.se](http://www.br-leksaker.se))*

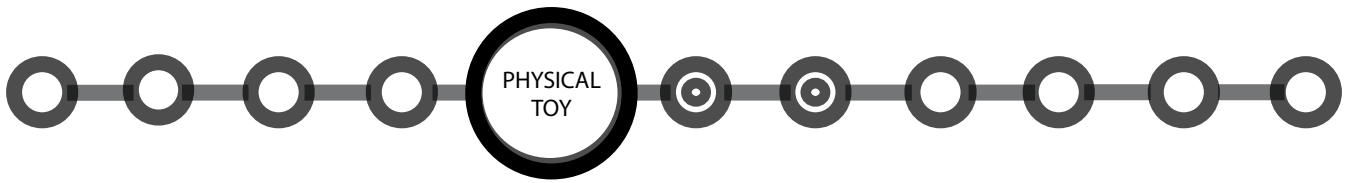
By looking for markings on toys in stores the hope was to find a proper material. When it was realized that none of all the toys had any markings, and that none of the salesmen knew or could find any information, the method had to be changed. Instead the search continued at the Internet, trying to find information at the producers' homepages. Even the producers provided no information and of that reason interviews with material experts were done. When talking to Antal Boldizar, a professor working in the department for materials science and manufacturing technology at Chalmers University of technology, it was found that the polymer HIPS, High Impact Polystyrene, was the most common material for toys with electronics. Some of the advantages of HIPS are good impact resistance, good aesthetical qualities, it is easy to paint and glue, has low cost and good machinability. Because the material is used in CE-approved toys and because of its advantages it was initially chosen.

The main disadvantage of the material, for this project, is the flameproof properties, which are not very good without additional treatment. Making it flameproof would therefore cause a bigger impact on the environment something that will be discussed in next part.

### **5.1.7 Sustainability**

Choosing material had a big part in considering sustainability. After being told that HIPS is the most common material, it was confirmed that it would be easy to recycle since a common plastic is better recycled than e.g. a more unusual composite. The additional treatment to get flameproof HIPS material would on the other hand make the toy have bigger impact on the environment, but this was to seen





be compensated by the ability to recycle. There are probably many materials that have similar properties as HIPS that have less impact on the environment but the fact that the toy has electronic components and circuit boards, and that the project result would not be prepared for production, it seemed more relevant to leave the effort of finding those materials for future development.

When it comes to recycling of the toy it does not really help to only choose a good material if it is inseparable with other materials. Therefore it would be of great importance in a further development to make sure that the toy is constructed in a way that enables easy separation. Alternatively to construct the toy so that it is easy to repair or establishing some kind of service where the customer for example may leave a broken part and get discount on a new one. In this way, possibly less raw material for manufacturing the HIPS would be needed. Construction of the prototype will enable electronics to easily be taken out from platforms only by opening the pieces up, a solution that could be suitable also for a future product.

#### **5.1.8 Prototype**

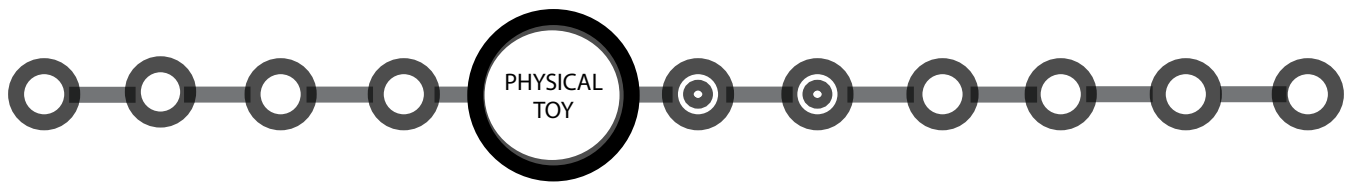
A prototype of the train was next to being built. The train parts were made of the material Ureol (Polyurethane), often used in prototypes and sketch models. The machining was made in a workshop using band saw, grinders, post drilling machine and some hand tools. After having the parts done, they were divided and prepared to make room for the electrical components, which were then placed, and the parts were glued together. Finally the parts were painted and details were put in place.

### 5.1.9 Result Physical Train



Figure 47. *Final result of physical toy, one cargo train and one passenger train (the set with parts only contains five platforms as a total)*

The complete set provides the user with many possible combinations of rhythms and world music depending on how the parts are chosen and in what order they are placed on the train. This does not only enhance the possibilities to creativity but will also make use of the players' detail memory when and if they would want to recompose certain music loops. As indicated in Needs and requirements chapter, section 2.1.10, making use of memory could be beneficial. By relating the three learning dimensions to this, one can argue that the same content, (which in this case would be what order the top parts are structured in rhythms, color or type of top parts), would clearly give the same result every time and therefore also could



increase the propulsions to recompose this particular set up of train parts. This argument relates to the specific target group of children with autism that, as already stated, might have certain strengths in noticing details and remembering them. Below a summary of the physical toy is provided.

**Amount of parts:** 15 (5 platforms, 2 noses, 2 cabins, 4 cargo wagons, 4 passenger wagons)

**Amount of rhythms:** 2 claves (Nose), 2 shakers (cabin), 4 base (Cargo1), 4 drums (Cargo 2), 4 percussions extras (Cargo 3), 4 acoustic (Cargo 4), 1 horn sound (Passenger)

**Material:** HIPS, recyclable plastic.

**Measures:**



**CABIN 1 (mm)**

Width: 55  
Height: 75  
Length: 45



**CABIN 2 (mm)**

Width: 55  
Height: 65  
Length: 45



**NOSE 1 (mm)**

Width: 40  
Height: 45  
Length: 75



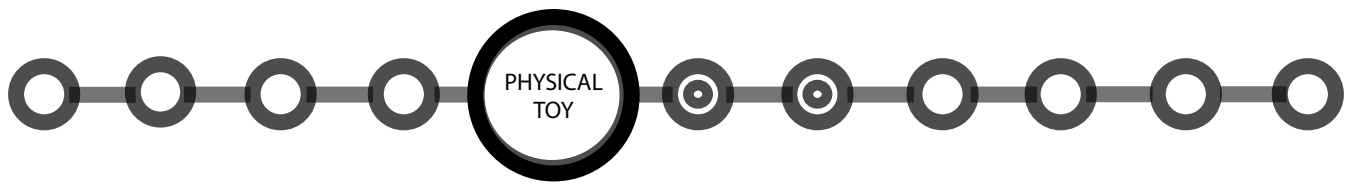
**NOSE 2 (mm)**

Width: 45  
Height: 50  
Length: 75



**PASSENGER WAGON (mm)**

Width: 55  
Height: 65  
Length: 115



**CARGO 1**  
Width: 55  
Height: 65  
Length: 115



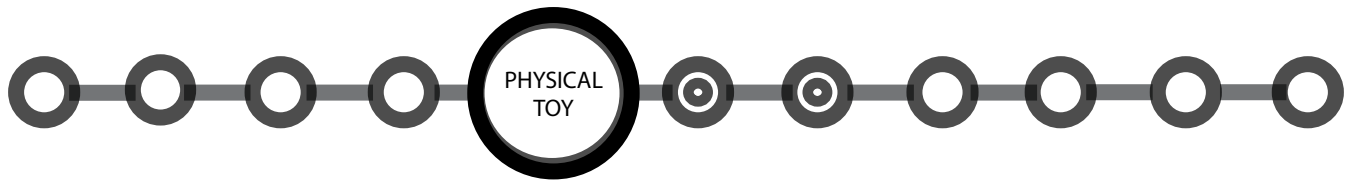
**CARGO 2**  
Width: 55  
Height: 75  
Length: 115



**CARGO 3**  
Width: 65  
Height: 50  
Length: 115



**CARGO 4**  
Width: 55  
Height: 70  
Length: 115



#### **HEAD PLATFORM**

Width: 55

Height: 25 (excl. wheels)

Length: 130



#### **REGULAR PLATFORM**

Width: 55

Height: 25

Length: 115



## 5.2 APPLICATION

### 5.2.1 *Synthesis of functions*

Also the development of the application was started with a synthesis of functions. The main functionality was as mentioned in the concept evaluation phase (Chapter Concepts, section 4.6) kept from the “Build a car concept”, therefore the five keywords were used as further inspiration for finding important functionalities needed in the new interface.



Figure 48. *Five key words*

The synthesis of functions resulted in something similar to the one for the physical toy (Section 5.1.1) but there were some additional aspects.



### **Main function application**

Practicing turn taking, creativity and replication

### **Part functions**

- Enable player-name typing
- Enable player to take photo
- Enable voice synthesis
- Enable online playing and chatting
- Allow player to finish game early
- Allow player to give turns
- Allow player to change choice of part
- Allow for different options of parts
- Allow visual and audial feedback
- Allow players to play with built result

### **Support functions**

- Enable audial feedback according to what type of part is chosen
- Allow shut off audial feedback
- Reality based visual feedback of train parts

### **Extra functions**

- Allow for upgrading of software
- No saving to force a reconstruction

Figure 49. *Synthesis of functions for application*

## **5.2.2 Interface design**

With the synthesis of functions in hand it was possible to begin sketching for ideas of a flow chart. The sketches were made very quickly and simple with aim to find a possible and good flow for the different scenes in the game (Appendix 8). In this phase also functionalities of the application were investigated: where to place different elements, how they should work and of course, how the functionalities should work considering autism. The most logical flow created by sketches was then selected and refined by computer software to give some structure to the ideas.



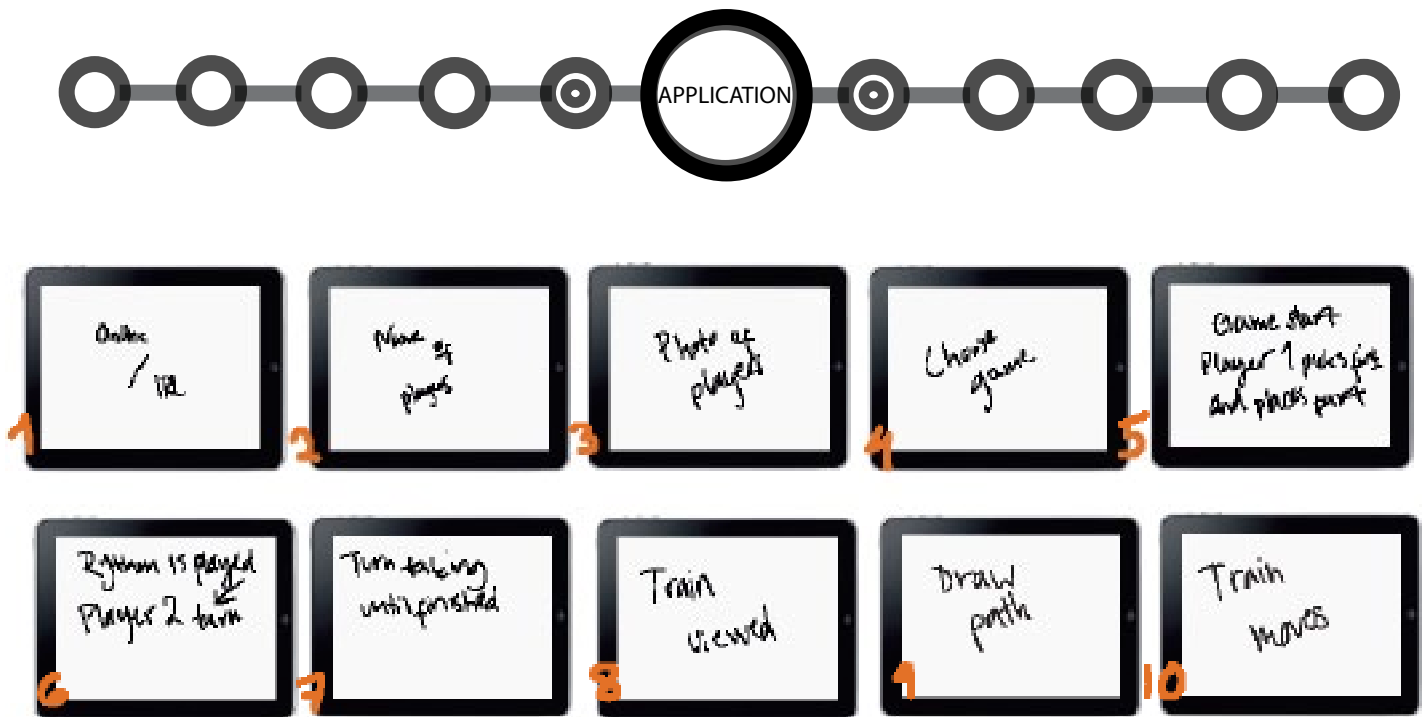


Figure 50. *Refined flow of application scenes*

The sketches now resembled simple storyboards and the next step was to take final decisions regarding the order of functions and to choose an appropriate theme for graphic design elements. This was done by relating the decisions to theory of designing interfaces (Chapter Needs and requirements, section 2.1.9).

When decisions regarding the interface were taken, it was possible to create a final storyboard to be used for visualization and explanation of all elements.

Finding a theme for the graphical elements started with a small idea generation where something relating to workshops, mechanics, trains, train stations etc. was sought. As earlier mentioned, contrast and limitations of surfaces could be important aspects for a child with autism. Furthermore, graphical elements should be structured and the total impression of the interface should be kept clean and simple to give it an inviting expression as well as to keep the child's focus more easily. The theme was then gradually built up by using computer software.



### **5.2.3 Result Application**

The final theme is inspired by old school product construction when paper and pen were the main tools used for making a drawing. The theme also relates to carpenting because of the main function of building the train hence, toolboxes are used in the turn taking game. Surfaces are mainly made up by wood panels and squared paper. The squared paper is used for elements relating to sketching or writing and the wooden panels are used as tool bars and other elements relating to usage of the interface. In the turn taking part of the game, train parts are hidden inside wooden tool boxes, the reason to this is first of all because the train parts have different colors which is why the game surfaces need to have a one colored but not white background, otherwise there will be too much details in the interface at once. Second, the train parts that belongs to the player waiting for a turn need to be covered, both to limit the amount of elements on the screen and to emphasize whose turn it is. In the following pictures the different elements will be more thoroughly explained.



## 1. IRL OR ONLINE



Figure 51. *First scene of the application*

### *Mapping and constraints*

In the first scene the player(s) is/are to choose whether there are two players present or if a single player wants to play together with someone online. There are two main surfaces for the choices, this to create distinct limits between the two. The two surfaces are placed on top of each other to strengthen the understanding of having to make a choice. Using a dark wooden texture on a white background creates contrast and simple line sketches explain the two choices present. The surfaces are simple squares used to increase a sense of structure, something that been mentioned earlier to be important for some children with autism.

### *Affordance*

Looking at the first scene there is nothing that could really tell the user how the interface works, except for the cues that are given by the mapping and the constraints, i.e. the placement of the surfaces together with the text and graphic information given within them make up the affordance. One could also discuss about usage of applications in general since many users already expect to click or swipe surfaces and buttons. Therefore the principle of usage of this application might be perceived quite simple. However, keeping in mind that children with autism might have difficulties in relating knowledge and applying it on different areas, the argument of similarities with usage of other applications is a bit weak and should only be seen as a positive extra. The main importance of this interface is to create something that is easy to understand every time it is used. Of that reason, the relation and limitations of the surfaces are important.



### *Feedback*

When the surface with the choice is touched, both audial and visual feedback is given. The audial by a “click”-sound and the visual by both adding a green frame and blur to the surface of the active choice.



## 2. NAME



Figure 52. *Second scene of the application*

### *Mapping and constraints*

As in the previous scene, two main surfaces are used to type in the players' names. The dark wood reappear against the white background and creates the same effect as before. In the surfaces there are now fields for typing the name instead of pressing the whole box. When touching the field for writing a keyboard will appear. The idea is inspired by iOS and its functionality in an iPhone or iPad but is mainly used as a tool for visualization of the function, it is fully possible that the key pad as well as how it will appear could be reconsidered, especially if the application is to be used in an Android smart phone. Only one name might be written at a time, a function that will begin the practicing of turn taking already at this stage of the game.



### *Affordance*

The information by text in the surfaces together with the distinct name field should give the user quite clear cues of what to do in this scene, of course, thinking about the target group, there is a quite big risk that the child with autism cannot read or write but since the game should be played together with another person it is assumed that the other person can help. Alternatively, a parent or another outsider have to help out until the children learn how and what to do.

### *Feedback*

Audial and visual feedback is given when both touching the typing field and when typing. The typing field turns grey when it is touched and at the same time the click sound is given. When typing the letters appear on the field and the typical iOS typing-sound is playing.



### 3. PHOTO



Figure 53. Scene 3 of the application

#### *Mapping and Constraints*

In the scene for taking the photos the screen will start empty and one surface with a wooden frame and a symbol for taking photo will slide in from the side. This surface has the player 1 name on it so that it should be clear who is to be on the photo. The functionality should work and look like it normally does in the actual operative system of the tablet so that the chances for relating the right action are greater. When one photo is taken and chosen, the surface continue to slide to the left side of the screen and another surface appear for the other player to take a picture. The reason why the surfaces now are standing instead of laying is because of the format of the pictures, which makes it more natural to let the surfaces stand. They are sliding instead of being placed next to each other right away both because it should help clarify who is player 1 by letting that person begin, and to offer a feature that could catch attention if the start up phase is perceived as boring. Just like writing one name at a time will practice turn taking, so will taking the photo one at a time. The new feature of sliding the surface could potentially also practice flexibility for the child with autism, since it needs to learn that the interface will not act identically in all moments but in all times of usage.

#### *Affordance*

As said above, the symbol for taking photo should be alike the one that is used in the operative system of the actual tablet, in attempt to increase the chance of making the right decisions in the interface, taking that the persons playing eventually will learn what the symbol means.



### *Feedback*

The feedback is given audial when taking the photo, i.e. there will be a camera shutter sound. Visually the feedback will be made up by color changing of the camera button during touch as well as a light flash of the photo screen, and finally when the picture is placed. Furthermore, pictures of the persons placed on the standing surfaces can be seen as feedback that might help strengthening the understanding of the connection between the setting up phase and the actual game phase.





#### 4.CHOOSE GAME



Figure 54. *Fourth scene of the application*

##### *Mapping and Constraints*

When choosing a game one needs to touch one of the pieces of paper. In this scene it was chosen that more options than building a train were to be offered. This, because of the possibility to further develop the complete product with both application and physical toy by using different objects as foundation. In this project however, only the train option has been considered. The options are placed on the whole screen with distinct boundaries from each other. They are placed in a structured way and even if the hand made sketches on the papers are unstructured, the squared paper shape balances the impression of light and easy and structure to make it more interesting to look at.

##### *Affordance*

In a similar way as in the first scene, this scene's affordance is made up by experience and expecting that the elements are touchable, that something will happen with them.

##### *Feedback*

Also the feedback is similar to that of the first scene, i.e. when touching one of the pictures it will get a green frame and the picture itself will be blurred and the opacity will go down. At the same time the "click"-sound will be played.



## 5. LOADING

This scene is the page where the game is loading. When the game is chosen to build a train there will be a train sketched in lines that will “drive” in a circle until the game is fully loaded. Would the choice be the car or the building then the loading picture will relate to this, still sketched in the typical lines found throughout this application interface.



Figure 55. *Fifth scene of the application*

## 6. TURN TAKING GAME

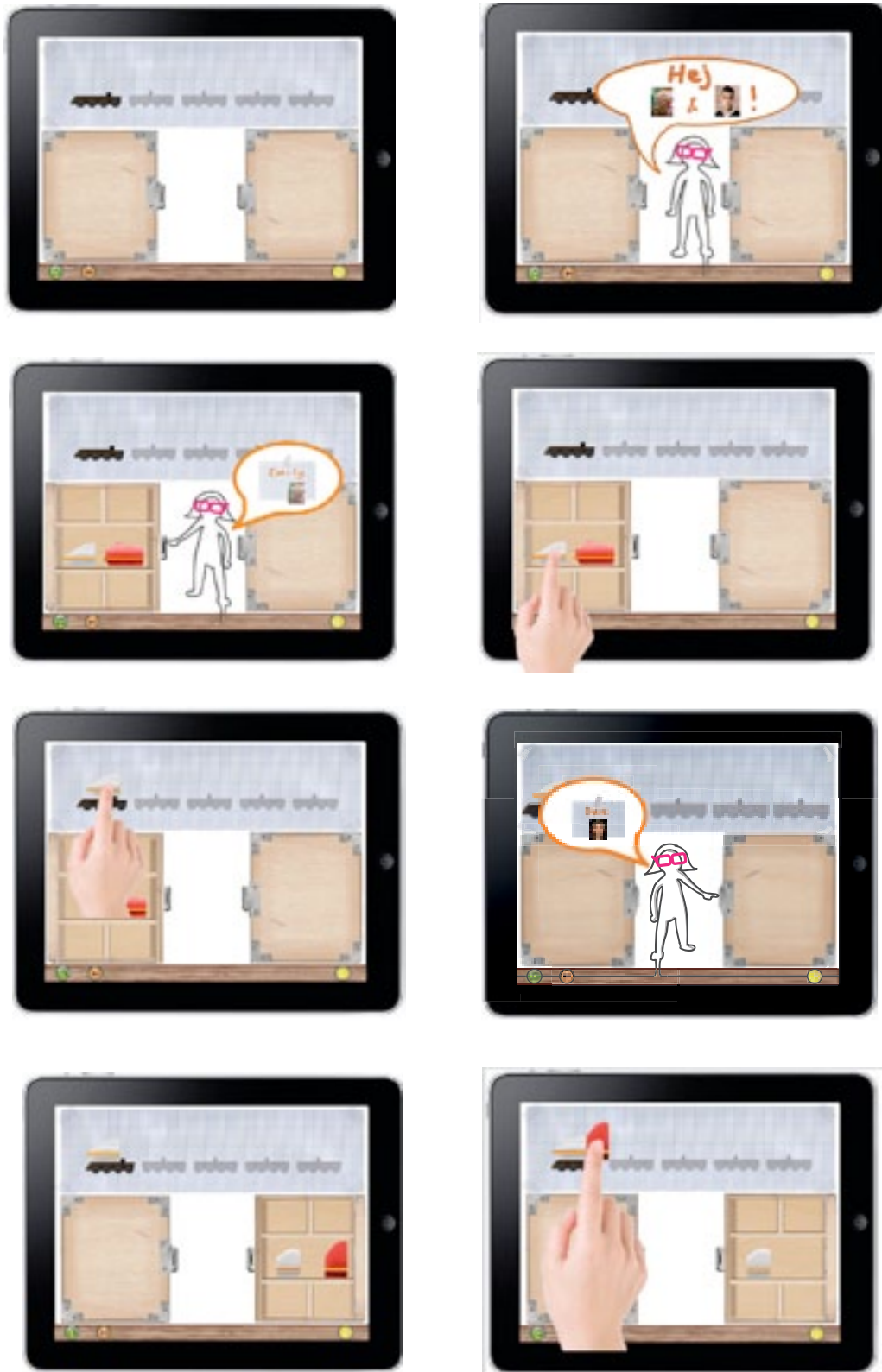


Figure 55. *Turn taking in choosing parts*



### *Mapping and Constraints*

When the turn taking part of the game starts, which also is the actual game; the players will be met by three main surfaces; one common surface to build on, and two surfaces for picking parts. In the top of the screen the building surface is placed. The squared paper makes up the surface and on it are the platforms placed in a row. When building the train the parts will be placed from the left to the right according to the western way of reading. Below the paper the players will find two wooden boxes, one for each player.

The function of the boxes is as mentioned, to restrict the amount of details on the screen at the same time, and to emphasize whose turn it is. It also emphasizes the feeling of having an own side of the screen. The color of the wood in the boxes is light in order to differentiate from the tool bar in the bottom of the screen. It also gives a soft contrast between the train parts and the box when it is open, and it relates to the theme of construction or maybe even carpentry. When the turn comes to a player, his/her toolbox will as implied, open to reveal the train parts. The player then touches a train part and drags it up to the actual platform. The part might be released a bit from the platform and will still snap into the right position of the platform, but if this is done in a great distance, the part will fall back into the toolbox. This function is chosen because there should be a possibility to change part if the wrong one is picked but, in order to prevent that some children with autism will concentrate on only changing parts, the possibility to change is only open until the part is snapped on the platform. When that is done, the turn will automatically go over to the next player so that the turn taking function, which is also the main area of practicing, will be ensured. The reason why the parts should be dragged into place is to strengthen the feeling of building something instead of only picking it, since this is what is to be done with the physical train. A train part that has been placed properly will start playing the rhythm accordingly before the other player's toolbox is opened.



Figure 56. *Toolbar*

The tool bar has three buttons, one for music, one for all sound and one for finishing the game early and move to the next scene. The “Music”-button manages only the music and the players can switch on or off. The “All sounds”-button is also for switching on/off all sounds, which include the music. Therefore, touching the “All sounds”-button will turn off all sounds, and to start only music the players need to switch it on by clicking the “Music-button”. The “Next-button” will directly take the players to the last scene, importing the existing train from the paper surface.



Figure 58. *Sound and music settings*

Between the two toolboxes there is an empty surface in which a “Little helper” will appear. The “Little helper” grows and contracts from a line in the tool bar. She will appear in the beginning of the game and will greet the players by saying hello to both by name and photo, then welcome them to the game. The “Little helper” will then throughout the game reappear to direct the players in whose turn it is.

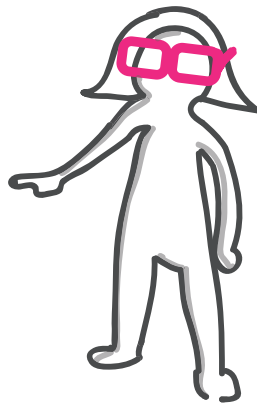


Figure 59. *The little helper*



### *Affordance*

In the beginning of the game, the first platform, i.e. the head platform has full opacity while the four coming ones have less opacity. When one platform is fulfilled, the next one will be lit up and get full opacity so that it is in a functional mode. This is to make sure that the train is gradually built up, to ensure the functionality of turn taking. The reason why all platforms are shown at one time is because children with autism often need support in knowing what happens next. In this way, a graphic scheme is provided where the child easily can see how many platforms that might be built on until the game is done. A distinct end of the game is therefore created.

The visual appearance of the “Little helper” was chosen because of its simplicity, which was needed in the interface in order to keep it structured and graspable. It also ties the different scenes together and gives the interface a coherent theme. Together with the speech balloon and the voice, hopefully the child with autism can learn to relate this figure to a person.

### *Feedback*

Toolboxes and train parts have both audial and visual feedback. When the toolbox is closed there is a “Closing-sound” when the lid of the toolbox is all down. When it opens the “Little helper” will say whose turn it is, and when the lid of the box is all open the player may pick a part. Touching a part will give a “Click-sound” and if the finger keeps pressing the screen while moving, the part will follow the finger. Placing the part on the platform will make the music play which then becomes the feedback for knowing that the part is placed. Feedback is instant since that is of great importance for many children with autism in order to understand the connection of the feedback and the action.

The “Little helper” also gives feedback both visually and audially to ensure the function regardless the sound/music-settings. Audially she will speak and direct by saying e.g. “Nu är det din tur Emily” (“Now it’s your turn Emily”). To strengthen the impression of taking turns, the words “Din tur” (“Your turn”) are consciously used in all sentences together with the visual feedback, which is given when the “Little helper” points and turns to the side of the toolbox in turn. The pointing and turning is visually supported by a speech balloon, in which the player’s name and photo is placed. This is thought to symbolize what she is saying if the sound is switched off.

The buttons in the toolbar will visually have two states. Either they will have colors or they will be grey. When touching an active button it will turn grey and when it comes to sound and music settings, it will also stay grey until it is touched again. i.e. when the button has color the function is enabled. When it is grey, the function is disabled. There will be a “click-sound” when touching the buttons as



long as the button for “All sounds” is enabled. The functionality of the “Music” and “All sounds” is supported visually with a square that will appear on practically the whole screen of the tablet, showing with both text and the symbol (relating to the state the function is set) what setting is to be chosen.





## 7. DRIVE THE TRAIN

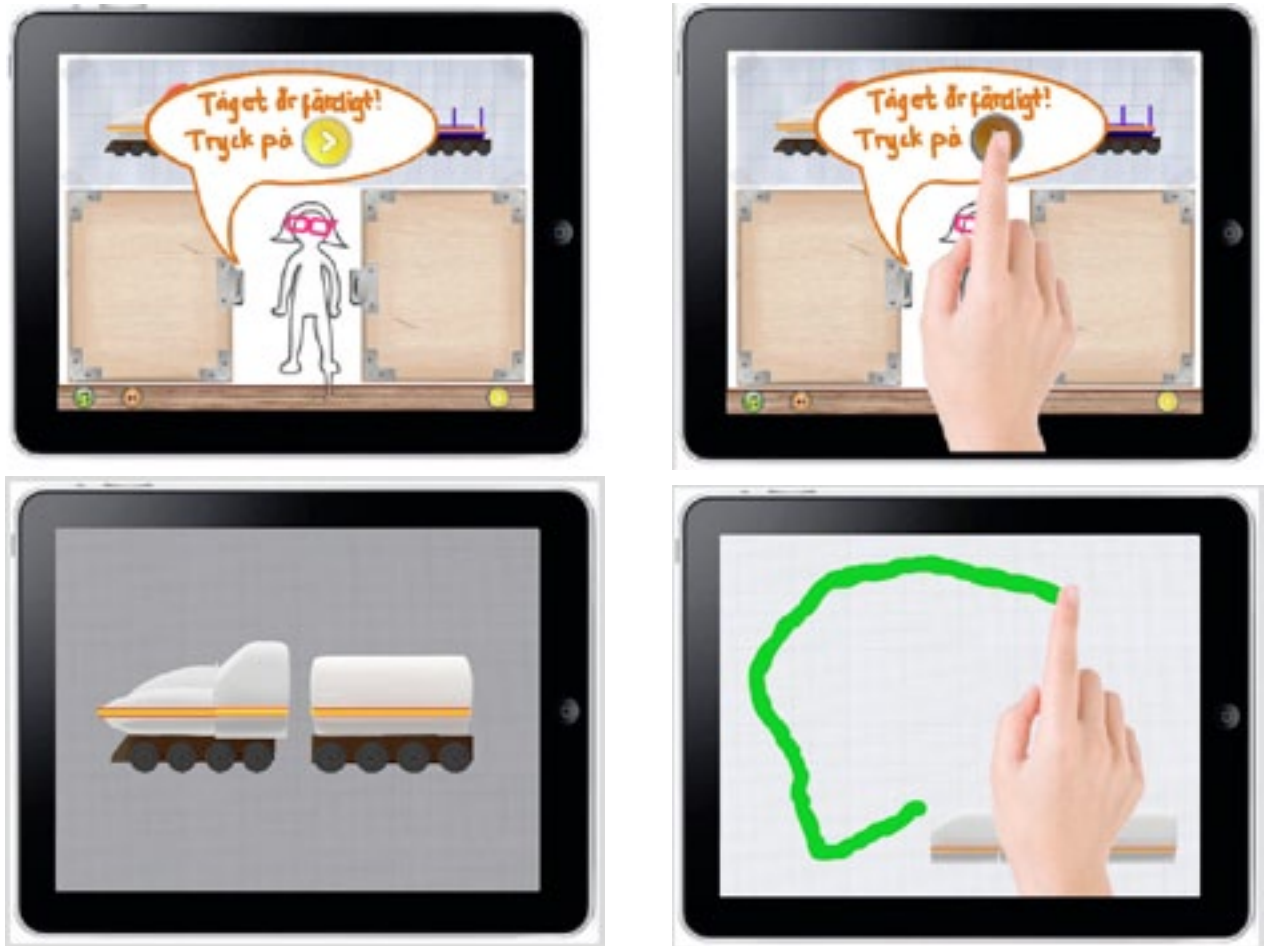


Figure 60. *Finishing game and dawning path for train*

### *Mapping and Constraints*

In the last scene the complete train will appear on the whole tablet screen. After few moments the train will decrease in size. One of the players can now draw a path with the finger in which the train is meant to drive. When the finger is lifted the line is perceived as done and the train will start following it. When the train starts moving, the rhythms of all train parts present will be put together and music will be played. The path might be drawn as many times as wished and when the players feel done with it, they can touch the train and then it will be fit on the full screen again.

### *Affordance*

The same train as was built in the turn taking game is used in the last scene, therefore the usage in the last scene should become relatively clear.





### *Feedback*

When the train appears on the full screen the first time, the feedback will be given as when taking a picture, the sound of the camera shutter will play and the train will be lit up for a moment as if there was a flash. The train then decreases in size and the path might be drawn. When drawing the line the audial feedback is given by the sound of drawing with a pen and the line will be visually marked with green until it is finished, then it will disappear and the train starts moving and playing the music. Lights on the train will also be lit up.

### **5.2.4 Interface analysis**

Using an HTA as base, a Cognitive Walkthrough together with a Predictive Human Error Analysis was done to evaluate the usability of the interface and the actions possible to make within it (Appendix 9 and 10). The analysis covered the actions of turning off /on music and sound, finishing the game early, placing top parts on the platforms and drawing the path in which the train will drive.

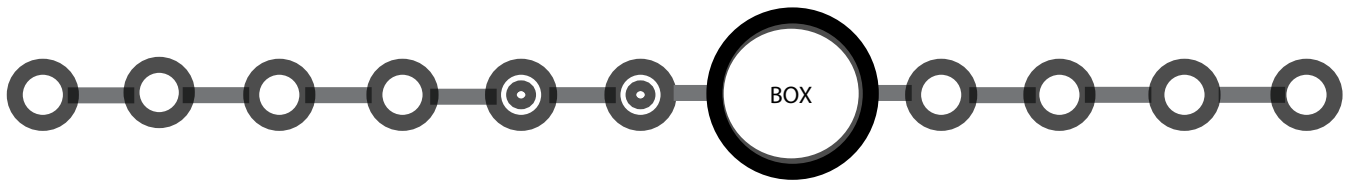
The analysis showed that there were some potential errors and wrong makings present within the interface.

Firstly, there are two buttons for managing sound and music. The reason why there is one for each is because of the need of being able to shut off either all of the sound, background sounds, or just the music. This because there might be sounds that will be perceived negatively for some children with autism, but this does not necessarily regard all of the sounds. For example, the child with autism might not like the button-click sounds but could just as well enjoy the music or the other way around. The symbol on the “All sounds”-button is a speaker, a symbol that is commonly related to volume and other sound settings. The symbol for music is a note, which is also commonly related to music. Both could be used for sound settings, which is why this could cause a potential user error in the interface. The effects of choosing the wrong button will only result in the wrong sound settings, which will be easy and fast to correct since the user only need to click the other button to get it right. The use of the functionality when having these two buttons is important, therefore the buttons are kept as they are.

Another error that was found regards the function of finishing a game early. There is a button for this on the tool bar, the yellow arrow. After pressing this, there is no possibility to regret the choice and the game will proceed to the last scene where a path for the train might be drawn. Of course, this would be to take away the control from the user, which also could cause irritation. In other words, an error that needs to be adjusted in a future and further development of the application.



It was also found that most of the potential errors could emanate from not understanding what to do next in the game. Therefore it was decided that in a finished version of the application there would be an introduction to the game available, meant to be used as help for understanding it. Another possibility would be to add an “Help”-button on the toolbar in the game scene, or in other ways make options for help visible when needed.



## 5.3 CONSOLIDATION OF PHYSICAL TOY AND APPLICATION - BOX

### 5.3.1 Construction and aesthetical design

Having both the physical train as well as the application fairly developed, it was realized that something more was needed to tie them together. A decision was taken to create a box in which the physical toy should be delivered. The box should have the same layout as the application so that the physical game would be as similar to the application as possible. The functionality of buttons and other surfaces as well as the “Little helper” would have to be taken away, and the actual turn taking function would be hard to force on the players and therefore, it was thought that the similarities in the box and the application might help inspire the players to act in the same way.

The size of the train parts together were measured and placed in the most logical way. Thereafter the functionality of the box was decided. Since it should be as similar the application as possible it became natural to use two “toolboxes” that could be opened and where the train parts would lay. The platforms should also be placed in a row in the top of the play surface. To increase the area for playing, the upper straight side was elongated enough to form a sort of a folding table with the platforms pre mounted on top.

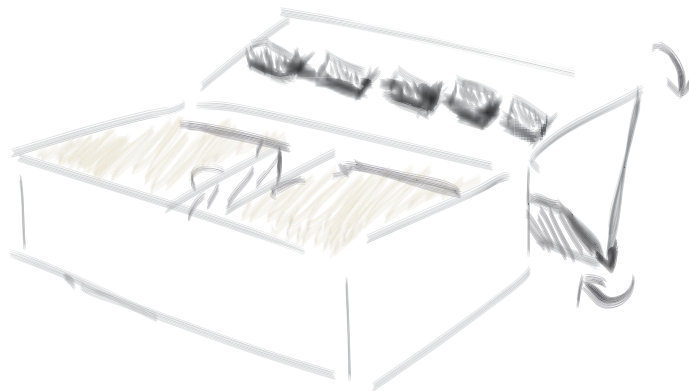
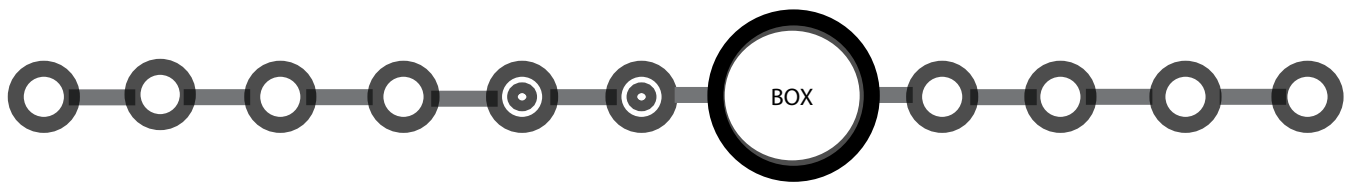


Figure 61. *Quick sketch of box*

The box should be made in a cardboard that is strong enough to be used in play but still be easy to recycle. At this stage it did not seem relevant to calculate the perfect dimensions of the box, instead it was built with measures that would be suitable for presenting the concept.



### 5.3.2 Result Box



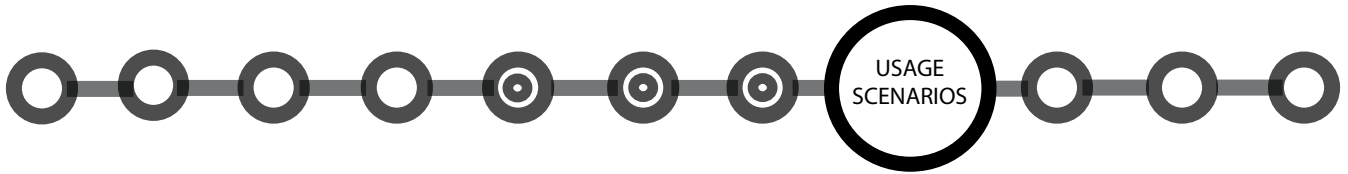
Figure 61. *Complete box*



Figure 62. *Box, front*



Figure 63. *Folding to support game area*



## 6. Usage scenarios

As the results of the three parts of the total concept have been thoroughly explained in previous chapter, this section will focus on the total result and in what way it might be used. To summarize the functionalities and possible actions in the total product some usage scenarios will be presented. If a more detailed description of both the application and the physical train is wished for, please look at chapter Development, sections 5.1 and 5.2.

## 6.1 SCENARIO 1 – TURN TAKING AND FLEXIBILITY



Emily is a girl with autism and she is going to play with her dad Dan. They are sitting next to each other at the kitchen table with a tablet between them.

Figure 62. *Emily and Dan, tablet*

Dan starts the application and they start to play. Taking turns seems to work fine for Emily but she does not like the voice of the little helper, therefore Dan turns off all feedback sounds but keeps the sound of music. He does so because he knows Emily likes music, there are just some sounds she cannot accept.



Figure 63. *Sound settings*



The game suits Emily better now and they continue until the whole train is finished and the result is shown. Emily or Dan can now draw a path for the train to move, but Emily is not interested, she is now focused on dropping a fork to hear what sound it gives. Instead, Dan picks up the box with the physical train parts.

Figure 64. *Emily and Dan, box*

When the box is opened, Emily's attention is captured again. She seems to recognize the black frame on the box and also she finds the two toolboxes. Dan opens the toolbox on her side of the box and asks her by signs if she wants to build the train again. She does not answer him but does not seem to mind either; therefore Dan places the tablet with the picture of the train next to the box. Emily now grabs the right nose part and places it on the first platform and instantly a rhythm is played.



Figure 65. *Usage of tablet and physical toy*



Emily is now waiting and Dan realizes that she is waiting for him to place the next part. The train is then built identically as the picture made in the application and the same music will play in the end. Emily can now drive the train by hand if she wants to.

Figure 66. *Emily and Dan, finished train*

## 6.2 SCENARIO 2 – CREATIVITY, MIMICING AND MEMORY

Emil is a boy with autism. He and his dad Dan are going to play the train game. Dan picks up the tablet and starts the application. Emil knows how to write his name so he starts by typing it. Dan then types his name and photos of both are taken. The game starts and Emil waits. Dan tells Emil to pick one of the parts and drag it up to the platforms, and so he does. The turn goes over to Dan but Emil gets frustrated, he wants to pick the next part. Dan tries to explain that it will be Emil's turn next which calms him down a bit, but now Emil seems to have lost his interest. Dan picks a part and the music will start playing when Emil suddenly focuses on the game again. It is now his turn but he doesn't want to choose a part, he is more interested in the sounds. Dan helps him to choose a part and then he finishes the game early.



Figure 67. *Dan finishes train game early by pressing the yellow arrow*



When the last scene is shown Emil drags his finger in front of the train and a line appears. When he lifting his finger the trains starts to move and sound.

Figure 68. *Emil discover the draw a path functionality in the application*



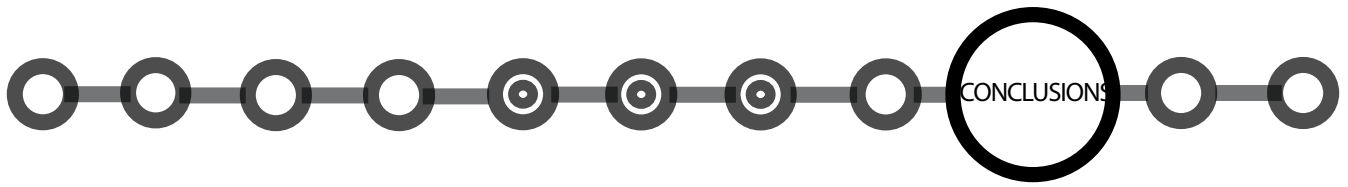
Emil is now excited and Dan figures that the physical train might be interesting to Emil. He picks it up and Emil immediately starts attaching parts to the platforms and many different sounds start playing. With high intensity, Emil is now exploring the many possible combinations of music by changing the position of parts while Dan sits next to him commending his work. Emil seems to find a special combination that he likes and Dan now asks him if he wants to play the application again. He does, and this time he is building the favorite combination. He still didn't understand why Dan should help, but with time he started to let him have a few turns.

### 6.3 SCENARIO 3 –INTERPLAY AND FLEXIBILITY

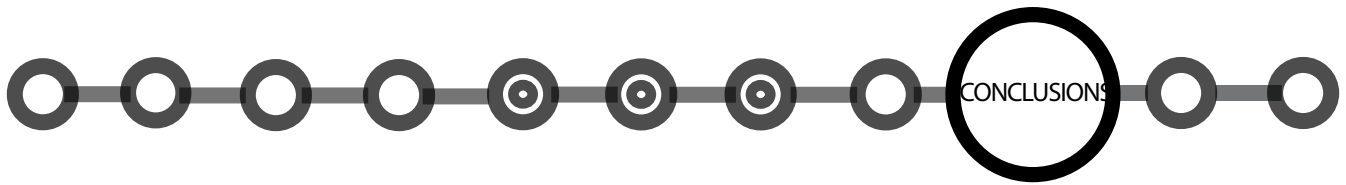


This family does not own a tablet, but they got the physical train as a gift for their boy with autism. The boy has a special interest in trains and likes playing with the sounds and lights turned off. He usually plays with his older sister who talks to him and asks him to show her new combinations of train parts. The boy does not always respond to his sister but at times he builds something new without her asking him to, and some of these times, he starts to drop the train to the floor, making a sound. The family is not sure yet, but they believe that this is his way of trying to make contact to show what he has built.

Figure 69. *Brother and sister playing with the physical toy*



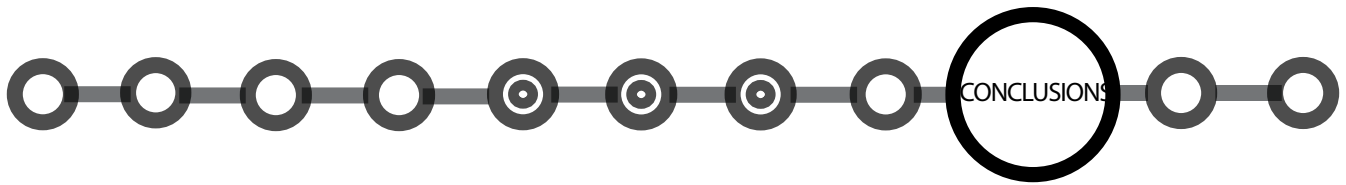
## 7. Conclusions



The final concept is based on dependency of two players taking turns. The application and the physical toy together, offers a broad target group of children with autism, fun learning of communication skills, one of the main aims of this project. The tablet's popularity and the classic feature of the physical train make it easy for the child to blend in with others. At the same time it provides a chance to interact with neurologically typical persons in different environments. The benefit with being able to play in different environments is that the child with autism may play where he or she feels safe and enjoys being. Assuming that learning is situated, i.e. that both environment and what is to be learned, affects the learning itself, it is reasonable to believe that the game has ability to motivate some children with autism, and that they possibly might adopt more knowledge and deeper understanding of how and why we need to communicate. By concentrating the theme of the total game to common special interests such as trains, music and applications, the hope is to also increase the motivation of letting other persons participate. Although this concept is developed for children with autism, there is nothing that restricts other persons, with or without any neurological disability, to have fun with it as well. With this in mind, the concept should enable more chances to practicing communication skills if more persons are interested in playing, given that the child with autism allows for it.

Integration of interaction design, sustainability, and cognitive processes in both the toy and the application, has directed the development to suite the special needs of the target group. The goal to offer an aid that helps practicing communication skills, creativity and flexibility is met through the combination of the two types of games. In the application and the toy the persons can practice creativity with help of the many combinations of parts and rhythms that may be done. Both the physical toy and the application will be based on a structured environment that is predictable. Choosing different train parts and using the physical toy/application in reversed order may practice flexibility, still keeping the predictable feedback throughout the game. The usage of both application and toy will therefore deliberately expose the child to new usage situations within the frames of a safe game.

In the usage of the physical toy, it will be impossible to make an error because of the possibilities to connect the train parts. The only errors that might occur are if the toy itself breaks or of some other reason won't behave as programmed. Errors like placing a top part in the wrong order of the platforms are not seen important since it is easy to change the order and the decisions lies in the users hands. Also in the application, the risks of making errors are minimized by allowing the players' to control the situation such as sound settings and ability to finish a game early. The controls are reversible, i.e. the settings are easily changed back if an error occurs. There is however one error that has not been adjusted in the application, and that is the functionality of the "Next"-button which is not reversible at this point, something that is left for future development.



The users will be in control of every choice that is made but control is also taken away from them since the turn taking functionality is more important than the control in that situation. This means of course that some children might have difficulties with the game but that is also the reason why it should be played. If the turn taking part of the application does not suite the child, there is also the possibility of trying to practice it with the physical train.

Both the application and the physical toy will be structured in the same way. The aesthetical design has taken contrast, visual limitations and functionality under consideration and furthermore, a limited area is provided where attention of the child might be more easily focused. As been discussed throughout the development of aesthetical design and music functionality, the child is provided with details to focus on. There is both the ability to notice details in music if one part for example is taken away. There is the line on the train parts that will connect all of them and there are lights for those who appreciate that. In addition, the train wheels and different parts themselves are details that are potentially interesting to a child with autism.

As construction, final material and manufacturing technique is not decided a relevant cost estimation cannot be done, but, looking at other toys with the approximately same functionality, the pricing lay between 200-700 SEK. It therefore seems reasonable that this toy will be positioned somewhere in the upper limit or above, if the toy is to be sold in normal stores. Will it on the other hand be provided through aid centrals, the pricing might change since the production probably would be lower because of the limited reach to costumers. Providing the toy through these centrals would however possibly make it more available to the target group since they might get the game paid by the county council.

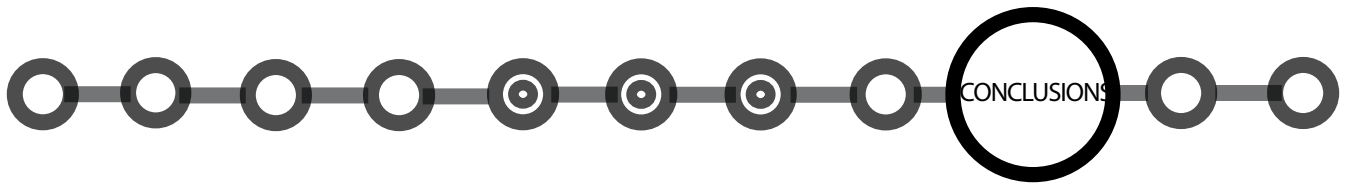
To finally conclude whether the goal stated in the chapter Introduction, section 1.3, are fulfilled, the proposed research questions are here answered:

*- How to motivate as many children as possible within the target group, to learn by playing?*

By integrating many different areas of interest such as, usage of different sensory stimuli, usage of trains as being a special interest, enabling construction and building structures, usage of computers/applications and music, the hope is that more children with autism will find something to show interest for within the koncept.

*- How to make use of the individuals strong abilities?*

Thinking about for example an enhaced sense of details, there are many details provided on the concept for the children to discover. There is the line placed on the side, the lights and not to forget, combinations of colors and music that may be reconstruted and therefore enable memory/detail-games.



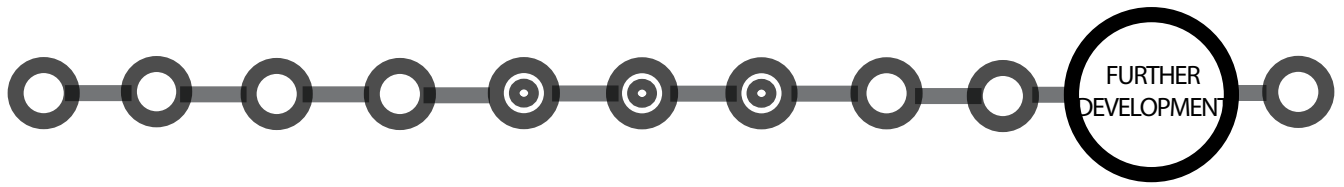
*- How to use sensory stimuli in a way that rewards a broad group of children with autism?*

Sound is used both as feedback for actions made in the applications and as functionality for the music. The sound is possible to switch off still keeping the music, or the other way around, giving the possibility to adjust stimuli in a way that is appropriate for the child with autism. Light is used as a substitute if the person with autism does not like the sounds at all but who enjoys light. Also the light is possible to switch off if needed. In this way, sensory stimuli is used in a way that might suit and reward many children with autism and different abilities in perception.

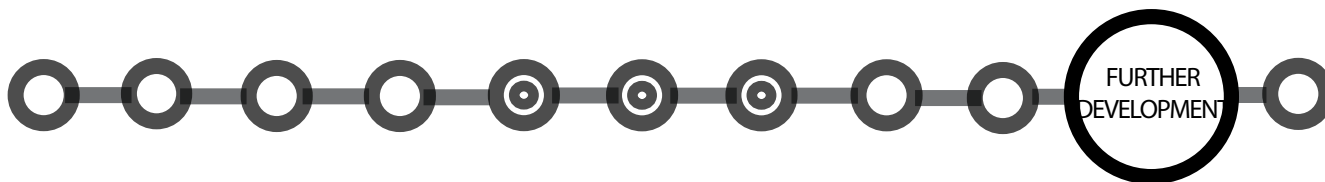
*- How to create a concept where flexibility might be practiced without losing important predictability?*

By having a consistency in combinations vs. feedback throughout the whole concept, flexibility might be practiced in many ways, either by using the many combinations of parts and rhythms, by playing the application first and using the physical toy after, or, the other way around, using the physical toy in order to motivate the child to use the application. Furthermore, the application and the physical toy might be used separately and really, what type of flexibility and how it is to be practiced also depends on the creativity of the parent or neurologically typical person playing with the child, since the concept may be integrated in many different learning situations.

Based on these arguments the initial expectations, stated in the goal and aim for this project, seem to be fulfilled.



## 8. Further development



Since both the application and the physical toy are at a conceptual state, further development is needed before they are ready to be tested by the users. Common areas to develop upon are the music functionality, lights and details, more options in objects to build and programming functionalities.

The music that was chosen in this thesis was a simple principle of composing music. What kind of rhythms and music that is most beneficial to use, thinking about interests and type of sounds, could be investigated far more extensively, or maybe, should there in the future be possible to switch memory card and in that way change the type of music in the train?

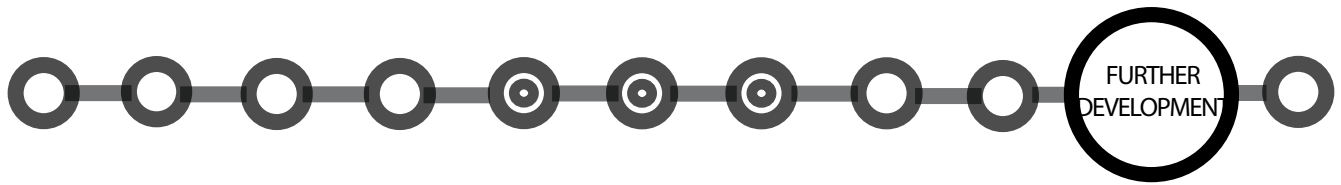
Another idea, of using different surface textures on the physical toy to strengthen the perception for children with an increased haptic sense, would be interesting to investigate as well.

The lights, contrast and the details might in the same way as the music be investigated in what will suit the target group the best, that will say, if it is possible to find something more or less general. Really, finding something that would be general for this target group should be very interesting and useful in development of other products.

The idea is to offer the players more options in the game, so future development should be done on more objects such as ambulances, buildings etc., using the same principle as the current train game.

In order to test the usability, acceptance and positive effects of both application and physical toy, programming of both need to be done. This programming will be quite extensive for the physical train because of the functionality in it, and depending on the final programming certain components will be needed in the train. The current prototype is connected to a computer, which means that components such as speaker, battery and holders, memory cards and possibly more components are not needed. In a future prototype however, these components have to be built in to make it possible to test. With more components comes less room in the platforms where it is placed, which then means that construction needs to be reconsidered in some aspects.

Also the connections between parts and platforms need to be developed. The wish is to create connections with physical constraints and distinct affordances so that it is obvious how the parts/platforms can and should be attached while fulfilling the safety requirements of toys with electronics. Regarding the CE approval that is needed to sell the toy on the European market, the development need to be done with aim to fulfill the requirements, for example, durability and strength of the toy needs to be calculated.



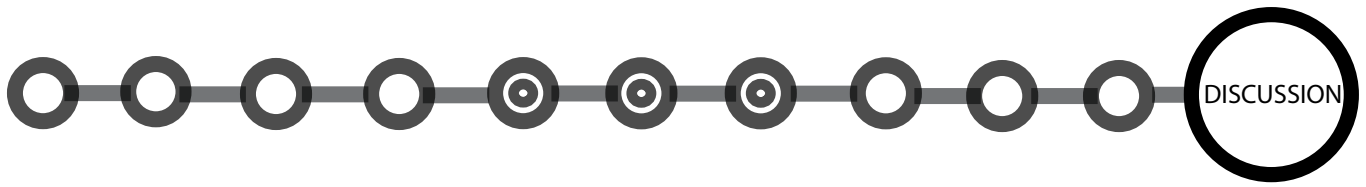
As mentioned in the chapter of development for the physical toy, the choice of material could be made more thoroughly; therefore, future development should consider an extensive search for materials that are easy to recycle and still makes less impact on the environment.

Before programming the application so that it is possible to test with the children, some extra functions should be considered. In the current application interface, the train parts are in 2D, which possibly could make it hard for the child to understand that it is the same parts as in the physical toy. One idea is to add a 3D feature to the application when the technique is more developed. That would enable the players to see the whole geometry of the parts but this feature alone should be tested within the target group first. The reason is that the children might still not understand that it is the same part that is rotated of the focus is set on other things, therefore, 3D could just as possible be confusing. The option of playing online should also be developed and an online chat should be considered for that game mode.

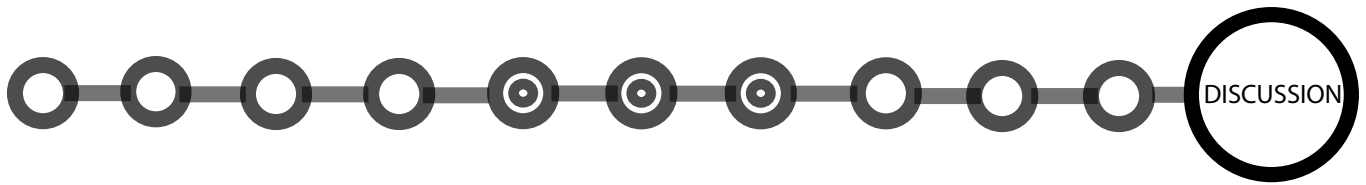
Testing is what probably will give the most information in what to change or further develop since everything else is based on theory and experiences of others. One area that could be investigated is the one of interface design and guidelines connected to this. The theory is applicable on neurologically typical persons, but it would be useful to have the same theory but with focus on children with autism since there is a rapid development of applications and computer software for that group of persons.

Last but not least, the box should be developed when it comes to, material, construction, graphics and size. Sizing the box should be done considering the pallet area in order to minimize the carbon footprint from transportation.





## 9. Discussion



### *Market analysis*

When looking at the market for applications it becomes apparent that it is impossible to know exactly what applications exist or not. The analysis was made quite extensive in just looking for different applications available, even in the USA market. It is therefore possible that something similar to the application in this thesis does exist but it has not been found yet.

Interactive toys like the physical train might also be available for children with autism within the aid centers but this is nothing that I have had access to nor heard of, therefore the market analysis should be found reliable.

### *Idea generation*

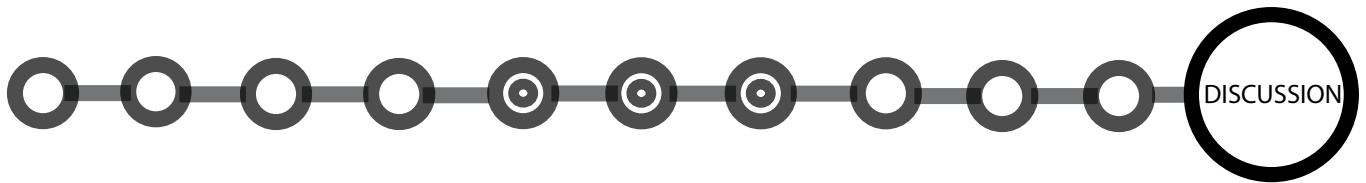
As in any product development, the ability to come up with great ideas depends on what creativity is available. More time and maybe use of other methods could have generated more and different ideas. Also, with more financial support, the whole development including methods might be performed in a more creative manner. However, the methods seemed appropriate at the time of their execution, therefore, if doing the project again, methods would be kept but maybe applied in different order. Taking the focus group brainstorm as an example where creativity was lacking, a more direct question formulation might have helped bringing more ideas, but then it would have to be performed at a later stage when there actually was any direct question to ask.

### *Information gathering*

The literature that was used was chosen because of it being well known and approved by many but of course there will always be different opinions present and choosing other articles, books and meeting other people might have affected the final criteria listing based on the analysis. Different references were chosen in order to prevent that one truth would be perceived as the only truth. The aim was to keep objective and not prefer any opinion to another since my knowledge of the area was/is somewhat limited.

A distance to parents and professionals was deliberately taken in the second half of the project. The simple reason to this was that the information flow and different wishes from all of them was too much and misdirected the project. Instead the material that was gathered up until now was used for argumentation of design decisions.

A new method for me was to use Facebook as a channel to get in contact with parent and others with knowledge about autism. I was accepted to join three Facebook groups that were mainly used as forums where people could discuss



anything but mostly regarding autism, and there was also a group focused on application for persons with autism.

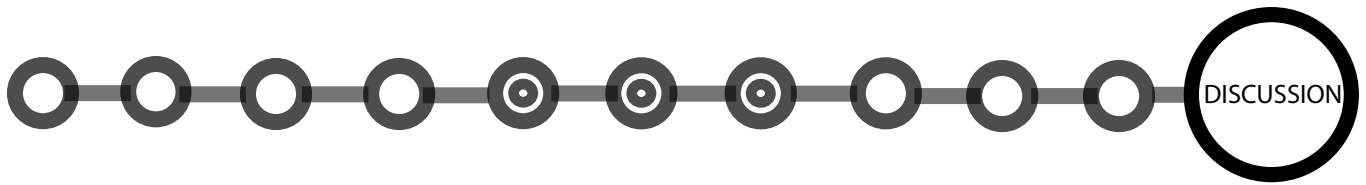
Usage of Facebook might initially sound doubtful, but in this case it proved to be the outmost efficient way of gathering information about specific questions and children with autism. One reason could be that product development for this target group is not generally prioritized in society and therefore many seemed grateful that someone even posted a question or showed interest in it. The rate of answers was high, much higher than expected since it earlier during the analysis phase had been hard to get in contact with many parents for making interviews in person. A possible explanation to the high rate of answers is therefore maybe because most parents don't have time to meet since they have an extra load on everyday life, but answering a question while being on the internet anyway takes little time and still leaves an impression on something that might help their child/children.

Not to neglect the personal interviewing. Interviewing has been one of the most important methods for gaining information in this thesis. Knowledge and experiences could, and have, of course been gathered by literature but the really useful experience and knowledge is found with parents and professionals working with autism. These are the persons who are interacting with the diagnosis on a daily basis; therefore they should also be the persons who naturally can relate to it. This thesis has been in high need of such competence since initially this has been a quite new situation in the area of product development as I know it. As well, the target group has not been available for communicative interchange because of some particular abilities, and has not been asked to participate in earlier phases of the process where the evaluation situation could cause confusion or anxiety.

At all study visits the interviewed persons have been very helpful and they all offered further contact and help whenever the project would need it. Therefore these four organizations have been fundamental help to the project and critical in establishing new and relevant contacts. They have been supportive and contributing throughout the whole process and in many different aspects. This has been crucial for the project since the result is dependent of how the target group will receive the product and the only way to find valuable information this time, has been through parents and professionals.

#### *Selection of final concept*

Since there was no company with any special points of interest, the final choice of concept was done based on how the concepts fulfilled the meaning of five keywords. The keywords were based on the criteria list and tried to capture the most important properties of a final product. Would other keywords have affected the choice? Probably if they would be contradictive to the criteria list, but they



weren't, therefore I believe that the choice was based on the needs of the children with autism, not on what their parents believe is best for them.

#### *Development*

The beginning of the development was a bit unstructured because much iteration was needed between functionality of turn taking and what object to build would be most proper for the target group. After deciding this the development got more structured and was divided into three parts, the physical toy, the application and the box. The physical toy was first to be developed of fair reasons and the final result would probably be different if I would have started with the application instead. At least this regards the aesthetical design of the train parts. However starting with the application would have caused a bigger need of iterations in the work, why it hindsight is realized that the actual choice of process also was the most time efficient.

#### *Ergonomy and safety*

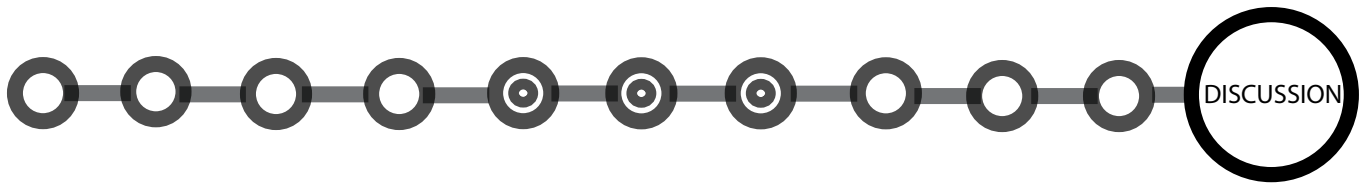
The ergonomy study and safety analysis was quite short because it seemed like a more extensive analysis would be better placed in a later phase of further development processes if the toy at some time is going to be realized and produced.

#### *Construction*

The same reason as for ergonomy and safety applies to construction of the prototype. Since it at this stage only demonstrates little functionality, there should not be too much of interest to replicate it. Because of the thought functionality which would require more components than what is needed in the present prototype, it was not possible to know what a future construction would look like, therefore it was kept very simple.

#### *Interface analysis*

During the interface analysis it was described that an extra button for help could be placed on the toolbar, this could add another detail for the child with autism to focus on, a detail that might draw attention from the game itself if the child would like to investigate all buttons instead of playing. The sound and music buttons as well as the "Next" button would of course also possibly draw attention in the same way but these functionalities are important to have close to the user during the game since preferences might change. The game and its interface have a very simple principle, and the way of managing the application should not be forgot after using it once. It was therefore evaluated that the introduction to the game would be enough help. However, since it is implied that persons with autism might have difficulties in recognizing semantics or maybe better described, some might focus on details instead of the whole picture, symbols potentially might not



be perceived as logical as for a neurologically typical person. Therefore symbols throughout the whole interface might be discussed and should also be evaluated in a usability test.

It should also be noted that the analysis was done with considerations to the target group, which could react to the possible errors with great frustration just as well as they might not receive any of the usage as errors, something that will have to be investigated through usability testing.

Finally, there is much information to find about autism yet still so much missing. When developing a product for this target group the challenge has really been in arguing for something that theoretically should be good for a user that just as well might perceive things in an opposite way. Because of this, it is impossible to tell whether this game will good or bad or even accepted by the children. Only testing and redesigning will tell how it works, but since it is based on experiences and theory, the game should at least theoretically be good for some in the target group. Discussion has been present throughout the report in an attempt to remind the reader about the special target group and the problematic coming with it, this in order to understand why I have taken certain decisions.

To finish the thesis I would just like to say that it has been hard, stressful, at times even annoying but also very interesting, fun and almost exhaustingly motivating to do this. I am happy that this will be my last and best memory from school.



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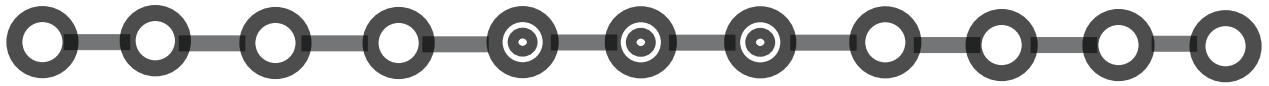
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# Appendices

- 1. COMPILATION OF INTERVIEWS**
- 2. EVALUATION OF EARLY CONCEPTS**
- 3. MIND MAP IDEA GENERATION**
- 4. FACEBOOK SURVEY**
- 5. COLOR DEVELOPMENT**
- 6. ERGONOMY**
- 7. CE REGULATIONS**
- 8. QUICK SKETCHES OF FLOW FOR APPLICATION**
- 9. HTA**
- 10. CW/PHEA**



## 1. COMPILATION OF INTERVIEWS

### QUESTIONS FOR FOCUS GROUP

*What is important to think about regarding autism?*

*Products, games, exercises?*

*How is it to live with autism? Everyday chores, routines, difficulties, positive?*

*What aids are used? What aids exist?*

*What is popular of the aids?*

*What is wished for? what does not exist?*

*Is quality or easy to access most important?*

*Computers or interaction with persons?*

Answers:

Children with autism need focus on limited area.

Individuals have different strengths/difficulties.

They need regularity, it needs to be predictable.

Changes might be hard for children with autism, flexibility need to be practiced gradually, not too much input at the same time.

Important that is not “dangerous to do wrong”.

Hard to express themselves verbally and non-verbally.

Motivation is individual.

One should work in the pace of the child, still push limits.

### INTERVIEWS WITH PARENTS

*Author: What does your child like?*

Parents: Applications, dancing, hater demanding situations, look at [www.auigeaac.com](http://www.auigeaac.com), Dance party zoo (balance), Fizz brain (eye contact), [autismspeaks.org](http://autismspeaks.org), singing, glitter, ambulances, polices, trains, computers, listening to sounds of objects,

*Author: How is it to live with autism in the family?*

Parents: Routines routines routines, schedules with pictures, adapting to the child, respect and considerations to the child at all times, effort in exercising,

### INTERVIEWS WITH PROFESSIONALS

#### MUSIC

Music is often used to practice gross motor skills, sense of time and creativity.



There are different instruments used, continue a song, hitting on the strings of a guitar just to hear the sound, drums and rhythms, games etc.

#### SENSES

Music is often used, experience rooms with soft materials, hard material, fire, water and air themes, discovering sounds and textures

#### PRODUCTS

Needs instant feedback, imitation is common to practice, let person work in own pace, predictability, music is common for all levels of disabilities,

#### EVALUATION OF FIVE KONCEPTS

Applications are good, easy to bring, easy to let child play on his/her own, Car is interesting, puzzle and continue a song as well, 3D puzzle is interesting but how to realize? More unusual than applications, abstract things are more easily interpreted for some than others,

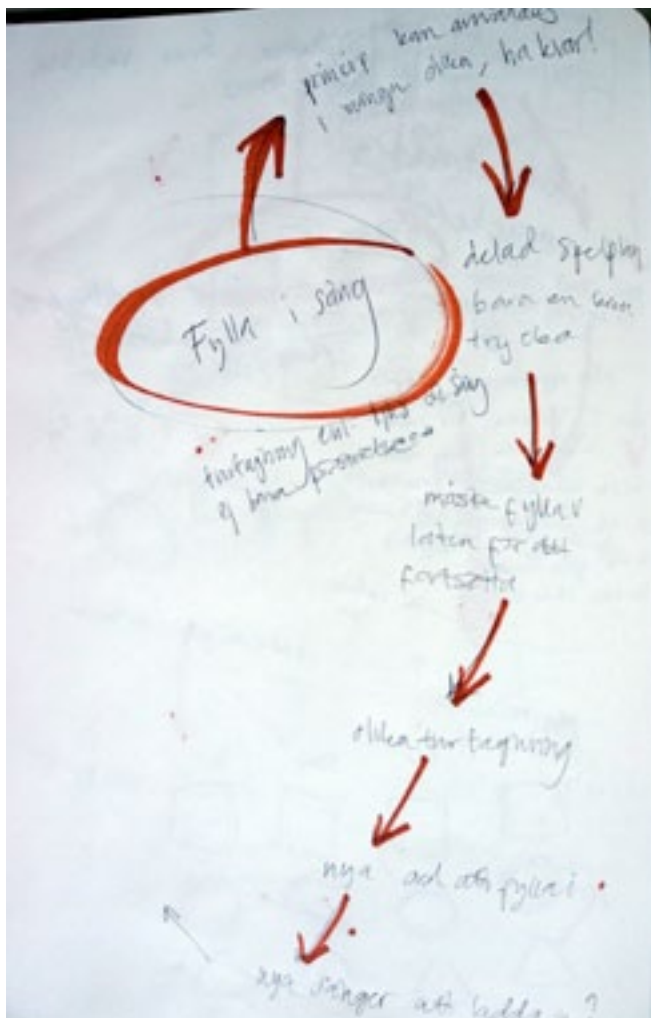


## 2. EVALUATION OF EARLY CONCEPTS

	Tram rally	Food shopping	Finish song	Hide things, memory test	Music puzzle	Build car	mutual song	så ska det låta	car track	3D Puzzle	bathroom rock	happening machine	treasure hunt	letter box
Encourage interplaying and having fun with others	Y	Y	Y	S	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Provide understanding of users mutual dependency of each other	DP	DP	Y	S	Y	S	Y	Y	Y	Y	S	Y	Y	S
Provide support for practicing turn taking	Y	Y	Y	S	Y	Y	Y	S	Y	Y	Y	Y	Y	Y
Provide possibility to practice flexibility	DP	DP	Y	Y	Y	S	Y	S	DP	Y	S	DP	S	Y
Provide predictability of the usage situation	S	S	Y	Y	Y	S	S	Y	S	Y	S	Y	Y	S
Provide the user with clearness of the usage situation	S	S	Y	Y	Y	S	S	Y	S	Y	S	Y	Y	S
Offer safe error making	Y	Y	Y	S	Y	Y	Y	Y	Y	Y	S	S	Y	Y
Offer the user a sense of control	Y	S	S	S	Y	Y	Y	S	Y	Y	S	S	S	Y
Offer a structured usage situation	N	N	Y	S	Y	Y	Y	Y	S	Y	S	S	Y	Y
Offer the user an ability to create structure	N	N	N	S	Y	S	N	N	S	Y	S	S	N	Y
Offer possibility for the user to use memory	N	DP	Y	Y	Y	DP	S	Y	S	Y	Y	S	DP	Y
Support the users ability to note details	N	DP	S	Y	S	DP	N	Y	S	S	Y	DP	S	Y
Offer the user an ability to practice gross motor skills	DP	DP	S	DP	Y	DP	S	DP	DP	Y	DP	S	Y	Y
Encourage the user to reflect over the result	DP	DP	S	S	S	S	S	DP	S	S	DP	S	S	S
Offer the user ability to play in own pace	S	S	S	Y	Y	Y	Y	Y	Y	Y	Y	S	Y	Y
Offer the user a fair area of focus, not too big	N	S	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y
Offer sensory stimuli	Y	Y	Y	Y	Y	DP	Y	Y	Y	Y	Y	Y	Y	Y
Offer personal settings (switch on/off light/sound)	Y	Y	S	Y	Y	Y	S	S	Y	Y	DP	Y	Y	Y
Offer an easy set up	DP	DP	DP	Y	Y	Y	Y	DP	Y	Y	DP	DP	Y	Y
Y- yes	6 Y	5 Y	11 Y	9 Y	17 Y	10 Y	12 Y	11 Y	10 Y	17 Y	9 Y	8 Y	13 Y	16 Y
N- no	5 N	2 N	1 N	0 N	0 N	0 N	2 N	1 N	0 N	0 N	0 N	0 N	1 N	0 N
S- somewhat	3 S	5 S	6 S	9 S	2 S	5 S	5 S	4 S	7 S	2 S	6 S	8 S	4 S	3 S
DP- development potential	5 DP	7 DP	1 DP	1 DP	0 DP	4 DP	0 DP	3 DP	2 DP	0 DP	4 DP	3 DP	1 DP	0 DP



### 3. MIND MAP IDEA GENERATION







#### 4. FACEBOOK SURVEY

*Hejsan! Jag gör ett examensarbete där jag utvecklar en leksak/app för barn med autism. Jag behöver veta vad just ditt barn tycker extra mycket om. Det kan vara bilar, flygplan, tåg, glitter, ljud, färger... ja vad som helst! Alla ni som känner ett barn med autism samt dess favoritintresse får jättegärna skriva till mig antingen privat eller här som en kommentar! Svaren kommer endast användas i en kvantitativ undersökning och inga personliga uppgifter behövs*

Theodor som är sex år, har autism och är normalbegåvad gillar lego, lego och lite mera lego. Och så gillar han poliser, brandmän, byggarbetsrelaterade saker och glitter

Min 9 årige son med autism älskar lego, spel och mjuka saker.

Erik, 8 år med autism och utvecklingsstörning gillar också Lego, både att bygga själv och att titta på YouTube-klipp av andra som bygger. Han gillar också linjer och olika perspektiv, t ex att titta på vägar och annat på Google Earth. Annat han är intresserad av är hissar, tåg, bussar, lampor, vattna, bada, cykla, göra fint i dock-skåpet, siffor

Pojke, 5 år, älskar tåg (särskilt Thomas the tank engine/Thomas & vännerna). Finns studier från både UK och AU som visar att många barn med autism fastnar för dessa tåg pga deras tydliga ansiktsuttryck. Vill gärna se filmerna och bygga själ..

Min dotter på 9 år har autism med utvecklingsstörning och hon bara älskar allt med polis/brand/ambulans bilar,cykla,spela enkla spel på datorn och på min iPhonone :) varje dag sitter hon bänkad framför teven kl 18.00 och 20.00 för att titta på 112 och sen repriserna på söndagar

Sonen som är 4,5 med bla autism och utvecklingsstörning är en fena på datorer/ipad, älskar att surfa runt på svtplay och youtube (just nu är thomas tåget en stor favorit!). Annars gillar han bilar och pappersrullar! ;-)

Hahaha, pappersrullar :) Då känner jag att jag kan berätta om min pojks favvosak också, Autism med svår utv.störning, älskar presentsnören :)

Dottern på 8 surfar mest runt på typ svtplay (och alla engelska motsvarigheter typ ;)). Annars är störst intresset där Melodifestivalen och Eurovision! (jo hon kan vilka år som det varit deltävlingar i Leksand...villken deltävling det var där och har ganska bra koll på vilka låtar som var med också...inte konstigt att en del annat inte får plats! ;))





Just det, glömde naturligtvis att säga att min son älskar datorer och tvspel. Dessutom är han smått galen i schack, spelar schack och tävlar i

Min pojke som är nio med autism, adhd och utvecklingsstörning är tokig i tvättmaskiner. Han kan allt och intresset har hållit i sig i stort sett hela livet. Tåg känner jag igen, och rymden är nog vanligt.

Hej! Kul idé! Vår flicka är tolv och har autism. Hon älskar alla sång- och dansprogram på TV. Hon sjunger med för full hals. Tänk om det fanns en "sing-star app" med glitter och glamour där den som spelar inte kan misslyckas. Det tror jag skulle gå hem hos vår lilla prinsessa :) Lycka till med ditt examensarbete

vår son på 5 år är just nu inne i vapen - maskingevär o andra stora saker. Fick han skulle han gärna spela Call of duty o sådana saker.. men det känns fel till ett litet barn... men ett "pangospel" som inte är blodigt men där han panger något som försvinner... han gillar snabb belöning..

Min son är 4,5 år och har autistiskt syndrom. Han älskar tåg, bilar och stora maskiner. Alla knappar och tekniska grejer är ytterst intressant. Men tåg är nog första, och största intresset, allt blir tåg, smörgåsen, halsduken och sönderrivna hushållspappersbitar :-)

Nej inte vad det gäller tåg, annars så verkar han inte använda fantasin. De sa på Bup att det kan vara så att det fungerar när det gäller barnets intresseområde=) Ja, om jag visste vad det är som är så speciellt med tåg.. :) Men han gillar att bygga på vagnar, han har t ex byggt ihop en lång rad av pusselbitar och kört med "Tut tut"! När han kör med egna tåg måste alltid alla vagnar som "hör till" vara med. Han är ljudkänslig, men ett "lagom mjukt" Tuut gillar han..

sopbilar , tåg han kan sitta i timmar på you tube titta på sopbilar

Son, snart 12 år, älskar vapen, krig, militärer etc sen 3 årsåldern. Och det blir mer och mer ju äldre han är.... Han är också jätteintresserad av hur människokroppen fungerar i belastningar, rörelser, etc (hur snabbt en högpresenterade människa kan springa på hur lång tid, vilka muskler som då används, hur lång är återhämtningstiden etc) och han älskar kanal 10 med en massa dokumentärer om tex militärer, poliser etc.

Min son har sedan han var liten varit periodvis fascinerad av dammsugare, traktorer och kranbilar t.ex. Senare övergick hans intresse mer till konstruerande och kreativt byggande med lego, viss genre av datorspel med konstruktivt upplägg som runscape och minecraft. Numera är hans specialintresse bl.a. att skriva



fantasynoveller på engelska.

min son älskar dinosaurier och drakar =)

Tåg, tåg, tåg... Min 8-åring har en briobana som är lång som en anaconda... Han älskar att bygga banan, sortera, lasta o koppla vagnarna. Bilar ska vänta vid bomarna o köra över. Älskar att titta på filmer om tåg. Älskar att åka tåg, älskar att tjata om tåg, låta som olika sorters tåg (ånglok, diesellok, ellok). Vill äta i tåg, sova i tåg och gå på toaletten i tåg. Allra allra helst vill han nog köra ett tåg. Sen har vi släp på god andra plats. De ska oxå kopplas, lastas och köras till tippen. Både i verkligheten o på låtsas. Tredje är hästar. Samma sak där. Allt som man kan göra i verkligheten gör han i lekrummet.

s idé, sjunga och spela där man inte kan misslyckas. Min dotter, 9 år, älskar att sjunga högt och ljudligt. Snabb belöning är också viktigt. Hon gillar också hästar och ridning, samma sak där, det ska vara svårt att misslyckas, för hon blir SÅ ARG då :)

Data spel....

Som tonåring; tv-spel, sporttabeller.

Hejsan. Vi pratade ny ang. olika typer av bilar exempel polisbilar

Min 7:åring tycker om att konstruera maskiner av olika slag.

Pendeltågsstationer, busshållplatser, tunnelbanelinjer...

Min 6-åriga kille med Autism älskar djur, pussel o Teletubbies. Tror att de tydliga färgerna o stora ögonen lockar hos teletubbisarna.

Min artist älskar gitarr. Sambon spelar mycket så det kan vara därför. Trummor var skoj ett litet tag men mest när han fick sitta i baskaggen som dämpning.

Gärna bilar, traktorer o dyl. med ögon (typ Byggare Bob). Klassisk musik, Markoolio är bra, enligt sonen. Spela instrument är inte så lockande, däremot musik i dataspel är kul. Titta gärna på Boohbah på Zacbrowser.com så förstår du vad jag menar. Höga, plötsliga ljud tycker sonen inte om. Återkommande glatt ljud vid belöning i dataspel funkade dock bra.

Dinosaurer!

När han var mindre var det pärlbåtar och fladdermöss. Djuphavet och mindre arter



mest intressant. Star Wars hade vi en lång period av också.

Min son byter ibland men det har mest handlat om: döskallar, magneter, alfabetet, snören, superhjältar, musik, leta på bilder på nätet o skriva ut.  
glömde alla dessa listor som han gör om allt möjligt

Min 5 åriga son gillar Arbetsfordon, byggplatser, tåg, Pc & Wii spel, You Tube & spel på nätet, vissa bilar tex. från Cars, djur, böcker inga höga & plötsliga ljud är välkomna, vissa färger, allt har sin plats, har ordning o reda på sina saker, tycker inte om musik, radio, sitter ofta i flera timmar i sin la la värld o leker !!!

Tycker INTE om Bebisar, Clownar & Hästar

Vassego =) Något han har gillat starkt sen han var två skitar hög o är fruktansvärt bra på är Bokstäver & Siffror.

Alltid hatat utklädda personer! Du vet, maskerad å clowner.... Rädd helt enkelt! Å inte velat klä ut sig själv heller! Aldrig!

Min son är galen i späckhuggare o älskar piratskepp.

Har en 10 åring som alltid älskat tåg, alla slags tåg både på länden och tvären. Lego är också ett stort intresse. Sedan har dataspel, DS och Wii kommit nästan ikapp. Tåg säger han är för att han kan kontrollera dem. Klassisk musik vid avkoppling annars ska det vara melodifestivalen och fart. :)

Det viktiga är nu att man lyckas "trigga" igång dopaminhalten i hjärnan. Detta görs vid belöningar och spel som ger snabba belöningar gör ofta att man "fastnar" fast det kanske inte är favoritintresset.

Min sons stora intresse är historia helst stormakts tiden, och vatten i alla former

Hej Maria! Det här gäller inte mitt barn, men återkommande bland Eldorado-besökare är: BARN (Skratt, lek, gråt mm) APOR (gorillor, små apor, stora apor osv) och olika MOTORljud. Vibrations/VERKTYGsljud samt BARNVISOR

Min son gillar oxå vatten, sedan gillar han film, datorn, musik, läsning, alfabetet, siffror.

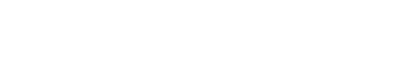
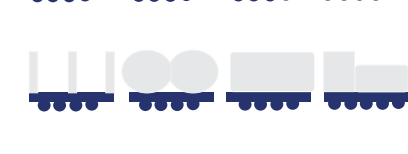
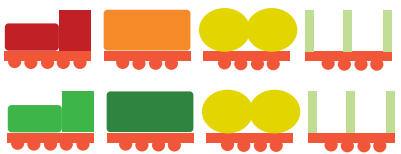
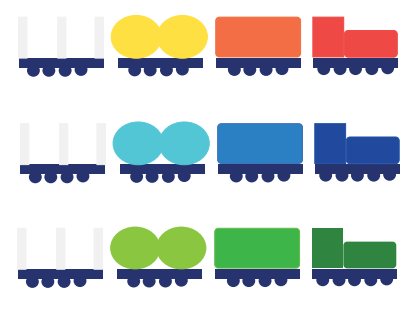
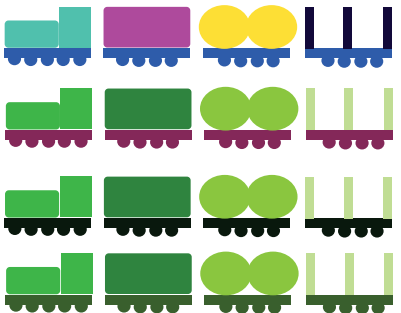
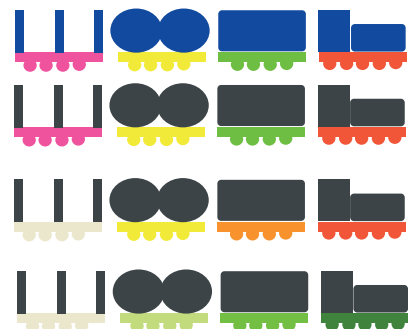
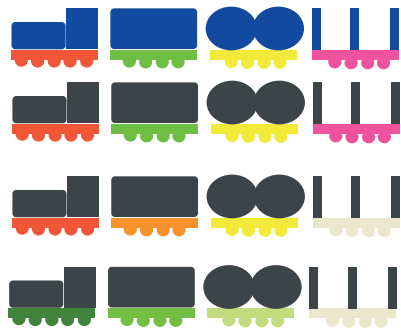
vet en som INTE gillar vibrationer... Kasta boll... Om synen är nedsatt är det bra med bjällra i. Annars bollar som byter färg..

Knappar, lampor, musik, siffror, bokstäver

tåg, tågbanor, bilar & bilbanor, klämmiga sånger och liknande..



## 5. COLOR DEVELOPMENT





## 6. ERGONOMY

Bent hand give 8,8 percent decrease of hand inner length hand

Equation for calculating decreased hand inner length >

**Hand length x 0.912**

Grip length needed for toy > Circumference of circle divided in two > Equation >

**(2 x pi x r)/2**

Calculation of decreased hand lengths of hand measures 100, 105 and 150 mm:

**100x0.912=91.2 mm**

**105x0.912=95.76 mm**

**150x0.912=136.8 mm**

Calculation of grip length needed for circle diameters 50, 60 and 70 mm:

50 x 3.14= 157 > 157/2 = **78.5 mm**

**60 x 3.14=188.4** > **188.4 /2 = 94.2 mm**

70 x 3.14= 219.8 > 219.8/2 = **109.9 mm**



## 7. CE REGULATIONS

### I. ALLMÄNNA PRINCIPER

1. I enlighet med kraven i artikel 2 i detta direktiv skall såväl användare av leksaker som annan person skyddas mot hälso- och säkerhetsrisker som uppstår när leksaker används på avsett sätt, eller på sätt som kunnat förutses med hänsyn till barns normala beteende. Det rör sig om risker

a) som har samband med leksakers utformning, konstruktion och sammansättning,

b) som är förenade med leksakers användning och som inte helt kan undanröjas genom ändrad konstruktion och sammansättning utan att funktionen hos leksaken förändras eller den berövas sina viktigaste egenskaper.

2. a) Graden av risk som den som använder en leksak utsätter sig för skall stå i rimlig proportion till den förmåga att hantera risken som barnet eller den som ser till barnet har. Detta gäller särskilt för leksaker som på grund av sin funktion, storlek och särskilda egenskaper är avsedda för barn under 36 månader.

b) För att denna princip skall kunna efterlevas måste det i tillämpliga fall särskilt anges en lägsta åldersgräns för den som använder leksaken och om det behövs tillsyn av en annan person för att leksaken skall kunna användas säkert.

3. Etiketter som åsätts leksaker och/eller förpackningen, samt medföljande bruksanvisning skall utförligt och effektivt fästa användarens eller tillsynshavarens uppmärksamhet på de risker som är förbundna med användning av leksaken samt hur dessa risker skall undvikas.

### II. SÄRSKILDA RISKER

#### 1. Fysikaliska och mekaniska egenskaper

a) Leksaker och dess beståndsdelar, liksom även fästanordningar när det gäller fast monterade leksaker, skall ha erforderlig mekanisk hållfasthet och, i förekommande fall, tillräcklig stabilitet för att tåla de påkänningar de utsätts för vid användning utan att brytas sönder eller deformeras med åtföljande risk för fysisk personskada.



b) Åtkomliga kanter, utskjutande partier, rep, snören, kablar och fästanordningar skall vara utformade och utförda på ett sådant sätt att risken för skador vid kontakt nedbringas så långt möjligt.

c) Leksaker skall vara utformade och tillverkade på ett sådant sätt att risken för fysiska personskador på grund av den inbördes rörelsen hos leksakens olika delar nedbringas till ett minimum.

d) Leksaker och deras beståndsdelar samt delar som kan tas loss från leksaker som uppenbarligen är avsedda för barn under 36 månaders ålder skall ha sådana dimensioner att de inte kan sväljas eller inandas.

e) Leksaker och deras delar, samt de förpackningar i vilka de saluförs i detaljhandeln, får inte medföra risk för strypning eller kvävning.

f) Leksaker avsedda att användas på grunt vatten och till att hålla barn över vatten eller till att stödja dem skall vara utformade och tillverkade på sådant sätt att risken för förlust av flytkraft och förlust av stöd för barnet begränsas så långt möjligt med hänsyn till rekommenderat användningssätt.

g) Leksaker som går att krypa in i och därmed bildar ett slutet rum för användaren skall ha en utgång, som användaren lätt kan öppna inifrån.

h) Leksaker med vars hjälp användaren kan förflytta sig skall så långt möjligt vara försedda med broms, anpassad till typ av leksak och till den rörelseenergi som leksaken utvecklar. Bromssystemet skall vara enkelt att använda av användaren utan risk för denne att kastas ur leksaken eller vid skaderisk för denne eller annan person.

i) Utförandet och sammansättningen av projektiler, och den rörelseenergi de förmår utveckla när de skjuts ut från en leksak avsedd för detta skall vara sådana att de inte innebär oskälig risk för fysisk skada för användaren eller annan person.

j) Leksaker som innehåller värmekällor skall vara konstruerade för att säkerställa

- att den högsta temperaturen på åtkomliga ytor inte kan orsaka brännskador vid beröring,
- att ånga eller gas inne i leksaken inte uppnår sådan temperatur eller sådant tryck att de kan vålla brännskada, skållning eller annan fysisk kroppsskada då de släpps ut från leksaken på annat sätt än vad som är avsett.



## 2. Brännbarhet

a) Leksaker får inte utgöra eldfarliga inslag i barnets omgivning. De skall därför bestå av material

1. som antingen inte brinner under direkt inverkan av en öppen låga, gnista eller möjlig annan antändningskälla,

2. eller som inte är lättantändliga (lågan skall slockna så snart som brandorsaken avlägsnas),

3. eller som, i de fall materialet antänds, brinner långsamt och med låga som sprids med låg hastighet,

4. eller som, oavsett leksakens kemiska sammansättning, behandlats i syfte att fördröja förbränningsprocessen.

Dessa brännbara material får inte utgöra en antändningsrisk för andra material som ingår i leksaken.

b) Leksaker, som för sin funktion oundgängligen måste innehålla sådana farliga ämnen eller preparat som bestäms i direktiv 67/548/EEG(1), särskilt material och utrustning för kemiska experiment, hopsättning av modeller, gjutning av plast eller keramik, emaljering, fotografering och liknande, får inte innehålla ämnen eller preparat som kan bli antändliga efter förlust av oantändliga flyktiga beståndsdelar.

c) Leksaker får inte vara explosiva eller innehålla beståndsdelar eller ämnen som kan explodera vid användning enligt direktivets artikel 2.1. Denna bestämmelse är inte tillämplig på slagtändsatser för leksaker, se punkt 10 i bilaga 1 och därtill hörande fotnot.

d) Leksaker, särskilt kemiska leksaker, får inte innehålla ämnen eller preparat som

- kan explodera när de blandas
- genom kemisk reaktion eller upphettning,
- vid blandning med oxiderande ämnen,
- innehåller flyktiga ämnen som är antändliga i luft och riskerar att bilda antändliga eller explosiva gas/luftblandningar.

## 3. Kemiska egenskaper

1. Leksaker skall vara så utformade och tillverkade att de vid användning enligt direktivets artikel 2.1 inte medför hälso- eller skaderisk vid nedsväljning, inandning eller kontakt med hud, slemhinnor eller ögon.





De skall i vart fall uppfylla bestämmelserna i gällande gemenskapsrätt om vissa produktkategorier eller om förbud, begränsad användning eller märkning av vissa farliga ämnen och preparat.

2. För skydd av barnens hälsa gäller speciellt som målsättning att biotillgängligheten per dag till följd av användning av leksaker inte får överstiga

0,2 ig antimon  
0,1 ig arsenik  
25,0 ig barium  
0,6 ig kadmium  
0,3 ig krom  
0,7 ig bly  
0,5 ig kvicksilver  
5,0 ig selen

eller andra värden för dessa eller andra ämnen som på vetenskapliga grunder kan komma att fastställas i gemenskapens lagstiftning.

Med biotillgänglighet för dessa ämnen menas det lösliga extrakt av ifrågavarande ämnen som har toxikologisk betydelse.

3. Leksaker får inte innehålla de farliga ämnen eller preparat som anges i direktiv 67/548/EEG och 88/379/EEG(2) i mängder som kan medföra hälsorisker för de barn som använder leksakerna. Det är under alla förhållanden strängt förbjudet att i en leksak ta med farliga ämnen eller preparat om de är avsedda att användas som sådana under lek.

Skulle dock ett begränsat antal ämnen eller preparat vara absolut nödvändiga för vissa leksakers funktion, bl.a. material och utrustningar för kemiska experiment, hopsättning av modeller, gjutning i plast eller keramik, emaljering, fotografering eller liknande, är dessa tillåtna upp till en viss övre koncentrationsgräns, vilken skall fastställas för varje ämne eller preparat efter mandat till den Europeiska standardiseringsorganisationen CEN enligt det förfarande som gäller för den kommitté som upprättats genom direktiv 83/189/EEG, förutsatt att de tillåtna ämnena och preparaten är i överensstämmelse med gemenskapens klassificeringsregler rörande märkning med undantag för punkt 4 i bilaga 4.

4. Elektriska egenskaper

a) Elektriska leksaker skall inte drivas med en märkspänning som överstiger 24 volt och ingen del av leksaken får ge en spänning över 24 volt.

b) Delar av leksaker, som är eller kan komma i kontakt med en elektrisk strömkälla som kan orsaka elektriska stötar samt kablar eller ledningar genom vilka elektricitet leds till dessa delar, skall vara väl isolerade och mekaniskt skyddade



för att förhindra risk för sådana stötar.

c) Elektriska leksaker skall vara utformade och tillverkade på ett sätt som säkerställer att den högsta temperatur som direkt åtkomliga ytor kan nå inte ger brännskador vid beröring.

#### 5. Hygien

En leksak måste vara så utformad och konstruerad att den uppfyller kraven på hygien och renlighet för att undvika infektion, sjukdom och smitta.

#### 6. Radioaktivitet

Leksaker får inte innehålla radioaktiva delar eller ämnen i sådana former eller i sådana mängder att de kan vara skadliga för barns hälsa. Direktiv 80/836/Euratom skall tillämpas(3).

(1) EGT nr 196, 16.8.1967, s. 1.

(2) EGT nr L 187, 16.7.1988, s. 14.

(3) EGT nr L 246, 17.9.1980, s. 1.

### BILAGA 3

#### VILLKOR SOM SKALL UPPFYLLAS AV DE GODKÄNDA KONTROLLORGANEN (Artikel 9.1)

De kontrollorgan som medlemsstaterna utser måste uppfylla följande minimikrav:

1. Det skall finnas personal tillgänglig samt nödvändiga hjälpmedel och nödvändig utrustning.

2. Personalen skall ha teknisk kompetens och yrkesmässig integritet.

3. Den administrativa och tekniska personalen skall i fråga om genomförande av provningar, upprättande av rapporter, utfärdande av intyg och den tillsyn som detta direktiv föreskriver vara oberoende gentemot alla kretsar, grupper eller personer som direkt eller indirekt har intressen på leksaksområdet.

4. Personalen skall upprätthålla tystnadsplikt.

5. En ansvarsförsäkring skall tecknas såvida inte staten står för detta ansvar enligt gällande nationell lagstiftning.

Behöriga myndigheter i medlemsstaterna skall med vissa mellanrum kontrollera



att kraven i punkt 1 och 2 uppfylls.

#### BILAGA 4

##### VARNINGSINFORMATION OCH INFORMATION OM FÖRSIKTIGHETSÅTGÄRDER VID ANVÄNDNING (Artikel 11.5)

Leksaker skall åtföljas av lämpliga lättläsliga upplysningar för att minska användningsrisker av det slag som beskrivs i de väsentliga kraven, särskilt följande:

1. Leksaker som inte är avsedda för barn under 36 månaders ålder

Leksaker som kan vara farliga för barn under 36 månaders ålder skall vara försedda med varningstext, t.ex. "Inte lämplig för barn under 36 månader" eller "Inte lämplig för barn under 3 år", kompletterad med en kortfattad upplysning, som även kan finnas i bruksanvisningen, om vilka specifika risker som ligger till grund för denna begränsning.

Denna bestämmelse gäller inte leksaker som på grund av funktion, storlek, utmärkande drag, egenskaper eller andra viktigare omständigheter uppenbarligen inte är avsedda för barn under 36 månader.

2. Rutschbanor, hänggungor, romerska ringar, trapetser, rep och liknande leksaker monterade på ställningar

Dessa leksaker skall åtföljas av bruksanvisning som fäster uppmärksamheten på nödvändigheten att regelbundet kontrollera och underhålla de viktigaste delarna (upphängnings- och fästansordningar, förankring i marken etc.) samt understryker att leksaker om dessa kontroller inte utförs kan förorsaka fallolyckor eller välta. Instruktioner, som anger hur leksaken skall monteras på rätt sätt och vilka delar som kan medföra fara om monteringen inte utförts korrekt, skall också tillhandahållas.

3. Funktionella leksaker

Funktionella leksaker eller deras emballage skall vara försedda med texten: "Varning! Skall användas under tillsyn av vuxen."

Dessa leksaker skall dessutom bl.a. åtföljas av bruksanvisning med instruktioner rörande leksakens funktionssätt och uppgift om vilka försiktighetsåtgärder som skall vidtas av användaren, samt upplysning om att denna vid underlåtenhet att iaktta dessa försiktighetsåtgärder utsätter sig för risker vilka skall preciseras som är normalt förknippade med den apparat eller produkt av vilken leksaken är en skalenlig modell eller en imitation. Vidare skall anges att leksaken skall hållas utom räckhåll för mycket små barn.

Med funktionella leksaker menas sådana leksaker som har samma funktion som apparater eller anläggningar avsedda för vuxna, av vilka leksaken ofta är en



skalenlig modell.

4. Leksaker som innehåller farliga ämnen eller preparat. Kemiska leksaker.

a) Utöver de tillämpliga bestämmelserna i EEG-direktiven om klassificering, förpackning och märkning av farliga ämnen och preparat skall bruksanvisningar för leksaker som innehåller farliga ämnen och preparat innehålla information om dessa ämnens farliga karaktär samt upplysning om vilka försiktighetsåtgärder som användaren skall iaktta för att undvika de risker som är förbundna med dem. Dessa risker skall kortfattat preciseras alltefter typ av leksak. Vidare skall anges vilka första-hjälpen-åtgärder som skall vidtas i händelse av allvarliga olycksfall i samband med användning av denna typ av leksaker. Slutligen skall påpekas att leksaken skall hållas utom räckhåll för mycket små barn.

b) Utöver anvisningar i punkt a ovan skall emballaget till kemiska leksaker vara märkta med texten: "Varning! Endast för barn över... år(1). Skall användas under tillsyn av vuxen

(1) Åldern skall fastställas av tillverkaren."

Som kemiska leksaker räknas bl.a. kemisatser, lådor för inbakning av föremål i plast, miniatyrverkstäder för keramik, emaljering, fotografering och liknande.

5. Rullbrädor och rullskridskor för barn

Om dessa produkter säljs som leksaker skall de vara försedda med texten: "Varning! Skall användas tillsammans med skyddsutrustning".

Dessutom skall bruksanvisningen innehålla en påminnelse om att leksaken kräver stor skicklighet och skall användas med försiktighet för att förhindra skador genom fall eller till följd av kollision mellan användaren och någon annan person. Vidare skall anvisningar lämnas rörande rekommenderad skyddsutrustning (hjälm, handskar, knäskydd, armbågsskydd etc.).

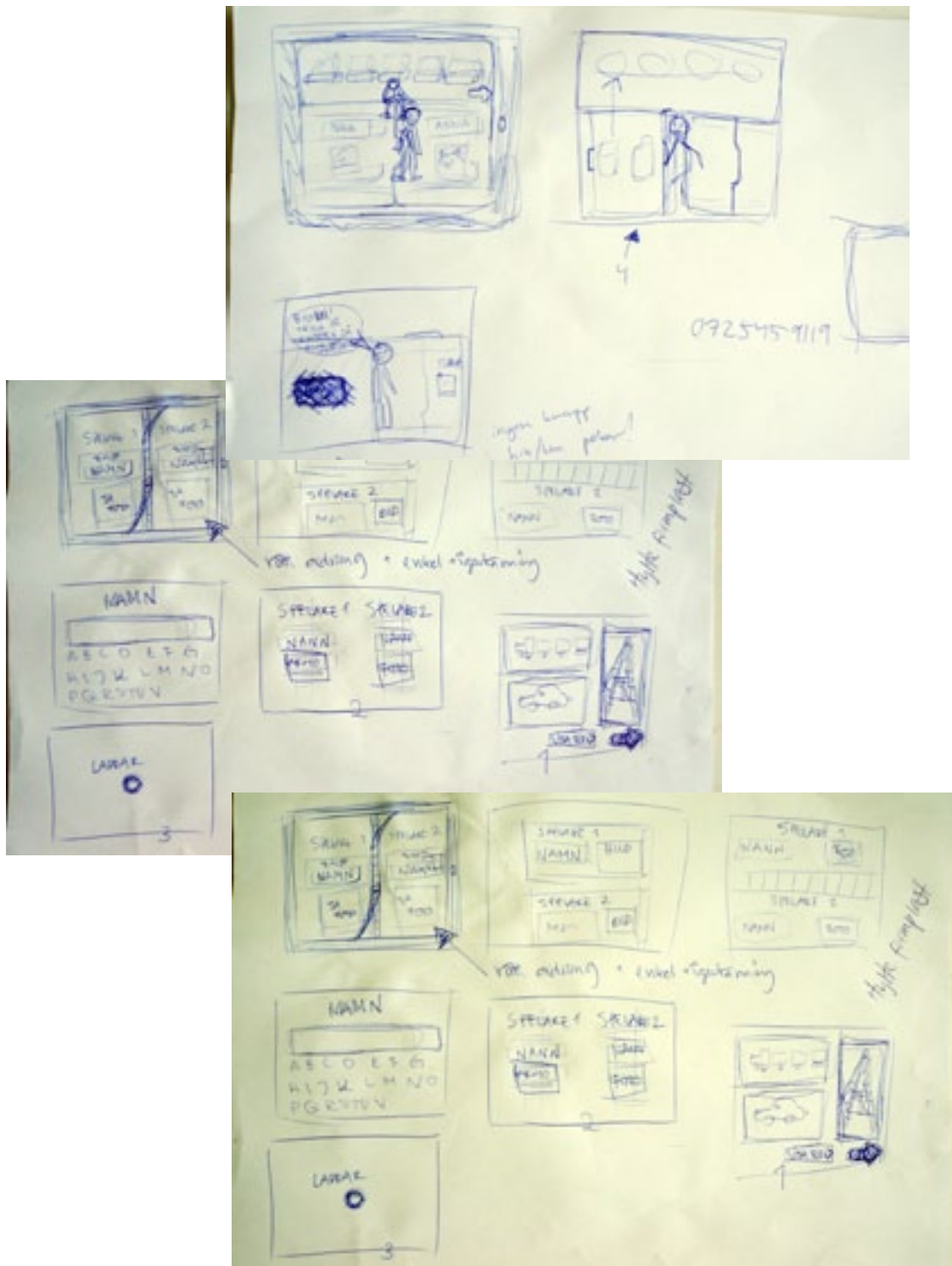
6. Vattenleksaker

Vattenleksaker enligt definitionen i bilaga 2, punkt II.1. f skall vara försedda med text enligt CEN:s instruktioner att anpassa standard EN/71, del 1 och 2:

"Varning! Får endast användas i vatten där barnet bottnar samt under övervakning."

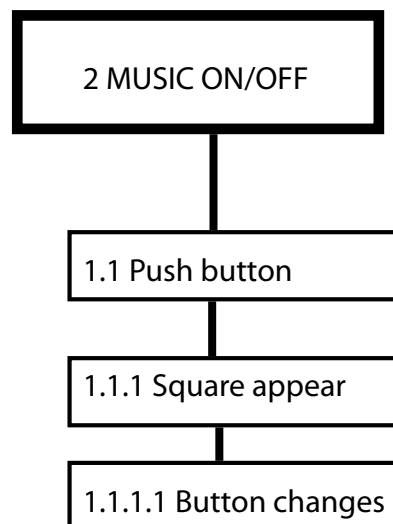
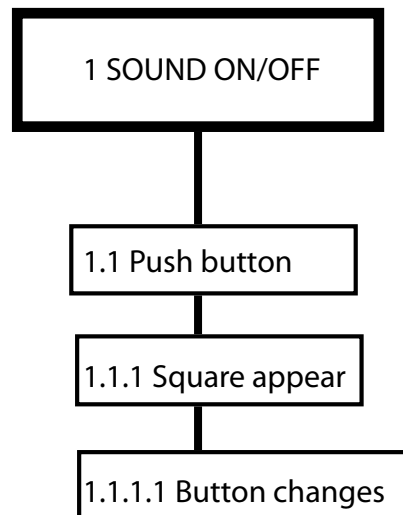


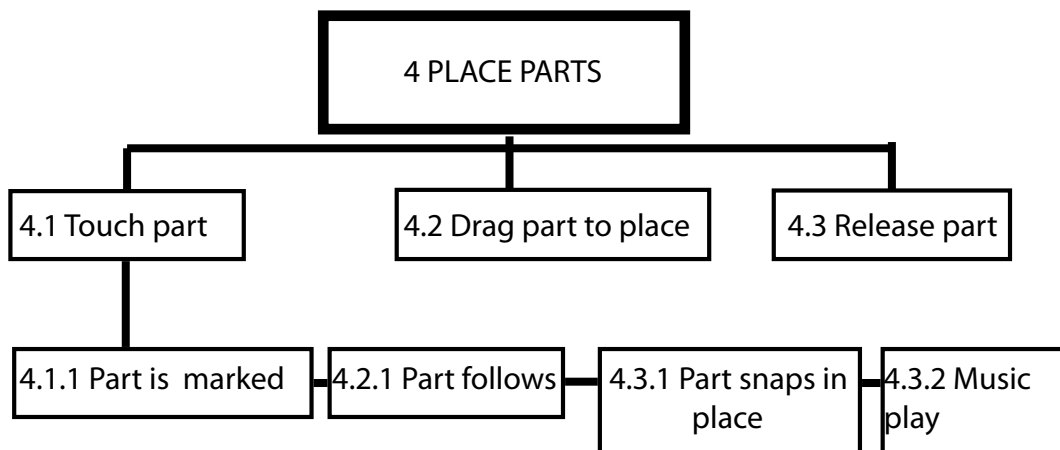
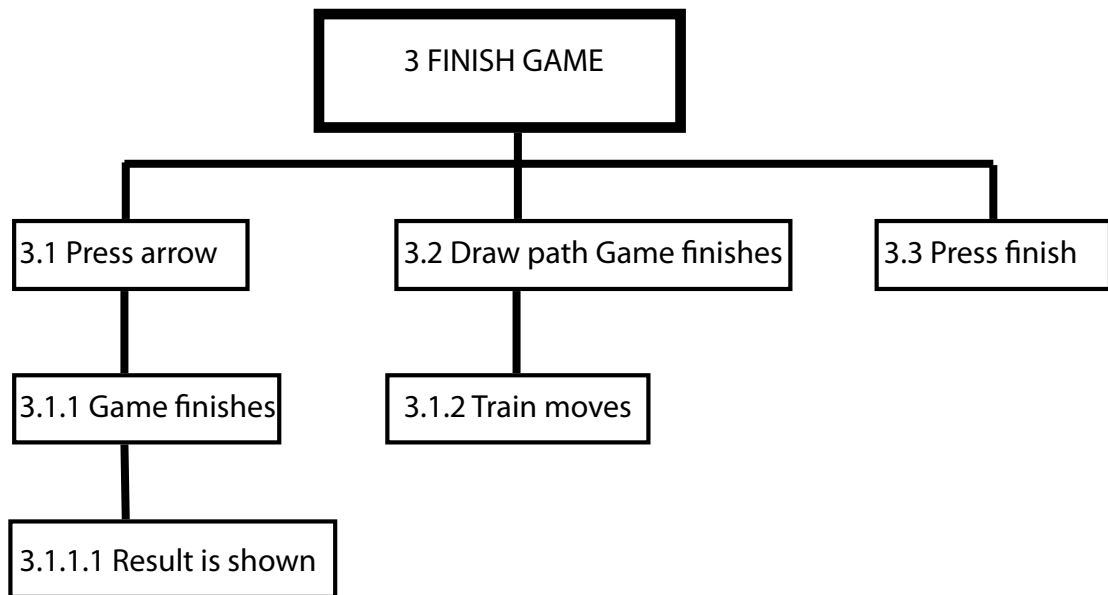
## 8. QUICK SKETCHES OF FLOW FOR APPLICATION

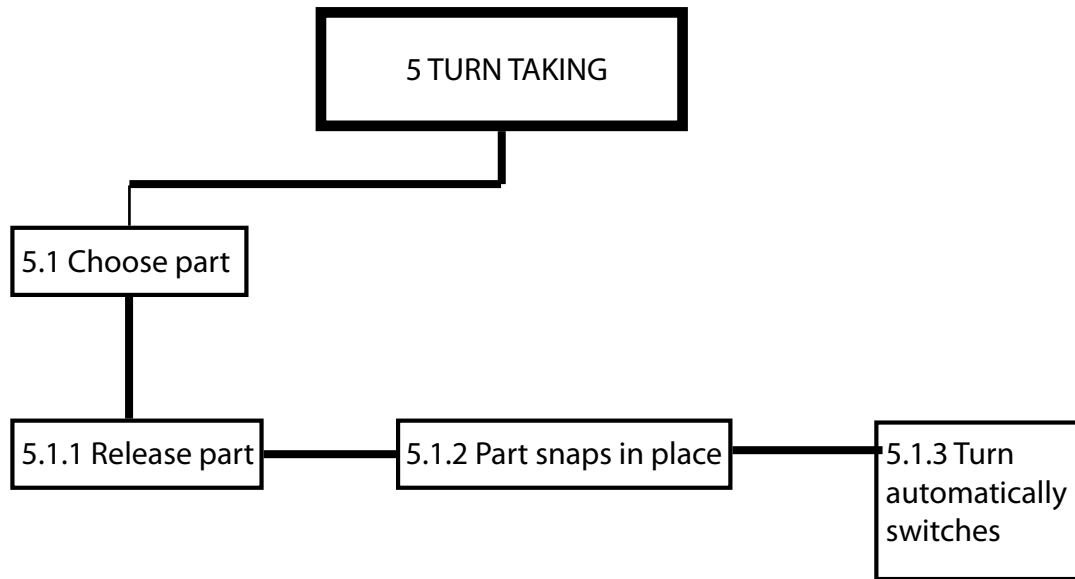




## 9. HTA











## 10. CW/PHEA

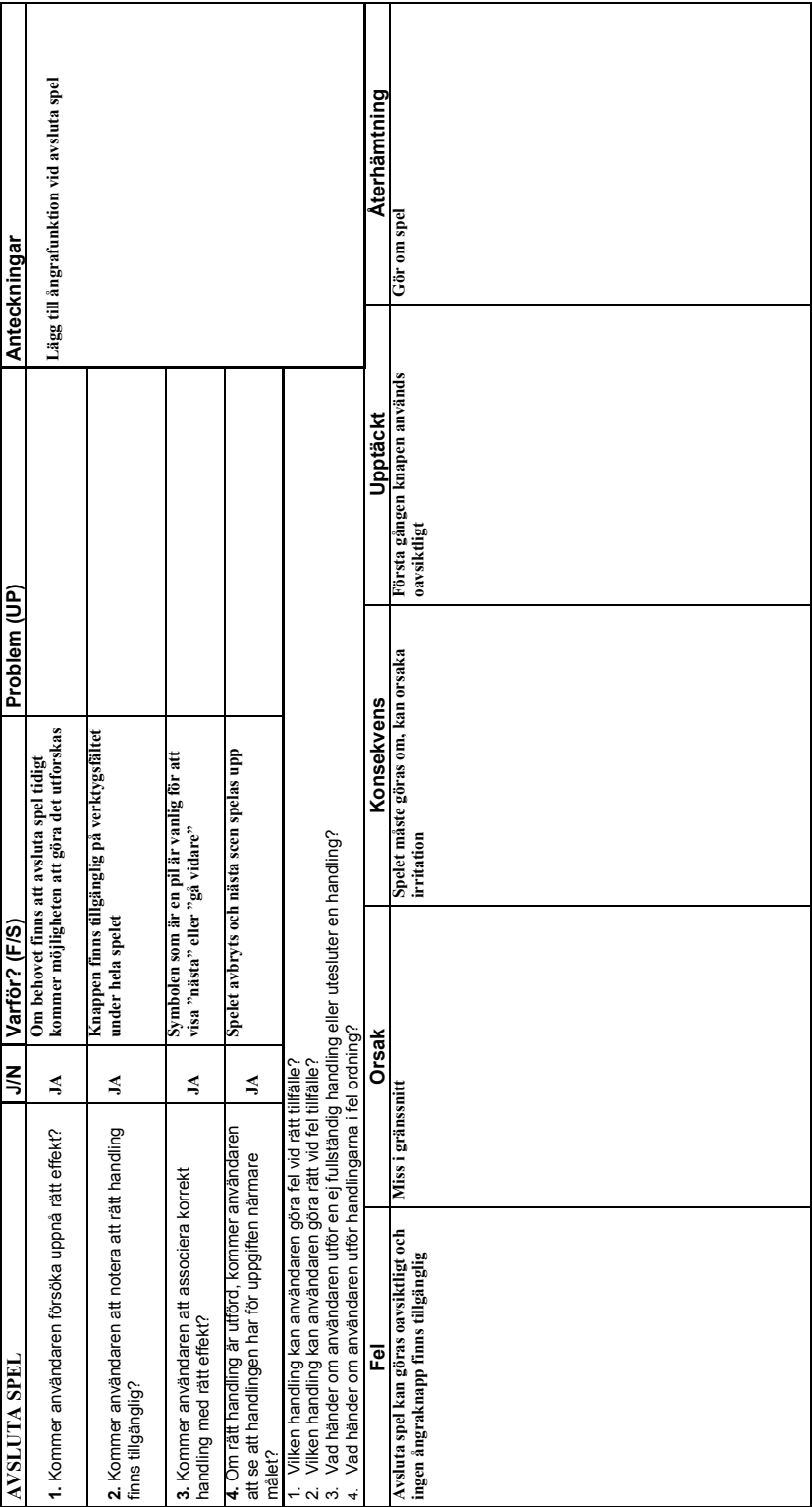
LJUD PÅ /AV	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	JA	Ljudinställningar är vanliga samt att applikationen är inställd att ha ljud på vid start, alltså måste ljudet stängas av manuellt ifall det behövs		
2. Kommer användaren att notera att rätt handling finns tillgänglig?	JA	Knappen för ljudreglage är alltid tillgänglig på spelplanen. Knappen har en vanlig symbol som associeras till ljud och volyminställningar		
3. Kommer användaren att associera korrekt handling med rätt effekt?	JA	Det finns två reglage för ljud och musik och ett för att gå vidare, dessa är de enda inställningar som kan göras och behövs		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	JA	När knappen trycks in ändrar den färg samt feedback i form av ljud hörs. Efter knappen trycks in visas en ruta som säger vilket läge inställningen är på och symbolen i verktygsfältet ändrar färg för att användaren ska veta vilket läge man står i.		
1. Vilken handling kan användaren göra fel vid rätt tillfälle? 2. Vilken handling kan användaren göra rätt vid fel tillfälle? 3. Vad händer om användaren utför en ej fullständig handling eller utesluter en handling? 4. Vad händer om användaren utför handlingarna i fel ordning?				
Potentiellt fel kan vara att man bara stänger av musiken och inte bakgrundsjud	Det finns två "ljudknappar" en för Allt ljud och en för musik för att kunna erbjuda musik utan bakgrundsjud såsom klick om dessa ljud är jobbiga, alternativt allt ljud av.	Ljuden (klick etc.) fortsätter men musiken av, kan eventuellt skapa irritation och förvirring samt ilska/rädsla hos barnet med autism	Om ljudet spelas när det inte förväntas upptäcks felet	Aterhämtning Användaren kan då se att musikknappen är grå medan ljudknappen är orange, kan då trycka på ljudknappen så stängs allt ljud av. Vill musiken ändå behållas kan man då trycka på musik igen för att stå på.
Potentiellt problem att barn med autism inte hunnit lära sig vad symbolen för ljud betyder  Då symbolen är igenkänd generellt får man ändå anta att barnen kan lära sig vad knappen betyder. I annat fall hjälper förälder.	Det semantiska minnet kan vara nedsatt, alltså vissa ikoner kanske är oklara.	Mental modell saknas då, eller gulf of evaluation stämmer inte bra, intention och handling stoppas av förvirring	När ljudet ska stängas av första gången	Symbolen är generellt igenkänd och använd för ljud/volym reglage, anta att barnen kan lära sig vad den knappen/symbolen betyder annars får förälder/ medhjälpare hjälpa. Om symbolen kan läras in kommer barnet kanske kunna associera denna i fler gränssnitt.



MUSIK PÅ /AV	J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?	JA	Om barnet inte gillar musiken kommer behovet att stänga av den finnas, därför försöker man också uppnå rätt effekt		
2. Kommer användaren att notera att rätt handling finns tillgänglig?	JA	Knappen för musik är alltid tillgänglig på spelplanen. Knappen har en vanlig symbol som associeras till just musik (en not)		
3. Kommer användaren att associera korrekt handling med rätt effekt?	JA	Det finns två regler för ljud och musik och ett för att gå vidare, dessa är de enda inställningar som kan göras och behövs		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?	JA	När knappen trycks in ändrar den färg samt feedback i form av ljud hörs. Efter knappen tryckts in visas en ruta som säger vilket läge inställningen är på och symbolen i verktygsfältet ändrar färg för att användaren ska veta vilket läge man står i.		
1. Vilken handling kan användaren göra fel vid rätt tillfälle? 2. Vilken handling kan användaren göra rätt vid fel tillfälle? 3. Vad händer om användaren utför en ej fullständig handling eller utesluter en handling? 4. Vad händer om användaren utför handlingarna i fel ordning?				
Potentiellt fel att man förväxlar de två symbolerna för musik/ljud och därför väljer fel knapp  Irritation kan uppstå om allt ljud stängs av, även musik, fastän man tryckt bara på att ljud av	Båda symbolerna kan användas för ljud, även om noten är mer relaterad till just musik och högtalarsymbolen till volym/ljudinställningar  Det semantiska minnet kan vara nedsatt, alltså vissa ikoner kanske är oklara.	Ljuden (klick etc.) fortsätter men musiken av, kan eventuellt skapa irritation och förvirring samt ilska/rädsla hos barnet med autism. Alternativt allt ljud av fast man bara tryckt på "allt ljud"knappen och kanske tror att det inte gäller musik	Om ljudet spelas när det inte förväntas och tvärtom upptäcks felet  När ljudet ska stängas av första gången	<b>Aterhämtning</b>  Användaren kan då se att musikknappen är grå medan ljudknappen är orange, kan då trycka på ljudknappen så stängs allt ljud av. Vill musiken ändå behållas kan man då trycka på musik igen för att slå på.  Symbolen är generellt igenkänd och använd för ljud/volym regel, anta att barnen kan lära sig vad den knappen/symbolen betyder annars får förälder/medhjälpare hjälpa. Om symbolen kan läras in kommer barnet kanske kunna associera denna i fler gränssnitt.



PLACERA DELAR		J/N	Varför? (F/S)	Problem (UP)	Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?		J/A	Spelet kommer stanna ifall ingen gör ett val av del		Lägg till ångrafunktion vid avsluta spel
2. Kommer användaren att notera att rätt handling finns tillgänglig?		J/A	Har man kollat hur spelet fungerar först borde man veta vad man ska göra		I framtiden göra en hjälpsida som visar hur delarna flyttas, vad knapparna betyder etc. Lägga till en hjälpknapp?
3. Kommer användaren att associera korrekt handling med rätt effekt?		J/A	För att fortsätta spela och få välja igen måste ett första val göras. Effekten med musik efter placering kan vara en överraskning men är en extra funktion tills man lärt sig		
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?		J/A	Täglarna fastnar på plattformen och spelar musik sedan går turen över		
1. Vilken handling kan användaren göra fel vid rätt tillfälle? 2. Vilken handling kan användaren göra rätt vid fel tillfälle? 3. Vad händer om användaren utför en ej fullständig handling eller utesluter en handling? 4. Vad händer om användaren utför handlingarna i fel ordning?					
Fel	Orsak	Konsekvens		Upptäckt	Aterhämtning
Kan vara svårt att förstå första gången att man ska dra delen upp till plattformen	Man kan tro att det bara är att klicka på delen	Klickar man på delen kommer ett ljud men den rör sig inte om inte fingret hålls kvar, spelet fortsätter inte förrän delen snäpps fast på plattformen		När inget händer i spelet	Prova dra över delarna så de rör sig eller gå till hjälpsidan





DRAW PATH		J/N	Varför? (F/S)	Problem (UP)		Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?		J/A	Efter att sett förklaring hur man gör	Finns risk för att man inte förstår vad man ska göra utan att ha kollat introduktion/hjälp		Lägg till ångrafunction vid avsluta spel
2. Kommer användaren att notera att rätt handling finns tillgänglig?		J/A	Förklaring av spelet visar hur det görs			Visa med animation för varje steg/gör hjälp knapp/ eller introduktion i början
3. Kommer användaren att associera korrekt handling med rätt effekt?		J/A	Att dra fingret längs skärmen ger en tydlig linje som tåget sedan följer			
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?		J/A	Tåget följer linjen automatiskt			
1. Vilken handling kan användaren göra fel vid rätt tillfälle? 2. Vilken handling kan användaren göra rätt vid fel tillfälle? 3. Vad händer om användaren utför en ej fullständig handling eller utesluter en handling? 4. Vad händer om användaren utför handlingarna i fel ordning?						
Fel	Orsak	Konsekvens		Upptäckt		Aterhämtning



TURTAGNING		J/N	Varför? (F/S)	Problem (UP)		Anteckningar
1. Kommer användaren försöka uppnå rätt effekt?		J/A	Om behovet finns att avsluta spel tidigt kommer möjligheten att göra det utforskas			Lägg till ångrafunction vid avsluta spel
2. Kommer användaren att notera att rätt handling finns tillgänglig?		J/A	Knappen finns tillgänglig på verktygsfältet under hela spelet			
3. Kommer användaren att associera korrekt handling med rätt effekt?		J/A	Symbolen som är en pil är vanlig för att visa "nästa" eller "gå vidare"			
4. Om rätt handling är utförd, kommer användaren att se att handlingen har för uppgiften närmare målet?		J/A	Spellet avbryts och nästa scen spelas upp			
1. Vilken handling kan användaren göra fel vid rätt tillfälle? 2. Vilken handling kan användaren göra rätt vid fel tillfälle? 3. Vad händer om användaren utför en ej fullständig handling eller utesluter en handling? 4. Vad händer om användaren utför handlingarna i fel ordning?						
Fel	Orsak	Konsekvens		Upptäckt	Återhämtning	
Avsluta spel kan göras oavsiktligt och ingen ångra knapp finns tillgänglig	Miss i gränssnitt	Spellet måste göras om, kan orsaka irritation		Första gången knappen används oavsiktligt	Gör om spel	