

















Master thesis ‘Design for Interaction’,
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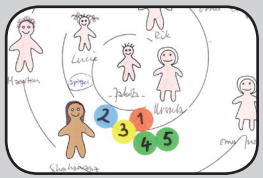
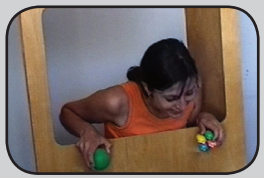
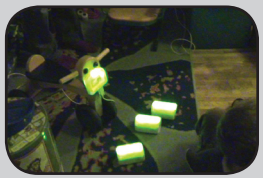
LINKX

a language toy for autistic toddlers
developed in co-creation with parents and pedagogues
by Helma van Rijn







Contents

Abstract

This master thesis shows the design process of LINKX, a language toy for children with a disorder in the spectrum of autism. Children with autism have an inborn brain disorder and therefore play and learn differently than children with 'typical' development. Language and speech of children with autism develops slowly or not at all. These children's 'different being' indicates a need for different toys. Main goal of this project was to design a toy that stimulates language development in a playful way.

Insight in how autistic children play and learn was mainly gained by high involvement throughout the whole process of autistic children, their parents, and their pedagogues. These children: Beer, Robbert and Jakob, played a leading role in this process. I observed them at home, at school, and at speech therapy, and interviewed their parents and pedagogues. Exploration resulted in a design framework for autistic children in which control, direct feedback, rewards, repetition, and memory, are important elements. After this exploration I realized that already within these three children there was much variation in needs. For example, the language development stage in which children were differed. A found similarity was that all children have trouble with giving meaning to words. Therefore they should learn to word objects in their environment.

With this framework in mind, ideas were generated. The idea with most potential regarding interaction was chosen and evaluated with parents. Their opinions contributed in further concept development and eventually led to LINKX, the final design of this project. This design aims for a connection on three levels: motor, cognitive, and emotional. On motor level children literally link play-elements together and thereby receive a visual and audio reward. On cognitive level, the children are triggered to link an object with a word. On emotional level LINKX aims to connect parent and child by providing a way to play together.

LINKX is elaborated into an experiential prototype and tested in several play-sessions with the participating children. Parents took on the role of co-researcher, because they are expert on their child's behaviour and feelings. The child's play served as reference for evaluation, both for me as for the parents.

In general the children enjoyed playing with LINKX. They laughed and repeatedly linked elements to hear the sound and let it move. The characteristics described in the framework seemed to be true. Especially when the prototype did not function as expected, the importance of 'giving sense of control' was evident. For the future I hope that my framework can inform and inspire other designers to develop more toys that facilitate the learning process of children with autism. With growing technological possibilities, technique can help these kids learn more, and thereby let them be more able to cope with life.

1. Introduction

This graduation on the development of an educational toy for autistic toddlers serves as example project for the project group LinguaBytes. LinguaBytes consists of the parties Viataal (RDS), ID-StudioLab (TU Delft), and the section Ortho-pedagogics of the Radboud University of Nijmegen. This multi-disciplinary group develops knowledge, tools, and techniques for multiple disabled toddlers to stimulate their language and communication skills (van Balkom et al. 2002, Hummels et al. 2006 and Hengeveld et al. 2007). This thesis shows the development of LINKX, a language toy for children with a disorder in the autistic spectrum. I refer to these children as 'children with autism' or 'autistic children'.

Autism is an inborn brain impairment. Children with autism have trouble with empathizing, with recognizing connections, and have difficulties in switching to new activities. They exhibit symptoms such as repetitive behaviour, impairment in imagination, and disorders in social interactions, communication and language. Language and speech develop slowly or not at all. When they learn language, they use it rather instrumental than social. Disorders in development of language and communication can have severe psychological consequences, especially in social and emotional development and the ability to do things independently. Autistic children with higher intelligence and language capabilities survive easier in society. Therefore stimulation of language and communication should be done as early as possible.

1.1 Problem definition

This project aims to design an educational toy for autistic toddlers. Designing for autistic children has a double challenge. First, autistic children learn language differently than children with typical development do. Second, getting autistic toddlers react on and interact with a toy often is a challenge in itself. They need to be triggered to explore and interact with something new. Playing has to be learned and asks for patience and repetition. Therefore the future toy should suit the children's way of learning language and playing.

1.2 Design brief

Design a toy, both playful and educational, which stimulates development of language of autistic toddlers. This educational toy for children with a developmental age from 1.3 till 4 years, which involves calendar ages of children in this project ranging from 3 to 5 years, should grow with the capabilities of the children and trigger them to explore and learn.

1.3 Reading instructions

This thesis shows my process and results. I split up these two to clarify reading. I start with showing the overall process and involved parties in chapter two. Here I explain what design methods I used and why. In this chapter an overview is depicted in which you can read the global structure as well. In the next three chapters, I show only results of exploration (chapter 3), conceptualizing (chapter 4), play-sessions with LINKX (chapter 5), and evaluation (chapter 6). Result of exploration (chapter 3) is a design framework for autistic children. Designers can use this framework as starting point for design. In conceptualizing (chapter 4) you can see how I used this framework to develop LINKX, a concept design from which an experiential prototype is built. Play-sessions with LINKX (chapter 5) served as reference for evaluation (chapter 6).

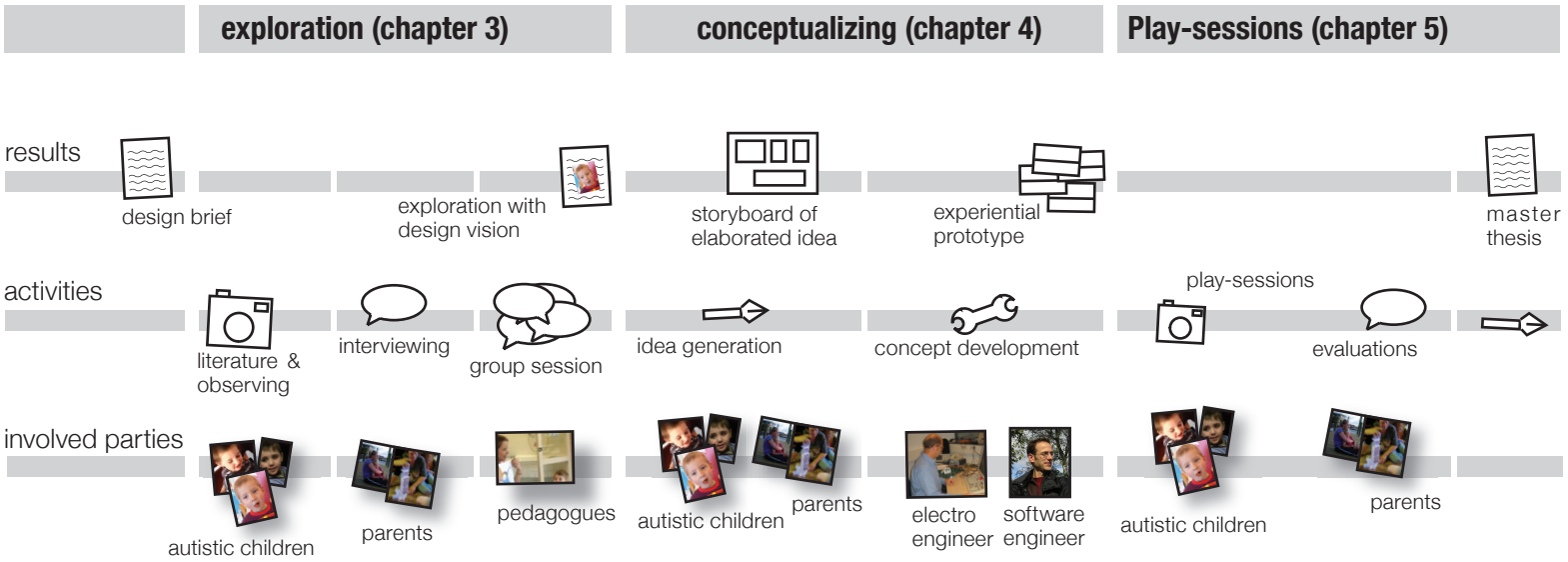
In the cover you can find a DVD. This DVD contains a digital version (PDF) of this thesis with movie clips. Movie clips are distinguished from images by means of a film roll in their caption. When you click on a clip, it starts playing. When you click on it again, it stops.

At the bottom of a page I sometimes appear with a text balloon. In these balloons I share my insights.

Enjoy reading!

2. The process and involved parties

Before going into depth about autism and the designed toy, I first show my process. My process consisted of three main phases which fluently transit into each other. These phases are exploration (chapter 3), conceptualizing (chapter 4), play-sessions with LINKX (chapter 5). After these three main phases results (chapter 6) and the process (chapter 7) are evaluated. During these main phases I used different design methods. In this chapter I tell in chronological order the used design methods and explain why and how I used these methods. The figure below gives an overview of the process combined with its (in between) results, activities and involved parties.



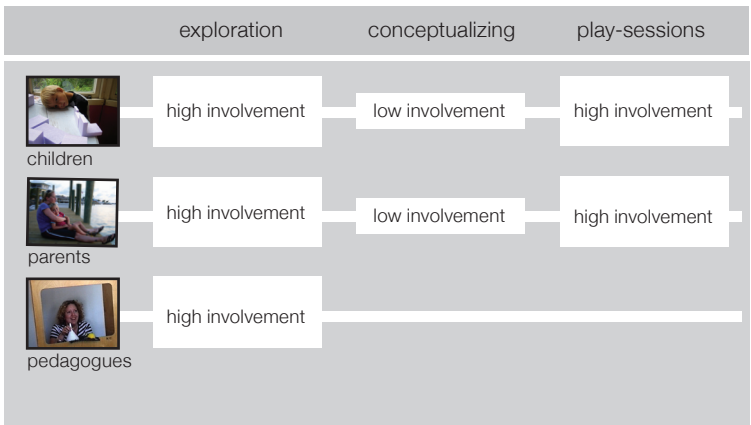
Overview of the process with (in between) results, activities, and involved parties

2.1 Exploration

During exploration I used contextmapping techniques (Sleeswijk Visser et al. 2005) to gain insight in the experiences and emotions of autistic children, their parents and pedagogues. These techniques provided me information and inspiration during conceptualizing. I used these techniques, because designers have the need for a direct link with users (Sanders and Dandavate 1999). Empathy with users is important for design (Koskinen et al. 2003). Contextmapping techniques enabled me to empathize with the children and their parents. Below I give an introduction to contextmapping techniques. After that I explain how these techniques are used in my design process.

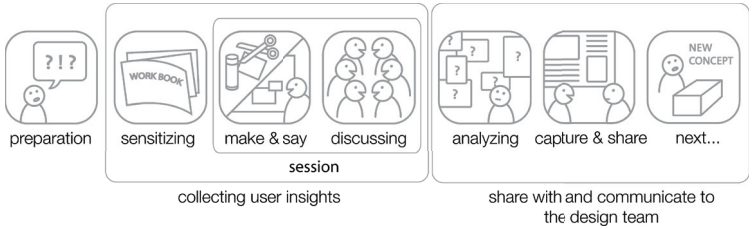
Contextmapping techniques: Involving 'autism experts'

Contextmapping data is gathered with people using methods such as cultural probes (Gaver et al. 1999, Mattelmäki 2005) and generative tools (Sanders and Dandavate 1999). These techniques evoke personal expressions of concerns, memories, needs, and dreams. Users are encouraged to take on the role of 'expert of their experiences', and to give their opinion about the matter. As depicted below, this principle of *putting parents and pedagogues in the position of 'autism expert'* is used throughout my whole process, not only during exploration.



The amount of involvement of different parties throughout the process

The figure below shows the steps involved in a contextmapping process. This process can be divided into collecting user insights and communicating these to a design team (Sleeswijk Visser et al. 2005). In this project I followed the whole process and shared the insights with 'myself'. The design framework that is result of analyzing, sharing, and capturing contextmapping data from exploration can be shared with other designers as well.



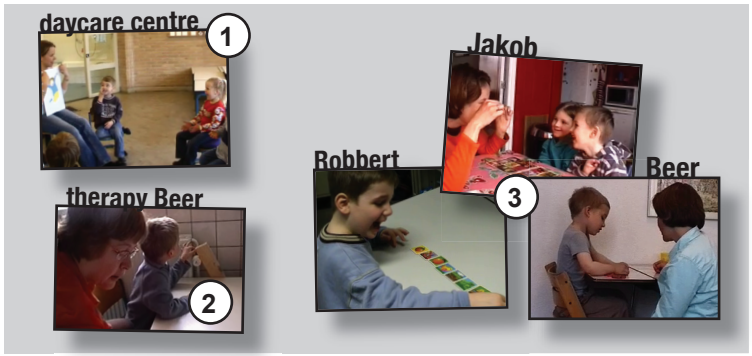
Steps involved in the contextmapping process

The standard form of collecting user insights in the contextmapping process involves users in three basic steps: sensitizing, 'make & say' and discussing, leading to progressively deeper insights (Sleeswijk Visser et al, 2005). During sensitizing, participants become aware of the explored topic by means of a booklet with small exercises that they are asked to complete over the course of a week. A typical session often includes three exercises: collage making with images and words, cognitive mapping with abstract images, and Velcro-modeling with 3D materials (Sanders, 2001). Every exercise is based on the principle of 'make & say'. In each assignment, users make an expressive artifact, such as a collage, that communicates their memories, feelings and experiences. During the making, participants build and formulate their ideas. After that participants present their artifact to the rest of the group. In the end participants discuss differences between and similarities in their artifacts. These techniques enable the researcher or designer to have a look at the context of product use.

Participants creating their artifact during a contextmapping session (van Rijn et al. 2006)

Literature research and observing children

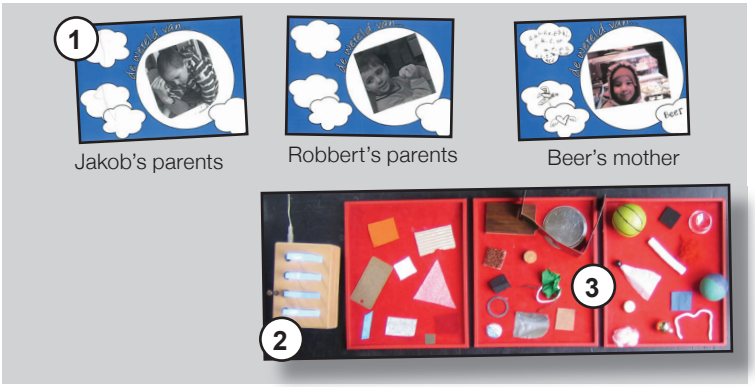
I started this project with literature research about autism and language learning. Besides literature research, I visited the medical daycare centre *'Albertus de Oudelaan'* in Voorburg. At this daycare centre a group of six autistic children with a calendar age of three to five years old gets education from three pedagogues. For two days I was part of their group and observed what they did during a day. This made literature come to life and provided insight in how children with autism play and what they like. After observing the children at school, I went along with the three participating children to their (speech) therapy to get a grip on their language skills. These three children are Beer, Robbert and Jakob. They will be introduced in chapter three. Gained insight from literature research and observation helped me to pose the right questions in further research during exploration.



Participating children in different situations and places: (1) an emotion lesson at medical daycare centre 'Albertus de Oudelaan', (2) therapy of Beer to learn all kind of skills, and (3) speech therapy of all participating children.

Interviewing parents

I conducted individual interviews with all participating parents. Main goal of these interviews was to gain insight in what their child triggers, and what aspects are important in their play and language learning. This was expected to be important for the future language toy. In these interviews I used contextmapping techniques, but with a somewhat different setup than explained before. Parents were only involved in sensitizing and discussing. They were not asked to 'make and say', because 'make' asks for attention and this is difficult with their autistic child around. Moreover, parents easily express their autistic child's desires. Parents received a sensitizing booklet a week before the actual interview. These booklets contained open questions that took about fifteen minutes per day. In the interview we discussed the answers parents gave in this booklet. After that we discussed what sensorial stimuli (e.g. light box, materials) their child likes, because this was expected to be an important trigger for play and learning. The parents of Robbert and Jakob completed the booklet together. These interviews combined with the booklets, let me take a look into their life and get a grip on what it is like to have an autistic child. All booklets are enclosed on the DVD.



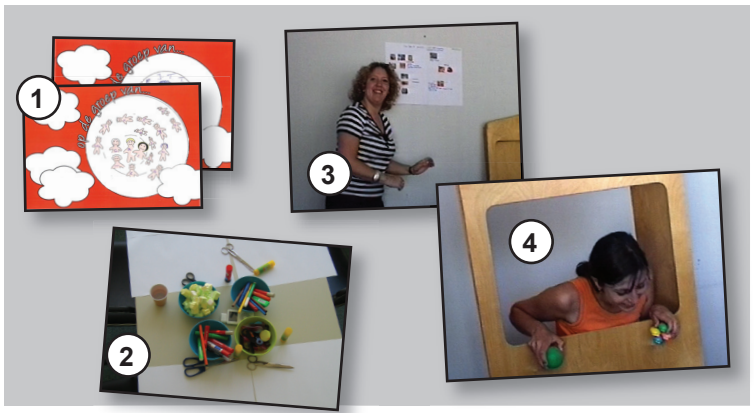
Tools that facilitated interviews with parents: (1) completed booklets from all parents, (2) a light box, and (3) displays with different materials.

Contextmapping session with pedagogues

Four pedagogues took part in a contextmapping session about language and communication development of autistic children. While the interviews with parents focused on the individual child and its personal preferences, the session with pedagogues focused on learning in general and how they achieved that with the children they work with. As said earlier, a standard contextmapping process involves users in sensitizing, 'make and say', and discussing (Sleeswijk Visser et al. 2005). In the session with pedagogues I followed this setup.

The four pedagogues received a sensitizing booklet a week before the actual group session. This booklet focused on how they teach language to children with autism.

The group session took place in a meeting room. Pedagogues were involved in three exercises. They first made a collage about what is important for teaching children with autism and the way these children learn. After that they made a cognitive map of the learning process of autistic children. Finally they did a Velcro-modeling exercise with 3D material about the ideal language learning toy for autistic children. Pedagogues presented this toy in the puppet theatre. This session helped me to get a grip on the learning process of autistic children.



Impression of the session with pedagogues: (1) completed booklets from pedagogues, (2) collage making kit for the first exercise, (3) a pedagogue presenting her collage about 'what's important for learning regarding autism', and (4) a pedagogue presenting her ideal language toy in the puppet theatre.

Exploration chapter

After researching literature, observing children, interviewing parents and a contextmapping session with pedagogues, I wrote my findings and insights on post-its and clustered them in themes. This led to a design framework for autistic children on the way autistic children learn language, how they like to play and where they are good at. I used this framework as basis for conceptualizing.

Clustered insights on my wall at home

The exploration chapter was sent to the cooperating parents and the pedagogues to check whether I interpreted their input correctly. Communicating my result kept them actively involved in my process.

2.2 Conceptualizing

Gathered insight from the exploration phase was used during conceptualising. The involvement of 'autism experts' was lower in this phase.

Idea generation

Ideas were generated, first in a brainstorm with fellow-students and later independently.

From all idea directions the best was chosen to be developed further. Important criteria were that the idea both fitted the child's way of learning as well as playing.

Idea generation with fellow-students: (1) clustering ideas in themes, and (2) preparing for a presentation of ideas.

Evaluating the elaborated idea with parents

To sustain the conversation with parents about the elaborated idea, I prepared a storyboard that told how parents and children would interact with this toy. I brought mock-up models of the idea to facilitate the communication. Children played with these mock-up models. Parents told me what they thought their child would do with such a toy and how they would react. This gave me a better view of the context of product use and what interactions I could expect. Goal of these meetings was to verify whether this idea fits the children. Because of the enthusiastic reaction of parents, I continued with the chosen idea. After these evaluations I continued to develop the elaborated idea into a concept. This evaluation with parents in this early stage was valuable for further detailing.

Evaluating the elaborated idea: (1) storyboard about the idea's interaction, (2) children playing with the mock-up models.

Experiential prototype

Next the idea was developed further into a concept design. From this concept design an experiential prototype was built. During concept development the 'autism experts' were not involved, although I once asked a mother by email whether her child would be triggered by the toy to exhibit certain behaviour or not.

2.3 Play-sessions

I tested the prototype with the three cooperating autistic children in several play-sessions. Goal of these play sessions was get insight in whether the children understand, like and are able to play with the prototype. Parents completed a workbook with questions about the concept. After and while each play session I evaluated the children's play with the parents and we discussed how we could improve the toy for their child.

Play sessions with the cooperating children: (1) Beer exploring the fishbowl, (2) Robbert exploring the babybike, (3) Jakob looking how his mom shows the operation of the prototype, Beer's mother and me together evaluating the session by means of the evaluation poster, and (5) a completed evaluation booklet.

2.4 Conclusion

Key aspect in my process was the involvement of 'autism experts', such as autistic children, parents, and pedagogues. In the beginning of this project they were mainly involved for information and inspiration. Later on they became important to evaluate my design solutions. Results of this process are a design framework for autistic children and an experiential prototype that is both a tool to verify this framework, as well as a design on itself.

After this chapter that shows my process, I present my results of exploration (chapter 3), conceptualizing (chapter 4), play-sessions (chapter 5), and evaluation of these results (chapter 6). Finally I evaluate my process (chapter 7).

3. Exploration: a map of the world of an autistic child

This chapter presents my result of the exploration phase. This result is a map of the world of an autistic child. This map can guide a designer into the experiences and emotions of an autistic child and thereby serve as inspiration for concept development. I end with a design framework that contains the most important interaction characteristics for autistic children.

This chapter contains a mixture of findings from literature research, observing children, and interviewing parents and pedagogues. I will introduce the three children who cooperate in this research. These children serve as an example and make literature come to live. After this I explain the neurological background of autism. Next to that, I tell what a different neurological background means for the development of children, especially that of language and communication. Finally I will give my gathered insight on their behaviour.

3.1 The children in this project

Three children are observed and their parents are interviewed. These children make the literature in this report come to live. That is the reason I introduce them before explaining more about autism. The children differ in age (both calendar- and developmental age) and in diagnose, but all have a delay in speech and language. By looking at these three children I got a broad idea of how autism effects their development.

Jakob

Jakob is a toddler of three years old. He lives with his mother, father, and sister Lucy in a house in The Hague. His sister Lucy is four years old. Jakob is diagnosed with autistic disorder. This is not further specified (yet). His developmental age of language and communication is conform a one year old.

Robbert

Robbert is an infant of 4 years old. He lives with his mother, father and baby brother Ewoud in a house in Delft. His brother Ewoud will celebrate his first birthday in August. Robbert is diagnosed with PDD NOS, a disorder in the spectrum of autism. He has a cognitive developmental age conform his own age now, but a delay in language and communication.

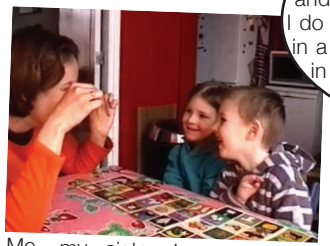
Beer

Beer is an infant of five years old. He lives with his mother in a house in The Hague. Since a year his mom and dad are back together and during weekends they do nice things together. Beer is diagnosed with classical autism. One year ago, he had a developmental age of fourteen months, but mom assumes the developmental age has increased to the age of three.

Now I will introduce these children more detailed. After this I show my insights by means of video clips, quotes of parents and pedagogues.

Jakob

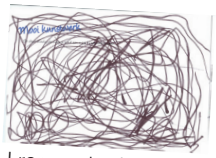
I am fascinated by colours, and like to play with numbers and letters. I can name them, but I do not always speak aloud words in a comprehensible way. I speak in one word and like to label things at the moment.



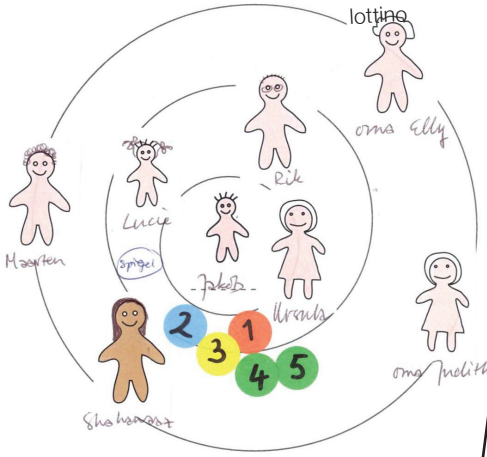
Me, my sister Lucy and my speech therapist

I love to play with lotting

I love to look at myself in the mirror, although it took quite a long time before I discovered this. When I sit on the back of my mom's bike, I look in the windows of cars to see myself. I also name the colours of the cars. Because my mom believes I learn from looking in mirrors, we have a mirror on the ground in the living room.



I research the possibilities of materials



My world with family and toys

Normally a baby sitter comes in the morning. In the afternoon I have therapy. On Wednesdays I have speech therapy. The other days my mom and I have training to learn how to stimulate verbal communication between us. My mom says I like everything and am a happy child.

The order of my favorite toys changes over time, but puzzling is constant. For this moment, it is like this:

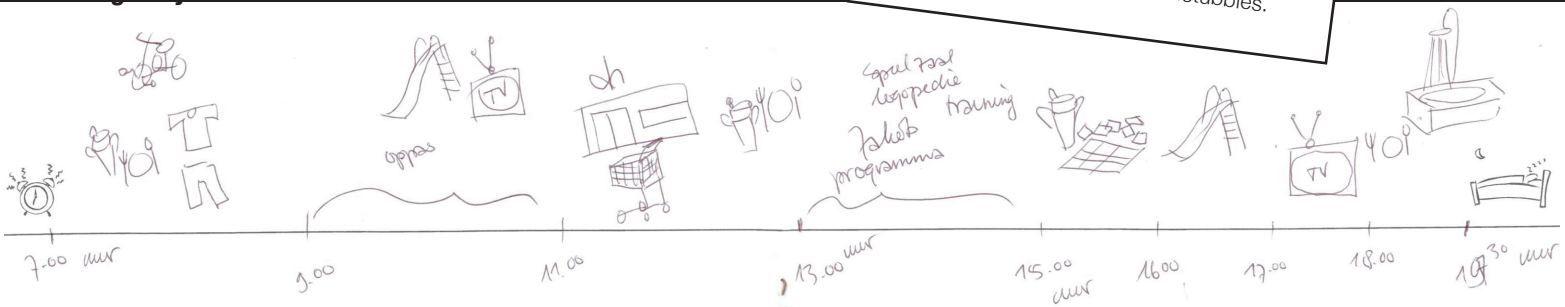
1. Puzzling
2. Lottino
3. Riding his bike
4. Playing with the ball
5. Playing with his cars

I play with toys which I can organize and arrange. I like elements that make a whole. I pile up my lego sorted on colour. Also while puzzling, I arrange the pieces.

My mom does not believe my toys are closer to me than family. My favorite spot is at the table, where I can puzzle, and play with lottino. I like to watch television; especially the teletubbies.

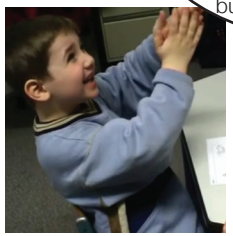
I just learned how to ride my bike

An average day in Jakob's life

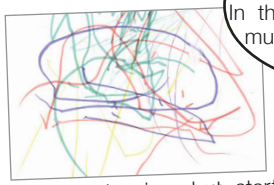


Robbert

I speak in sentences of three words, supported with gestures. When it becomes difficult, I continue in my own language. When I enter a new situation I search a phone in which I can babble in my own language, while I observe. This can be toy phone, but also a remote control.



My CD's of 'Ernst, Bobbie en de rest'

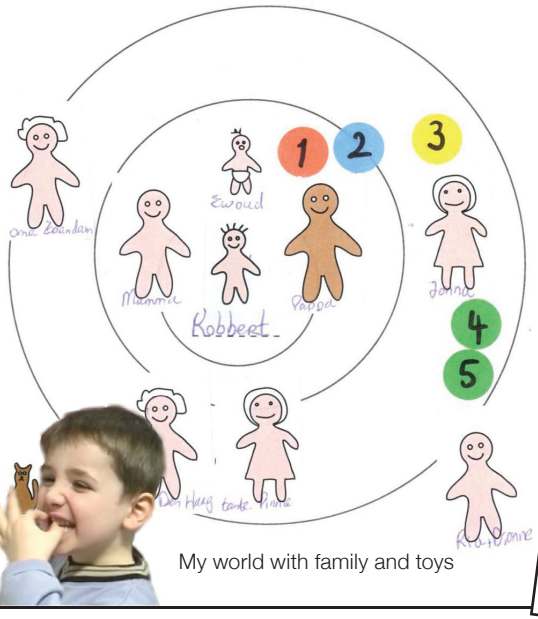


I dislike drawing, but start to give meaning to my drawings.

My favourite spot is my beanbag at home. In this beanbag I listen to music, watch TV and read my magazines.

My favourite spot

Normally I go to school. Before school I watch television at home. In the taxi I bring my magazines to make me feel secure. In the afternoon I watch television, play with the ball, the computer, and my CD's. According to my mom, the computer is a temporary obsession.



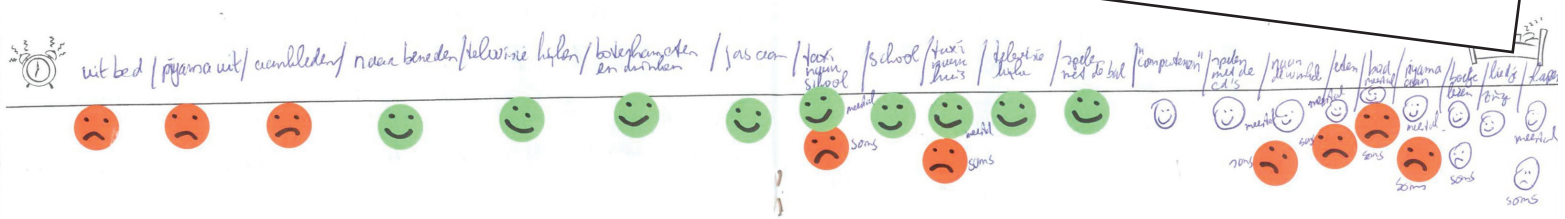
My world with family and toys

According to my mom, i like the following:

1. CD's of 'Ernst, Bobby en de rest', DVD's
2a. Magazines of Sesame Street, Walt Disney and Bobo
2b. Telephone
3. Playing with the ball outside
4. Computer games
5. Blowing bubbles

I love my CD's of 'Ernst, Bobbie en de rest', my magazines and my DVD's. When a CD of 'Ernst en Bobbie' is missing, I always notice. My CD's are very special to me. I not only listen to them, but also name them, open and close the boxes, watch the covers, show them to others and speak sentences of the CD's to myself and others. I like to listen to music a lot. From the lyrics of songs I learn language. Although in the beginning I will repeat sentences without understanding meaning, I sometimes later apply them in real life.

An average day in Robbert's life



Beer

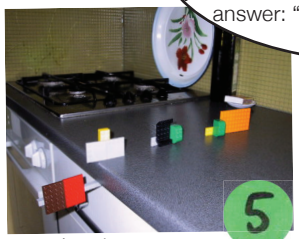
I watch numbers and letters from real close

I am fascinated by numbers. Also by letters, but mainly if they form a number (e.g. one). Out of my baby buggy I checked house numbers, and therefore I am good at plus and minus two. My first word was 'eight'. I can repeat words and read, but have trouble with giving meaning to words. I hardly talk.

I write numbers with french fries.

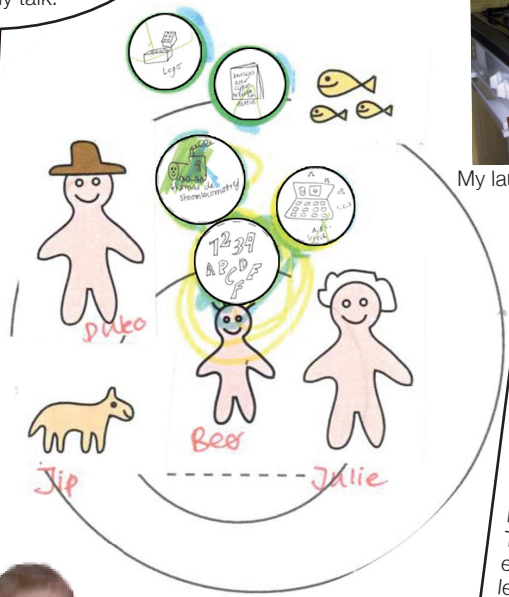
I draw numbers and letters

I research everything around me. When I was younger I made landmarks in the house with lego. I like to watch myself in the mirror, although I do not recognise myself yet. When my mom asks: "who is that?" I answer: "happy!"



My landmarks

I study Thomas the tank engine a lot



My world with family and toys

Normally I go to the medical daycare centre in the morning. In the afternoon I am home. Twice a day I have PIBA training, in which I learn practical things like words and actions. This training makes sure I never fail, by starting at the end of an action. Rewarding me every time, motivates me a lot. I like this training, but sometimes I find it hard to stop playing, and start working.

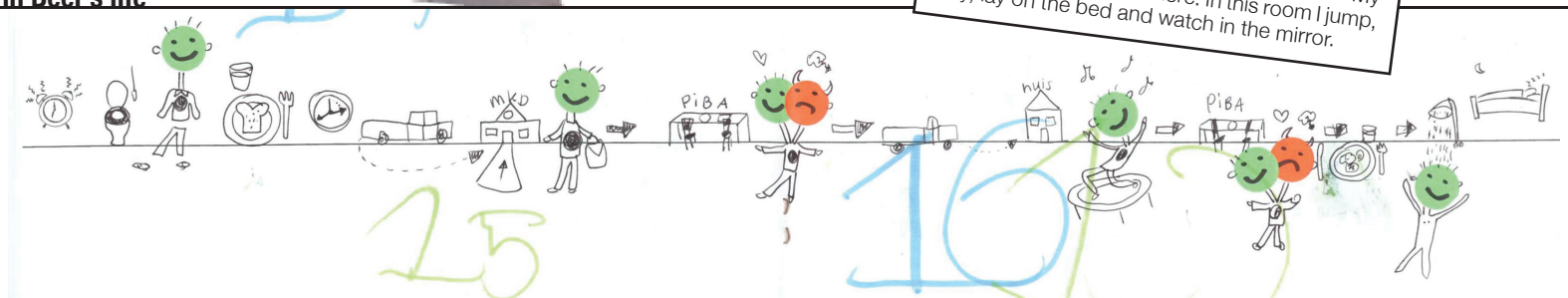
My mom says I like the following toys, but the order changes sometimes:

1. Numbers and letters
2. Thomas the engine machine
3. ABC computer of V-tech
4. Books about numbers and letters
5. Lego

I like to play with Thomas the tank engine, because these trains are based on numbers. Thomas is one, Edward is two, Pursey is three, etc. The basic elements of my play are numbers, letters, organising and ranking. I like to create order.

My favourite place is my mom's bedroom. My toys and trampoline are here. In this room I jump, play, lay on the bed and watch in the mirror.

An average day in Beer's life

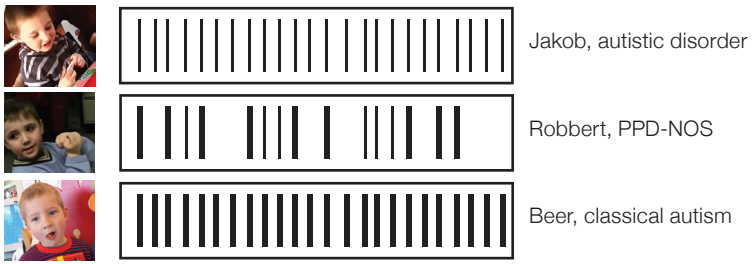


3.2 The underlying processes of autism

The children introduced in the previous chapter have a disorder in the spectrum of autism. Autism is a developmental disorder, which affects around 91 people in every 10.000. Leo Kanner (1943) is the first to describe early infantile autism. It affects three to four times more male children than female. There is much variation between autistic children and also within one child the diagnosis can change over time. Affected children may display a range of disabilities at many levels. Therefore it is better to speak of children with the autism spectrum disorder. In this report I refer to this as children with autism. The autism spectrum disorder consists of a number of classifications, including PDD-NOS (Pervasive Developmental Disorder - Not Otherwise Specified), Aspergers syndrome (sometimes referred to as 'high functioning autism') and classical autism. By means of the three participating children I explain the variation between these classifications.

Bar codes

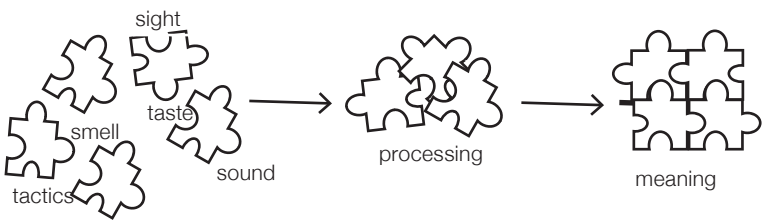
Differences in the autistic spectrum is visualised below as bar codes (de Bruin, 2004). The thickness of lines indicates the severeness of the autistic behaviour. The placement of the lines indicates whether or not a child exhibits autistic behaviour in an area. Jakob is diagnosed with 'autistic disorder'. This means he scores in all areas as autistic, and therefore has lines everywhere. Because he does not exhibit extreme autistic behaviour, the lines are not thick.



Robbert is diagnosed with PDD-NOS. This means he exhibits autistic behaviour in some areas, but not all. This is illustrated with some empty spots in the bar. Some lines are thick, and others not. Beer is diagnosed with classical autism. This means he exhibits much characteristic autistic behaviour in all areas. Therefore lines are thick and positioned everywhere.

Perceiving in pieces

Children with autism perceive differently than children with typical development; they perceive in a fragmented way. Autism is a inborn disorder in the brains. Perceiving is done with your senses: eyes, ears, skin, mouth and nose. This information is transferred to the brain, where the information is processed and gets meaning. Children with typical development process information subconsciously into a whole. Children with autism perceive stimuli as separate pieces. Children with autism first have to consciously process stimuli into a whole, before they can give meaning to what they perceive. So every time a child with autism sees, hears, and feels, it needs to puzzle. This processing time can vary from seconds to a month. After processing he can give meaning to it and also this is difficult. Children with autism have trouble finding the reference again. When they are ready with processing reference can be gone, because it took so much time. This process of perceiving is illustrated below.



This different way of perceiving makes children with autism run behind in many aspects of their development, including language and communication, which is the focus of this project.

Missing mirror neurons

A recent discovery is that autistic children do not fire mirror neurons in their brain (Giacomo, 1996). A mirror neuron fires both when an animal performs an action and when the animal observes the same action performed by another. Thus, the neuron "mirrors" the behaviour of another animal, as though the observer were himself performing the action. In humans, they have been found in Broca's area and the inferior parietal cortex of the brain. Ramachandran states that mirror neurons are important for imitation and language. Therefore, also these missing mirror neurons can explain why children with autism have trouble learning language.

Thinking differently

Children with autism perceive differently, and therefore think differently. In literature three theories are important: central coherence, executive functions and theory of mind. These theories are based on the principle of perceiving in pieces. Below these theories are briefly described.

Central coherence

Because children with autism have difficulties with processing stimuli into a whole and give meaning, they easily loose overview and panic. Therefore details are important. They cannot distinguish between prominent and side issues.

Executive functions

Performing a task asks for knowing the order of activities and therefore organisation and planning skills. Because children with autism have trouble seeing coherence, they also have difficulties with performing tasks. Therefore they need structure.

Theory of mind

The ability to see the inside of yourself and others is called theory of mind (ToM). Children with autism have a low ToM, and therefore difficulties with understanding the feelings and thoughts of other people (Baron-Cohen, 1993). They call this a special impairment in 'mind-reading mechanisms'.

The consequence of having atypical brains

The different set up of the brain of children with autism makes them develop and behave in a different way than children with typical development. In the next chapter I start to explain the developmental issues of these children. Successively I show the observed behaviour of the children and tell my insight about this.

3.3 Language development of children with autism

In this chapter I discuss in what way the development of children with autism differs from children with typical development. After this I go briefly into other developmental areas, such as cognitive, motor, and social development.

Communication and language

Communicating is sending and receiving messages. It is an interactive process; there is reciprocity and feedback. We communicate in an explicit and implicit way. An explicit message contains the content. An implicit message contains an intention. It is the underlying message, communicated by how we say it. We communicate in language, both verbal and non-verbal. Examples of non-verbal language are body language, facial expression and gestures.

Symbols and pictograms

Most human beings have the capacity to creatively use symbols, such as pictures, models, and maps. Symbols are systems for representing our thoughts, feelings and knowledge, and communicating them to other people. Because symbols are such an important source of learning, becoming symbol-minded is a crucial developmental task for children (DeLoache, 2002). Children with autism often read symbols easier than the spoken word, because an image stays visible, while a spoken word is temporary.

How to use the toilet?

Which toothbrush belongs to whom?

Pictograms at MKD ‘t Kleine Loo

Language

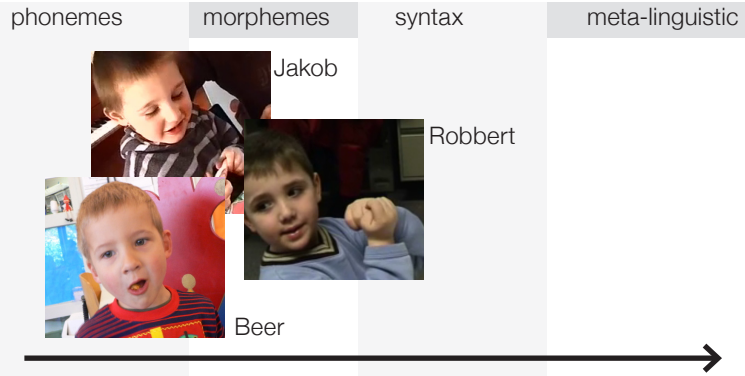
Using language involves both comprehending what others say, and actually producing speech. Comprehension precedes production: children understand words and linguistic structures other people use, before they use them their selves (Goldin-Meadow, Seligman, & Gelman, 1976).

All languages are based on a system of rules for combining different kinds of elements at different level of hierarchy. Sounds form words, words form sentences, and sentences form narratives. Therefore acquiring language involves learning the language’s sounds and sound patterns, its specific words, and the ways in which the language allows words to be combined. It also involves how language should be used in communicating with others. The benefit that emerges from this combinatorial process is generativity. By using the finite sets of words in our vocabulary, we can generate an infinite number of sentences, expressing an infinite number of ideas. Below I will list the elements of language and tell in which stage the participating children are at the moment.

Phonemes. Phonemes are elementary units of sound used to produce languages, and they distinguish meaning. Therefore, the fist step in children’s language learning is phonological development.

Morphemes. Morphemes are the smallest units of meaning in a language, composed of one or more phonemes. Morphemes, alone or in combination, constitute words. The second step in learning language acquisition is semantic development. This is learning the system for expressing meaning in a language, including word learning.

Syntax. For every language, a large set of rules – the syntax – specifies how words from different categories can be combined. Examples of these categories are nouns, verbs, adjectives, etc. Syntactic development involves learning the syntax, the rules for combining the words, of a language.



Involved children positioned in the sequence of language development

Metalinguistic knowledge. Finally, a full understanding of the interaction would necessitate knowledge of cultural rules for using language. Practical development refers to acquiring knowledge about how language is used.

The figure above is about the language production of the three children in this project, about their active vocabulary. Beer is busy with phonemes. He makes a lot of sounds, but these sounds often do not make sense. Once in a while he speaks a meaningful word, especially numbers. Jakob is in the phase that he likes to label things. It is difficult to hear, but he makes a lot of meaningful sounds, which even form words, morphemes. Therefore I positioned him more to the right. Robbert makes small sentences of about three words. He is busy with the syntax of language. His active vocabulary is bigger.

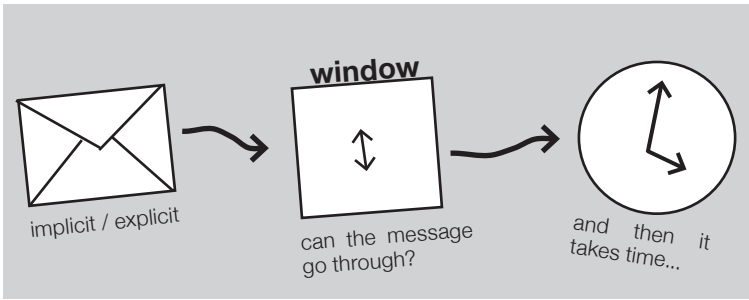
Reciprocity

In the first five to seven years children learn language and social rules. This happens in a process of reciprocity. Reciprocity is the reaction of the other from which can be read how the message is received, also called feedback. This stimulates children to adjust their behaviour. Feedback is important as reward and encouragement for our efforts. Eye contact is very important in this. Children with autism have a deficit in reciprocity and therefore emit weird and confusing signals. Signals are misunderstood.

Processing information and stimuli

Basis of communication is processing information and stimuli. Autistic children perceive fragmented and therefore communication is often impaired. Communication involves at least two persons and has a lower and upper boundary. You have to be awake and able to process the amount of stimuli. Children with autism have a small window. For communication with an autistic child, you have to search for their window. An explicit message with an implicit appearance is difficult to understand. Processing takes time. You send messages, but a reaction stays out. This process is depicted below (Van der Gaag, 1996).

There are also children with autism that have a very big window, without being able to send something through. The child obstructs it with a continuous stream of his own messages. These children speak a lot about their favourite subjects, but do not listen. Contact is also severely disturbed by these children.



Visual of how communication with an autistic child takes place according to Van Der Gaag

Communicational symptoms of autism

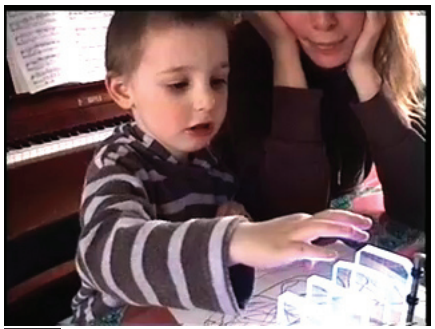
The impairment in processing of stimuli plays an early role in the development of language and communication. An important form of communication is joined attention. Children with autism look at your finger instead of where you are pointing at and make no or less eye contact.

Beer learning to make eye contact

At the movie of Beer on the right, you can see that Beer learns to make eye-contact and how difficult this is for him. He does not know how to interpret the eyes of the therapist.

Lingual symptoms of autism

Children with autism acquire fewer words, and do not understand gestures. Echolalia, repeating what is said, is normal in language development. Children learn through repetition, but soon it disappears. Children with autism use echolalia much longer.



Jakob repeats the word 'blue'

At the movie on the left can be seen how Jakob repeats the word 'lauw' (blauw, blue in Dutch). He does this all the time with the words he knows.

Neologisms are self-made words. Children with autism use neologism much longer than children with typical development.

Also the use of I-me-you is more disturbed than with children with typical development. It represents the impairment in reciprocity of communication.

Autistic children also have problems with generalizing learned language. Why do all pens have the label pen, while they differ so much? With typical processing of stimuli this shift is easily made, but children with autism do not link this spontaneously and have to learn this over and over again for every new thing.

In the table below I will list other lingual symptoms I found.

Table 1: lingual symptoms of autism (source: Expertise centrum Autisme)

Non speaking
Talking against instead of with you
Talks about the same subject over and over
Difficulties with jokes and expressions
Peculiar rhythm, pitch, volume
Functional use of language
Hardly speaks spontaneously
No intonation
Difficulties with jokes and expressions
Laughs non communicative
Difficulties with non verbal communications
Echolalia
Only literally understanding of language

The typical process of language acquisition

The typical process (Siegler et al., 2002) will be shortly described below. I will indicate where children with autism have difficulties in this process.

Speech perception
Learning language starts with perceiving speech. From the sounds you hear, children have to learn to filter speech. This is something children with autism can have trouble with, because they perceive in a fragmentary way.

Preparation for speech production
In their first months, babies are getting ready to talk. The repertoire of sound production is extremely limited. Around six to eight weeks, infants suddenly begin tp produce simple speech sounds. Through this practice, the motor control over their vocalization steadily improves. At the same time their sound repertoire is expanding, infants become increasingly aware that their sounds elicit responses from others. They begin to engage in dialogues with their parents and imitate their sounds. Children with autism often lack this reciprocity.

Babbling
Between six and ten months babies begin to babble. Standard babbling involves producing syllables made up of a consonant followed by a vowel ('pa'), which is repeated in strings ('papa'). Babies actually babble a limited set of sounds, including some not in their native language. A key component in the development of babbling is receiving feedback from the sounds one is producing. As infant's babbling becomes varied, it gradually takes on the sounds, rhythm, and intonation patterns of the language infants hear daily. Therefore, before they utter their first meaningful words, infants are, in a sense, native speakers of a language. Also here often children with autism misinterpret feedback.

Early interactions
Before the next big step in language production, it is important to consider the social context that promotes language development. Even before infants start speaking, they display communicative competence, the ability to communicate intentionally with another, and this is exactly what children with autism lack.

> *Turn-taking.* The first indication of this competence is turn-taking. In a conversation, mature participants alternate between listening and speaking. Children with autism have difficulties with knowing when it is their turn to do something and when not.
>
> *Reciprocity.* Successful communication requires reciprocity. Children with autism lack this competence which gives no steady base for language development.

First words and sentences
Normally naturally words result from babbling. When children master fifty words, they are ready to make sentences of two words.

The way of (language) learning

It is evident, that children with autism do not learn language on a typical way. They lack reciprocity, turn-taking, and imitation. There is no base to learn from their environment. In this section I will give my opinion about how I think that children with autism do learn language, based on the interviews with parents and the session with pedagogues.

An interesting fact is that children with autism learn language better from a voice in the environment without a person, for example from a speaker (Frith, 1989). Children with typical development learn better the other way around; from a real person.

First I will give a story of Beer's mom, which explained how Beer learned to say: *"I want a cookie".*

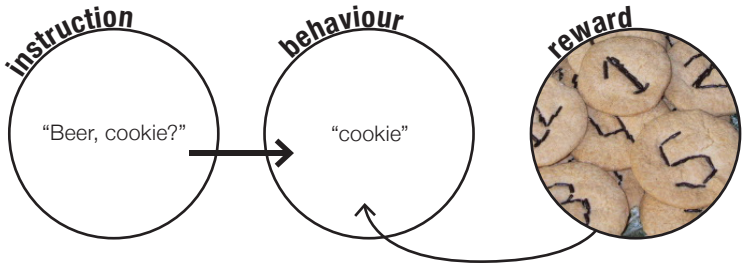
I started to talk to Beer in two words. You have to degenerate a sentence, because otherwise he will not understand the message. I asked him: "Beer cookie?" When he answered: "cookie", he received a cookie. Step by step we came to say to him: "Beer, I want a cookie". Than he said: "Beer, I want a cookie". On this I answered: "Do you want a cookie?" and than he said: "Do you want a cookie?". This took months, but eventually we learned him: "Say, I want a cookie". First he said: "Say, I want a cookie", but little by little he understood 'say' is an instruction and he knows now he has to repeat 'I want a cookie' to get a cookie, because every time he does it right, he receives a cookie as reward."

To make the cookies interesting to eat, his mom decorated them with numbers. Unfortunately he liked playing with them more than eating them!

From this story the key elements of learning can be derived, such as time, patience, repetition, and rewarding. Beer does not understand reciprocity in a conversation. What's an instruction and a question?

Operant conditioning

The only way to learn Beer something new, is operant or instrumental conditioning. With operant conditioning, children learn the relation between their own behaviour and the consequences of this behaviour. By rewarding good behaviour, children repeat this, because they want the reward again. This principle is used in learning of every child, but for children with autism this is often the only way. Everything needs to be 'programmed', nothing goes automatically, since there is no reciprocity, turn-taking, and imitation.

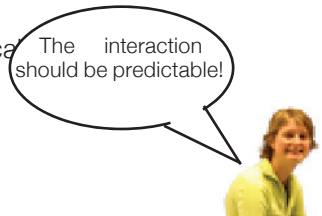


The way Beer learned to say 'cooky' by means of operant conditioning

Instruction. An instruction should be offered identically each time, otherwise autistic children will not understand your intention. When an instruction differs from the instruction before, it does not match the one in their memory. In this case they do not know what to do with it.

Behaviour. Of course they will not always exhibit desired behaviour. In this case it is best to *repeat* the instruction all over again. When the child comes close, for example he says 'coo' he can be rewarded as well. Pedagogues said you have to keep the capabilities child in mind. Negative behaviour needs to be ignored, not punished.

Reward. Also a reward needs to be identical over time as well. If not, they panic.



Meaning

Another important issue in learning language is understanding meaning of language. Children with autism are capable of repeating words and sentences (echolalia), but have difficulties with giving meaning them. A pedagogue said you could just as well learn a sentence of five words, instead of just one word. The only difficulty you encounter according to another pedagogue, is that they do not understand the meaning. What refers to cookie, I, want, a, or cookie? Therefore in my opinion, you have to start with learning one word, the word that refers to the object you want to learn the label of. So, start with the cookie, and them building a sentence around it. To be able to give this meaning they need to have reference.

Jakob is instructed to choose

That children with autism sometimes do not understand the meaning and consequences of things, can be seen on the left. The speech therapist asks him to choose between to images, the tree or the cow. She says to Jakob: “Do you want the tree or the cow?” His reaction to this question is laughter. He does not know what to do. When the therapist chooses for him, he can label the card as ‘tree’. So labelling the card is possible, but the meaning of the instruction ‘choosing’ is not understood.

Usefulness

With operant conditioning you can learn a child with autism any word you like. For a child however, it is important to learn words that are useful, so he can function in society. Therefore I want to learn them words that are in their direct environment. These are words you can add social communication to in a later stage of life.

Repetition and time

Children with autism need time to process stimuli into a whole. They need to repeat a lot, before things are learned, or better said, ‘internalized in their system’.

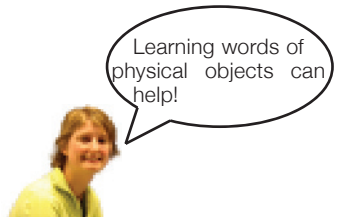
Language vision

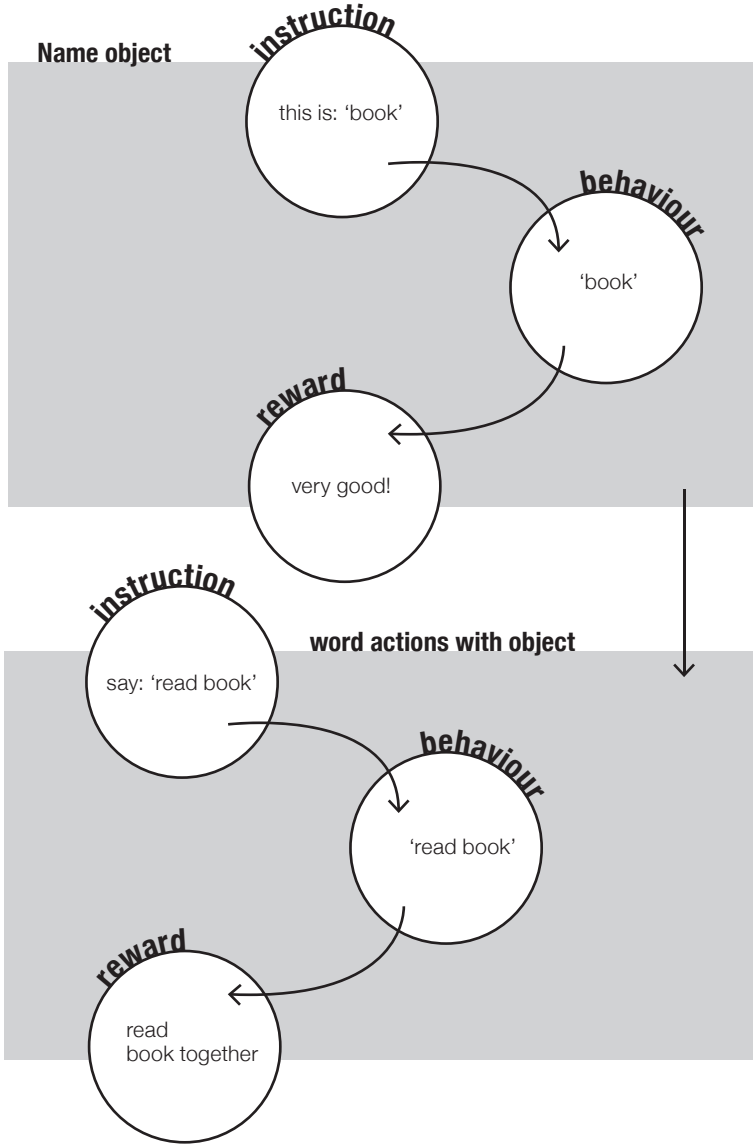
These language findings result in a vision on language learning for the future toy. I illustrated this vision on the next page. The toy should enable children to label objects with words. For learning the meaning of words, it is important that reference is close and clear.

When they do something correct, they will be rewarded to reinforce this behaviour. Probably it will take a lot of time and repetition before they have internalized a word.

When children master the word of an object, they can start to word the actions belonging to an object. Of course, this can be more than one action. You can read a book, get a book, open a book, etc. In this way they can experience what they say, and this is better for their linguistic understanding. Also here rewarding, time and repetition stays necessary.

Finally they can expand these sentences to indicate what they want, like: “mommy, can you read me this book?” In this way they learn language is a mean to get what you want.





3.4 Other areas of development

Autism does not only affect the development of communication of language. Briefly I will list atypical cognitive, motor, and social development in tables (Expertise centrum Autisme). Next to this I will share my insights clustered on the themes I found.

Cognition

atypical attachments to objects
difficulties with non-present things
preference for repetition
limited imagination
special interests
difficulties with content of read story

Motor

Stereotypical / repetitive movements
Flapping
Walking on toes
Moving rigid / mechanically
Over activity
Jumping
Spineless

Social

non-reacting
reacting extremely
Communicates functional
Not able to wait till turn
No eye contact

3.5 Tuning the different senses

As explained, children with autism perceive differently than children with typical development. Incoming stimuli, such as sight, sound, tactics, smell, and taste are perceived fragmentary, and not as a whole. This makes children with autism sometimes oversensitive, but also insensitive for perceiving with a specific sense. According to Jakob's mother *incoming stimuli are less disturbing when they are expected. His therapist added to this remark that choosing if these stimuli come is important as well. When the child controls the stimuli they will not be disturbed.*

Sensorial integration

This perceiving in fragments is referred to in literature as lacking sensorial integration. For improving this, they have therapies in which they brush the child real hard. They also test which parts of the body are most sensitive and which are not. All three children have done this therapy.

Self-stimulation

This search for sensorial integration often results in self-stimulation. This is some kind of sensorial research the children conduct. Robbert has never exhibited this behaviour. Jakob only does it with something really new and strange. His mom said: *"At the centre of autism they gave him a weird thing with shelves on it. I have no idea what it was. Jakob grasped the thing and put in his mouth. It was a long time ago he did this."*

Beer researches everything around him. He likes to look at things from real close, while he touches it with his finger. He puts things on his ear, closes one eye.

At this movie you see Beer researching the box, by looking from real close and touching it. After this he puts the blocks against his mouth. "What kind of sound do I make like this?", he wonders. After this he puts them against his ears, to hear what the world is like in that way. Beer is constantly trying to tune his senses.

Beer researches a yellow box

At this movie you can see how Beer researches what the walls feel like when you walk. While he walks he puts his entire body against the wall, but especially his head.

Beer researches the walls

At the next movie Beer sees a beam and gets distracted. He looks at it and touches it with his finger to feel the structure. After this the therapist removes the beam to keep attention.

Beer researches the beam

At this last movie about Beer's research, he is researching the blocks. After watching this movie several times I discovered he made a two and a three with the blocks.

Maybe linking language to their research can help them learn language. For example if the block says 'block' while touching it, this word can eventually be internalized as block.

Beer researches the blocks

Deep pressure

Children with autism like deep pressure. All three children like it, and Beer the most. Deep pressure lowers the incoming stimuli of the body (De Weerd), and this makes their world less complex. You can imagine that this relaxes these children.

At this movie you see how a ball rolls over Beer's body. You can see he likes it, because he throws himself under the ball. While the therapist bounces the ball on him, she words the action: "*on Beer*". Beer also likes to sleep with a heavy doll on his head according to his mom. This makes him feel relaxed.

Beer likes the ball on his body

Jakob's mom says he does not like to be caressed. When he shows affection it is a real firm embracement. In fact they all have this. Beer's mom says: *'Beer is now a bit becoming very cuddling. When he was younger other people saw this as cute, but now they think it is strange when he wraps himself around a stranger.'*

Beer likes to cuddle roughly

At this movie Beer is asking for attention. Sometimes he presses himself towards the pedagogue. According to his mom, he sometimes does this to strangers who do not understand why he does this.

Robbert loves to sit on his beanbag. He sinks into the material and this presses on his body. This relaxes him.

So all children search for pressure in some way. All parents said this pressure is a good way to reward them.

Robbert's beanbag

Jumping

Jakob, Robbert and Beer all love to jump. Jakob has a big mattress in the living room to jump on. Robbert has a trampoline on the camping. Also Beer's mom bought one, to make less noise for the neighbours downstairs. According to Jakob's mom the pressure feels nice under Jakob's feet while he jumps. To my opinion it can also have to do with the world that changes while you jump. In all different postures the world looks different.

Beer's trampoline with a number experiment

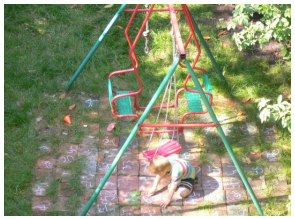
At the movie below Beer jumps around. He does this all day. If you link the jumping activity to learning language, they can learn a lot. I discussed this with the pedagogues and they said it would be good to try this.

Beer jumps around

Rhythmic movement

Rhythmic movement creates attention and focus. At this movie, Beer moves rhythmic on the ball. While he moves the therapist says: “one, two, one, two’. And he also says this himself later on. Difficult is trying to let him say something else on the ball. The therapist tried to sing a song with him, but he could only say: “one, two”. The ball is linked in his brain with ‘one two’. While she moves Beer back and forth she presses him together. As said earlier, he likes this pressure.

Beer moves on the ball



Beer writing numbers with crayon under his swing

Beer’s mother gave another example of movement and learning language. *She said that Beer could repeat real long sentences on the swing. He could repeat her and say: “I fly as a bird in the sky’.*

When I told this to Robbert’s mother, she said *learning on a swing would not work*. According to her Robbert is in his own world on this moment. It is difficult to make contact on this moment.

A physical rhythmic movement supports language production. Robbert speaks with gestures. So while he talks, he performs a gesture. His mother beliefs words are easier to produce for him when he does the gesture matching the word. So I think it can also help the children, when a physical action is related to the word.

Mirrors

During my interviews all parents told me about the fascination of their child for mirrors. During the interview with Jakob’s mother, Jakob himself was riding on his bike. Every time he passed the mirror, which was standing on the floor, he looked in it. In this way he could see himself. His mother thinks he learns from watching himself in the mirror. In this way someone repeats him. She thinks he likes this, because his mirror neurons do not fire. According to her, he compensates it in this way. But this is not scientific proven.

At the movie on the right you see Jakob immediately grasping the paint cover. According to his mother this is interesting for him because it mirrors and it is round. He watches himself from real close and moves his in front of his eyes.

Also Beer likes the mirror. It is positioned in his playroom near his trampoline. According to his mother belongs watching in the mirror to his favourite activities.

Finally Robbert likes to watch himself in the windows of houses, while he is playing football. According to his mother sometimes he does not perform well, because he is more focusing on his reflection than his activity ‘hitting the ball’.

The pedagogues said many children with autism love looking into mirrors, but some children are very afraid to do so.

A mirror attracts, but it distracts from learning. A mirror could be used as reward, but never it as mean to get attention.

Jakob likes the reflection in the lid

The way they play

Children with autism interact and play differently with material. A 'normal' child plays with objects out of curiosity, while a child with autism is more passive. He will not spontaneously grab toys and explore, but stay in a more stereotypical, repetitive behaviour. Toys do not evoke intentional play. A ball is for spinning, not to throw with. Children with autism need to learn the function of toys and play. In this section I give my insights on this matter.

Squeezing

Related to pressure and movement is squeezing in foam. I observed this by Jakob and also the another boy likes to hold a foam car in his left hand. At the movie on the right Jakob gets other material in his hand and puts them back right away. Eventually he grabs the foam thing again. Jakob's mother gets it eventually out of his hand. I think they like foam because when you press, it returns pressure.

Jakob squeezes in foam

Things that turn

Children with autism like things that repeatedly make the same movement, things that turn. When they play with a toy car, they often only turn the wheels. Beer was very good at making things spin around. When he was one and a half years old he could make primo blocks spin, but also coins. There are also children with autism who love to sit in front of the washing machine. Jakob loved to play with round toys, preferably red.

No pretend-play

Since children with autism lack imitation, they do not easily develop fantasy play. Beer puts his doll to bed, but only because he is conditioned in this way, his mom said.

Two-dimensional play

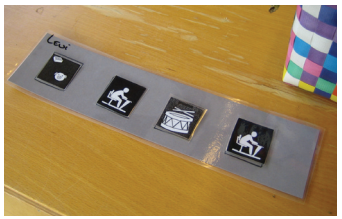
Children with autism like to play with 2D materials, such as memory and lotto. One pedagogue called this 2D play. Maybe because 2D materials have less visual input to process; it simplifies their world. The children love putting elements into a sequence.

3.6 Creating order

If you imagine what it would be like to perceive in fragments, you can maybe understand a little bit what it is like to be autistic. Everything needs to be explicitly stored in your memory, and every time you see a thing, you have to remember whether you have seen or experienced it before. In this case you can recall it, otherwise you have to store it. This storing is a process that has to be done many times before it is internalized.

Need for structure

Children with autism do not automatically know the order of things, due to the fact they perceive fragmentary. Getting dressed is difficult, because they do not know from logic that underwear comes before trousers. They have pictograms to help them structure their life. When they have internalized an order of e.g. the ritual 'getting dressed' these pictograms can be removed. On the right you can see an example of the pictograms used at the medical daycare centre. Even free play needs to be structured. They can choose the pictograms themselves and thereby they learn they are in control of what they do.



Pictograms to know with which toys you will play during 'free play'

Beer does not understand the transition to a new activity

When a transition to a new activity goes too fast, or is unexpected, the child can panic. At this movie you see Beer in his transition from claying to playing with the ball in speech therapy. You can see the therapist uses deep pressure to calm him down.

Memory

Because nothing is stored automatically, children with autism have an excellent memory. This is the part of the brain they function on. They do not understand things, they remember things. Beer for example sees the numbers and letters in the part of the brain where 'normal' people see images. That is the reason why he can order the alphabet from Z to A without any trouble. Try it, and you will see you can not do it like that. On the right you can see in what way Beer does this with numbers. Putting also the numbers upside down is his play element.

Beer stores numbers and letters visually

View on details

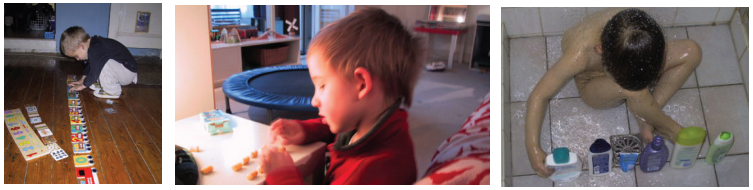
Children with autism store everything in their memory. What they have in their memory is what they know. Therefore they will notice it immediately when something is different. Robbert has a very detailed view on his DVD's and CD's. He can notice there a new one, only by looking at the sides of the covers.

Repetition

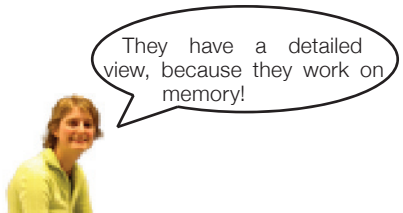
Children with autism need repetition in order to store and learn. But often they already know it, but still they repeat. They do this, because this is safe. If you keep repeating the same ritual, you do not have to perceive new things.

Organizing

Children with autism like to organise things. They love things that can be completed, like a puzzle. But when a piece is missing they will panic. Also putting things in a sequence and finding similar things is popular. When things are similar, they are already stored and therefore safe.



Beer arranges object in his play by making sequences of objects



Special interests of the children

After reading this you can probably understand why these children have special interest in things. They search for structure in a complex world. Robbert wants his CD's and magazines around him. This makes him feel safe. Jakob and Beer have found a regularity in life. Colours are everywhere, you can always perceive them. Also Beer with his numbers make sense. If you look around you see numbers everywhere. The thing Beer reacts on the best are numbers. This can be a spoken or written word of a number, or a number itself.

Beer likes to look at numbers and letters from real close

he draws numbers

Beer speaks about numbers

Also during speech therapy the numbers are a way to learn new things. At the movie on the left you can see how the therapist has learned Beer to say: "Do you want to make a 'five'? She expands it by asking him to choose between a five on a snake or a ball.

He does not understand choosing, because they do not understand the consequences of a choice, what an option means, or what choosing is.

3.7 Design framework for autistic children

This exploration of how children with autism behave and why, but also how they learn and play helped me to formulate a framework about the toy, which has to be designed. This framework contains the interaction characteristics children with autism like. This framework is the final step before conceptualizing.

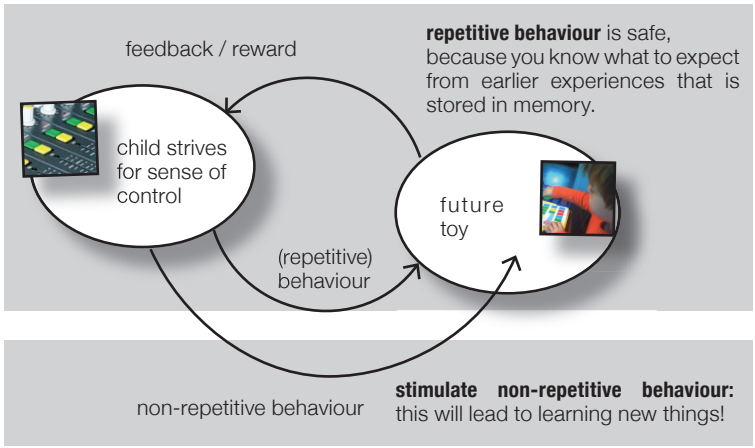
Language as tool and final goal

In my vision about learning language and communication of autistic children I already stated that children with autism should start with *naming* physical objects with words. In this way the meaning of a word is learned best. Next it is important they learn to word actions belonging to these objects. In this way they can experience the action, and this is good for understanding as well. The final step would be a sentences to indicate what you want. In this way they learn that language serves as a mean to get what you want.

Naming objects, and actions on the moment itself is important. Not only does it help with language comprehension, it also sustains the idea that spoken words can be integrated in structuring the world of an autistic child. When offered in a consistent way language is in fact a way to help the child with understanding the world around him.

Favourite interactions

As explained earlier, the way to learn the children new things (also play) is operant conditioning. Reward or feedback is important for them. Good rewards are deep pressure, music, sounds, light, movement, vibration, turning. On the next page I made an overview of important interaction characteristics and their relations. These characteristics are shortly described on the next page.



Design framework with important interaction characteristics for autistic children

Giving sense of control

Children with autism love to feel in control. They achieve this with toys by repetitively exhibit behaviour for which they are rewarded. If this reward matches their expectations they are happy and are likely to exhibit this safe behaviour again. Sense of control is achieved by giving direct feedback / reward and enabling repetitive behaviour.

Giving direct feedback / reward

Children with autism, who have trouble finding reference of things, like direct feedback. If they receive feedback in different ways, information will be better stored. The material of the toy should give clear feedback to the children as well. Foam is predictable, while plush is not. It tickles you, and this makes it unpredictable. Toys without feedback take away control.

Enabling repetitive behaviour

Children with autism learn from repetition. Repetition is safe and makes them able to cope with the world. Therefore it is important that actions can be repeated, simply because they enjoy it.

Stimulating non-repetitive behaviour

Although children with autism learn from, and feel safe because of repetition, non-repetitive behaviour should be extra stimulated. Often they know something already, but repeat because of safeness. When children explore something new, they made a big step, and this step should be rewarded.

Facilitating their memory

Children with autism have an excellent memory. Their memory is the thing they can trust on and therefore they have an eye for detail. This excellent memory should be facilitated by the toy.

Organising

The material should be organisable and form a whole. They like material they can organize. Therefore it should have a clear start and end situation. In this way you provide structure.

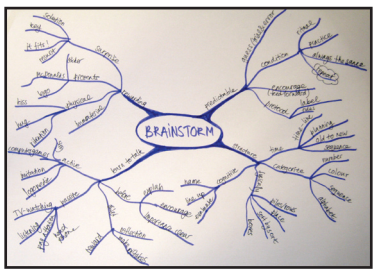
4. Conceptualizing: designing for children with autism

This chapter presents my early ideas and concept development on how to stimulate language for autistic children in a playful way. My vision with described interaction characteristics served as inspiration. I started with a brainstorm and idea generation. The idea with most potential was elaborated into a storyboard and evaluated with the involved parents. Next, this elaborated idea was developed into a concept design. Finally I build an experiential prototype, that enables me to test the concept design with the involved children.

4.1 Idea generation

4.1.1 Brainstorm

I started idea generation with a brainstorm together with five fellow-students. This brainstorm focused on characteristics belonging to my interaction vision, such as rewarding, structuring, and predicting, and the objective of the toy; learning to talk. This brainstorm led to some interesting ideas and idea directions. Most important outcome of this brainstorm was a overview of directions. This overview is depicted below.



Mindmap with an overview of ideas for the interaction characteristics.

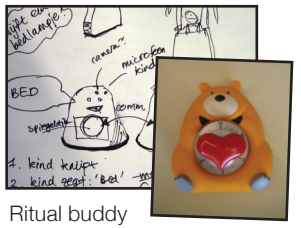
Participants clustering themes

4.1.2 Ideas and directions

After this brainstorm I realized there are several directions I could choose. The most important ideas and directions are presented to show the origin of the concept design.

Ritual buddy

Children with autism have trouble with the order of things. Structure helps them to cope with understanding when to do what. A possible direction is the design of a ritual buddy that names objects and actions while structuring a ritual. Visualising activities and objects in time combined with speech would be an important task for this buddy.



Ritual buddy

Speech-o-grams

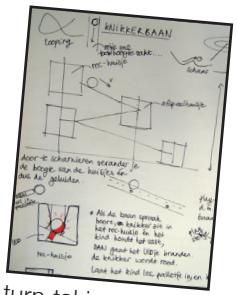
Pictograms are often used to structure and organise the world of a child with autism. By means of talking pictograms, children can research their own physical environment on their own initiative and learn from it. Their world gets structured by means of spoken language. By some sort of stethoscope children can activate and listen to pictograms, which I refer to as speech-o-grams.

Listen to 'speech-o-grams'

Speech sensitive toys
A toy that reacts on the child's speech is the best reward to learn language, and especially speaking. By means of voice recognition spoken language can become a tool to control your toy. In this direction I show two of my ideas.

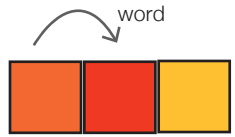
The train that wants to know where to go...
The first idea is a train track on which you can connect objects, such as a house, a tree and a flower. When the child passes for example the house with this train, the train says 'house'. In this way the child expands its vocabulary. When the child says 'house' the train automatically moves towards the house, stops and says 'house' to link its location with the object again. First the child learns the vocabulary of the toy and next they can implement it themselves, just as children learn language.

Turn-taking marble track
All children with autism like marble tracks, because the begin- and end situation is clear, the marbles look beautiful and rolling marbles produce a nice sound. The second idea in this direction is a marble track that has a conversation with the child. The marble rolls, but sometimes it is blocked on his track.
On these moments it is the child's turn to speak. When recognized the right word the gates open as reward and the marble continues its travel.


turn-taking marble track

Mirroring sounds
Another idea direction is mirroring your own voice. Being aware of your speech production can stimulate language development.
An idea of playing with your speech production is a sound transform ball that records and plays back sounds. By pushing into this ball you can change the pitch or speed of your (voice) recording. The children probably like the funny sounds it produces, but it can also get scare them of just as regular mirrors sometimes do.

Communicating play-elements
By physically connecting play-elements, such as blocks or puppets, communication can take place between these elements. A word can travel through them. Each time an element receives a word it can say it, so the elements repeat each other. Thereby children learn the principle of communication in a simplified and explicit manner. This idea fits children with autism, because they like to arrange things in a two-dimensionally and repeat actions.



communicating play-elements send and receive words

Conclusion
I choose to combine the idea direction of communicating play-elements with speech-o-grams as starting point for concept development, because it taps into the need for repetition in an organising manner. Moreover its origin does not lie in existing toys. Although the way of playing is rather structuring, the children are free to chose which elements they connect to each other and thereby between which elements communication will take place.

The speech-o-grams are a good solution to get a word into the toy that has clear reference. Children can explore and expand their vocabulary by means of these speech-o-grams.

Although ritual buddies are speech-o-grams in time that word objects *and actions*, I choose not to continue with them because I prefer free play. Ritual buddies are bound to specific moments, such as going to bed, or taking a bath. I aim for a design that gives more freedom to moment of use.
Mirroring sounds and speech sensitive toys make the children conscious about their own voice. I took this with me during concept development. In the next chapter you can see how I integrated these thoughts into the elaborated idea.

4.2 Elaboration of the idea direction: communicating play-elements

After choosing the direction of communicating play-elements, I generated more ideas on what this elements should be like and how a word can be meaningful for a child with autism.

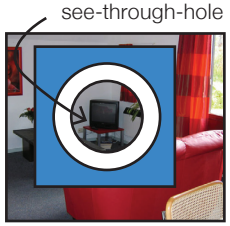
The appearance of the play-elements: blocks

An idea was to design puppets which can literally communicate. Seeing these puppets as 'real' asks for imagination. Pretend play is difficult for children with autism. A second meaning in the play-elements will hardly or not be seen by autistic toddlers. What the children do like are blocks, because the children can arrange them two-dimensionally.

Getting words to be meaningful: speech-o-grams

One thing I am certain of is that words should refer to physical objects. One idea is that by means of connecting the blocks to speech-o-grams words are spoken by the blocks.

Another idea is that a child can aim for an object by means of a 'see-through-hole'. Beer loves to look through holes and see what the bordered view looks like. When the toy knows to what object the child is looking, a word can be spoken by a block. Because speech-o-grams are easier to interpret for the children I chose to go for this solution. With speech-o-grams children physically have to be at the spot of the object that is reference for the word, while with seeing-through-holes there can be a distance between the child and the object. There is more certainty that children understand the reference with speech-o-grams, because with seeing-through-holes they can point in the right direction, but look at something else.



Blocks for listening and speaking

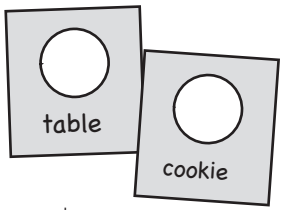
To stimulate language production as well as language understanding, I had the idea to have both a block for speaking and blocks for listening. By putting a block for speaking in the sequence and actually speaking results in a chain reaction. Children add their own version of the word into the sequence. Communication takes place between the blocks that are linked at this moment.

4.2.1 A storyboard of the chosen idea

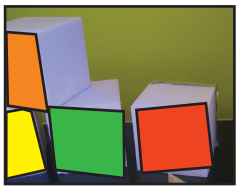
This idea served as basis for concept development and is evaluated with parents. To facilitate communication between the parents and me, I made a storyboard of the idea. This storyboard clarifies the interaction of the child with the play-elements. No physical design considerations were made yet to get feedback on their expectations about the interaction of their child with this toy, such as researching speech-o-grams and playing with communicating elements. For example how a parent exactly saves a word on a speech-o-gram is not important at this stage.

Communicating play-elements

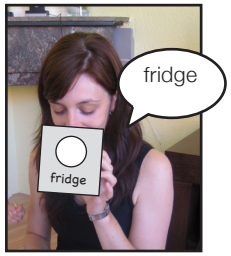
The toy consists of several play-elements, which are blocks for listening and speaking, and speech-o-grams. These elements communicate with each other when the child connects them.



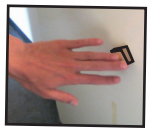
speech-o-grams


blocks for listening and speaking

Before playing begins...
The blocks communicate a word that is retrieved from a speech-o-gram. It is the task of the parent to fill the speech-o-gram with a sound and attach it to the corresponding object. Parents can add a written word or an image to the speech-o-gram depending on the needs of their autistic child.



Mother saves a voice recording into a speech-o-gram



and places it on the fridge

plant

window

After doing this with several objects, the environment contains 'tagged' objects

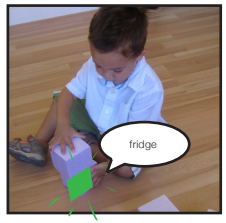
Researching objects
When the child connects a block for listening against a speech-o-gram, the block plays the recorded sound and lights up as reward. In this way the child can explore its new vocabulary. The child can do this over and over again.

Breathing
After connecting with a speech-o-gram the block keeps the sound inside. The blocks show this to the child by letting its lights breath. He keeps doing this for some time (e.g. two minutes). Eventually the light extinguishes, which shows the sound is gone.

breathing over time

Connecting blocks
By means of connecting blocks with a sound to empty ones, the sound jumps over to another block. Every time this happens the block plays the sound, whereby the child hears the word.

The block *breaths* to show that it wants to communicate with other blocks.



By connecting to another block, the *sound moves*. This block now says: "fridge" and lights up. Now this block breaths to show the new location of the sound.

The time value lowers and therefore also the volume and light intensity of the blocks gets weaker. The only way to give new energy connecting a block for speaking. This block blinks quickly and waits, blinks quickly and waits... In this way it asks for input, while giving initiative to the child.

When the child says 'fridge' into this block after connected to others, it is rewarded by repetition of the sequence back and forth with their own version added to it.

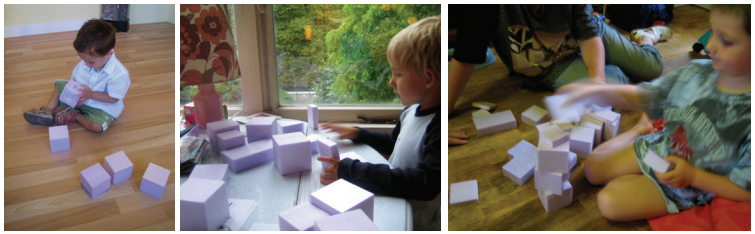
One by one a block lights up and plays the sound. When finished, the last block stays breathing (with maximal signal) and play continues.

4.2.2 Evaluating the idea direction

The elaborated idea of 'communicating elements' was discussed with the parents of Beer and Robbert. Jakob's and his parents were not involved because of their holidays.

Observing children play with foam blocks

I let the children play with different shaped foam blocks. In order to make the storyboard illustrated before, I also let Liam, a two year old child with typical development play with the foam blocks. Observing his way of playing and that of the two autistic children made me aware of differences. These observations I explain below.



The children who played with foam blocks (f.l.t.r. Liam, Beer, and Robbert)

Starting to play

All children found the foam blocks interesting, because they kept playing with them for a while without us forcing them to do so. For example, when I entered the house of Beer, he was playing with his Thomas trains in his playroom. His mother invited me to the kitchen table to discuss the storyboard. I displayed different shaped foam blocks at the table to faciliate our conversation. After a while Beer entered the kitchen and started to research the blocks without any instructions from us. He researched them for about an hour. Robbert on the other hand was informed by his parents that I came to play with him. My visit was part of his fixed schedule. Although playing was fixed in time, Robbert seemed to enjoy playing with the blocks and his parents.

The way of playing with blocks

It was interesting to see that all children played differently with the blocks, although this makes it more difficult to design something that fits all of them. Beer researched them without involving us in his play. Liam made a tower without instruction from us. When I showed him how to arrange them in a sequence, he imitated me at once. Robbert made a tower with guidance from his parents. He laughed real hard when they felt. The types of play of Beer and Robbert exhibited I discuss below.

Building a tower

Beer did not build a tower at all. This surprised me, because it was the first thing Liam, but also Robbert did. Important to mention is that building a tower was encouraged by the parents of Robbert. When Robbert's father tried to do something else after a while, Robbert rejected. Robbert said: "no a tower' when his father wanted to make a sequence with him.

Beer has learned how to build a tower at school, but he does not do this intuitively according to his mother. He prefers arranging blocks into a sequence. If it is possible to connect the blocks in horizontal and vertical direction, both children can play with it. According to Robbert's mother, Robbert can also learn how to play differently, as long as you show how to him.

Robbert builds a tower

Researching and making compositions
Beer started his play with the foam blocks by touching them with his hands and his head. He sort of hugged all the blocks that were at the kitchen table, to see what they looked like together from real close. Next to this, he enjoyed searching blocks of different shapes and making compositions with them. Over and over he positions three different blocks and watches them for a little while. He puts his eyes on the same height as the blocks while he studies them. Below are some pictures of Beer's research.

This is Beer's favorite composition according to his mom. He makes this one a lot with this with duplo as well.

Beer inspect blocks from the side a lot, because he prefers a two-dimensional view. The stimuli are less complex to process I guess.

Beer likes to make a sequence. He enjoys shapes with less symmetry.

And what does this sequence look like in the window?

Beer played a while with two cubes, but I seem to like the flat shapes better.

Evaluating with parents

Next to letting the children play with the foam blocks, I evaluated the idea with parents by means of the prepared storyboard. This conversation let to the insights I show below.

The blocks

Shapes
These different ways of playing of Robbert and Beer seem to ask for different shapes. A cubic block invites building since it is stable. On the other hand, a cubic block is visually less stimulating. According to Beer's mother a cubic block always stays cubic and is therefore boring to Beer. A rectangular changes when you change view and challenges him in to play with it. Different shapes such as a triangle, square, and rectangle interest him. Robbert on the other hand would be satisfied with one shape as long as he can build something according to his mother. The jumping sound and lights interest him already. The idea of communicating elements would not be stronger with other shapes for Robbert according to her. I think this is true for both children. A rectangular shape is visually stimulating for Beer and satisfies Robbert as well.

Amount
Beer studied only two or three blocks at a time. Robbert seem to like the fact there were a lot of blocks. But according to his mother he would play as well with four blocks. There were many at the moment so he played with many. Building four blocks into an experiential prototype is sufficiently according to her.

Material
Beer played with these foam blocks just as with the wooden blocks at the medical daycare centre. His mother suggested to make the blocks from white shiny plastic. The parents of Robbert loved the foam material. The blocks could fall without making noise. This is great for Robbert, because he is very sensitive to sound.

Record block
Challenging Beer to speak is difficult. Therefore his mother bought the 'magic mirror', a baby toy from Philips. It is a mirror that records and plays back sound. Unfortunately Beer only presses the red and green button, which produce some music, but has not spoken into it yet. One of my ideas was putting a mirror on the record block, just like the magic mirror of Philips. His mom advises me not to, because in this way he gets a reward before even speaking.

Beer's magic mirror

The speech-o-grams

Appearance
The parents supported my idea of making the appearance of the speech-o-grams identical. In this way there is a higher chance that a child links a word to the object instead of the speech-o-gram. They should be clearly visible, because the child should be able to recognise them.

Amount
We discussed the number of speech-o-grams and concluded that there should not be that many of them. Many speech-o-grams make the toy complex, both for the child and the parent. With less speech-o-grams parents are more involved in their play, because they can notice progress of the child. Beer's mother added that four to six speech-o-grams will stimulate change of position and content more frequently. According to her gradual change is most important to make Beer ready for society. Change challenges them to learn more words. Robbert's mother said she would probably start with four and interchange them not all at once. Because the content is flexible parents can do what they think is best.

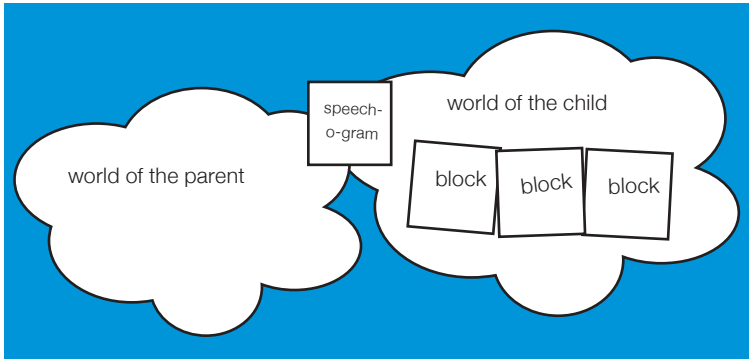
Reading a speech-o-gram
Goal of the to be designed toy is to stimulate language development. Since motor skills are developed slower in children with autism, parents advised me to make connecting easy. When they do not succeed in connecting, they will not hear the sound. Beer's mother thinks it should be an easy puzzle that is identical for all speech-o-grams.

Blocks as communication mean
Children with autism have difficulty with expressing their desires according to Beer's mother. She thought Beer can indicate what he wants with these blocks, such as I have to go to the toilet. By recording instructions instead of words, children can learn to communicate in an indirect manner. The mother of Robbert would not use them in this way, because Robbert can already speak to her directly.

Blocks as mediator
However, the mother of Robbert sees another opportunity. She thinks the blocks can mediate in a transition between different activities. For example when dinner is served, she can connect the block to the speech-o-gram at the table. In this speech-o-gram she recorded "Robbert dinner". In this way the toy sustains the communication between parent and child, because it makes the transition physical, and thereby understandable for Robbert.

Involving parents
The elaborated idea enables parents to enter the world of their child on an indirect way that is acceptable for the child. Beer's mother likes this a lot, because normally Beer plays with his computer and listens to the voice of a stranger.

Parents interact with the speech-o-grams. They decide what their child will learn by choosing the position and content of speech-o-grams. The child explores the speech-o-grams in its environments and plays with the sounds with their blocks. The speech-o-grams are their shared world. This is visualised on the right page.



The shared world of parent and child

Direct contact between play-elements

I also discussed blocks that communicate at a distance, without making a direct contact. The parents told me this would be difficult for their child. Sounds can jump outside their visual scope. Their cognitive abilities are in the here and now. Direct contact is easier to recognize.

Conclusion

After these evaluations I choose to continue with flat blocks, because this shape is visually stimulating and enable building.
I focus on the interaction of the child with the toy. It is outside the scope of this project to design the way a parent records sound into a speech-o-gram.

4.2.3 Evaluating by the design framework

While evaluating with parents, I crystalised why this toy and the interaction with it fits the autistic children. I will explain what fits and what is important for further elaboration on the basis of the design framework discussed in chapter 3.7.

Cause and effect on the place of action

Giving *sense of control* and *direct feedback* are important for learning. To magnify the sense of control it is important that feedback is given on the place of action. Only then they can learn that they cause the effect. In defining the precise interaction with the blocks and speech-o-grams, it is important to keep this in mind.

Enabling repetitive behaviour

By connecting a block repeatedly with a speech-o-gram, the children hear the word belonging to the object over and over again. Also when children connect blocks together the word is repeated again. Literally the children repeat sounds by putting them in a sequence. Although it seems a bit boring, I believe the children enjoy this.

Stimulating non-repetitive behaviour

Parents can stimulate non-repetitive behaviour indirectly by changing the position and content of speech-o-grams. The toy does not do this automatically, but asks for the parents involvement. When parents gradually change the position and content of speech-o-grams, non-repetitive behaviour of the child is stimulated in an acceptable way.

Facilitating their memory

The toy is predictable. Their memory helps them to know what to expect. Text or an image on the speech-o-grams gives an extra hint about what sound will be played by a block.

Organizing

The toy is organizing in two ways. First the speech-o-grams literally structure the world of the child by naming objects in their environment. These spoken words, maybe in combination with text and images, make their world less complex.
Second the interaction is organizing, because the shape and function of the blocks asks the child to arrange them in a sequence. This taps into the love of autistic children for two dimensional play such as puzzling and arranging objects in a sequence.

The organizing character of the idea taps into Beer's love for making sequences

4.2.4 Conclusion: from idea to a concept design

During the elaboration of the idea of 'communicating elements', several decisions are made on the design level. Below I will present these decisions and explain why. In the next chapter I present my final concept.

From cubes to rectangles

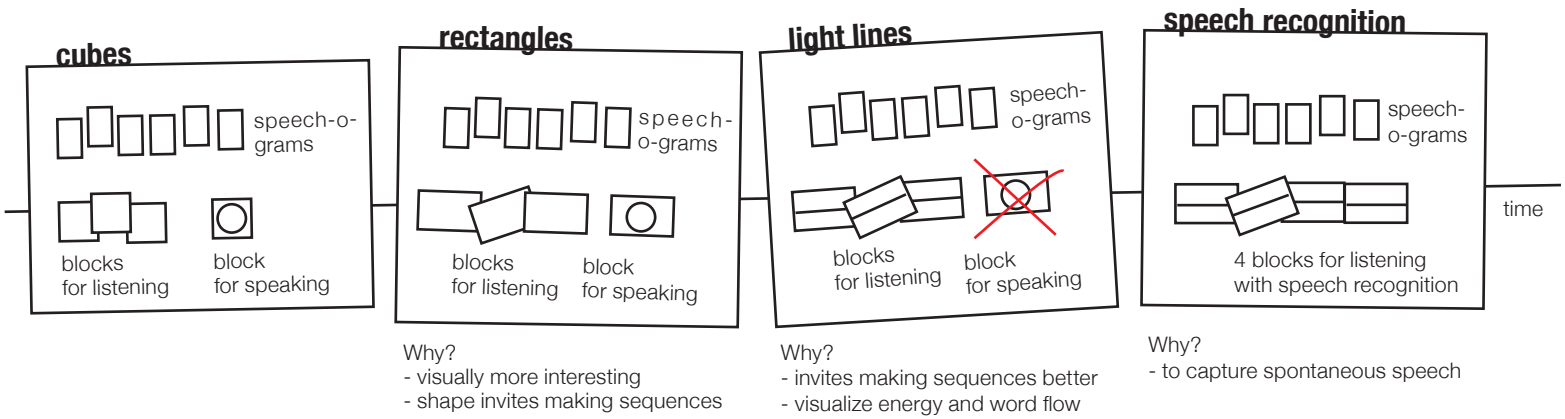
I started with four cubic blocks that communicate with each other. Three blocks for listening and one for speaking. Children can connect a block to each side and thereby make patterns and build towers. My evaluation with parents made me aware of the fact that children with autism do not build towers naturally. Autistic toddlers often have not learned yet how to build a tower. Connecting blocks in a two-dimensional way (a horizontal plane) is what these children intuitively do. Therefore I chose a clear top and bottom. Seeing Beer play with the foam blocks made me realize cubes are not that interesting to look at. In contrast with a rectangle that triggered him to play a lot more. Another advantage of a rectangle is that it stimulates the children arrange the blocks in sequences. This resulted into a shape with less connection possibilities that is easier to play with, because the children have less to chose from.

From rectangles to rectangles with light lines

To stress which surface can be connected to what I added light lines on top of the blocks. These light lines help to visualize the energy and word flow by means of putting LED's on and off.

Final concept: play-blocks and speech-o-grams

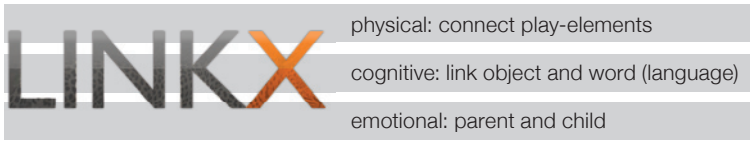
To get the record-block function as intended, the child needs to initiate recording. I discussed with Beer's mother how we could Beer initiate recording something. Although I had many ideas for making this switch inviting for the child, she told me that understanding you have to do something before speaking is too difficult for Beer. The speech-o-grams and the blocks for playing are clear. Combining the block for speaking in his play would give two ways of input and this is far too complex for Beer. Beer's mother said it could even scare Beer, because he does not like to hear back his own voice. For this reason I choose to leave out the block for speaking. The child's own voice cannot enter the system. With speech recognition the blocks can still reward the child with repeating the content, when it says the correct word.



4.3 Concept design: LINKX

4.3.1 Introduction

This project resulted in the concept design LINKX. This design aims for a connection on three levels: motor, cognitive, and emotional. On motor level children literally link play-elements together and thereby receive a visual and audio reward. On cognitive level, the children are triggered to link an object with a word. On emotional level LINKX aims to connect parent and child by providing a way to play together.



LINKX and its three levels of connection

LINKX consists of blocks and speech-o-grams. In speech-o-grams parents record a word. Next parents put these on objects in the child's environment, to help them learn the meaning of words. Children hear the word stored inside a speech-o-gram when they link a block with a speech-o-gram. This helps autistic toddlers to learn new words.

Speech-o-grams and blocks in the living room of a child

A speech-o-gram attached to a child's garbage truck.

When a block links to this speech-o-gram, its lights go on and it plays 'garbage truck'.

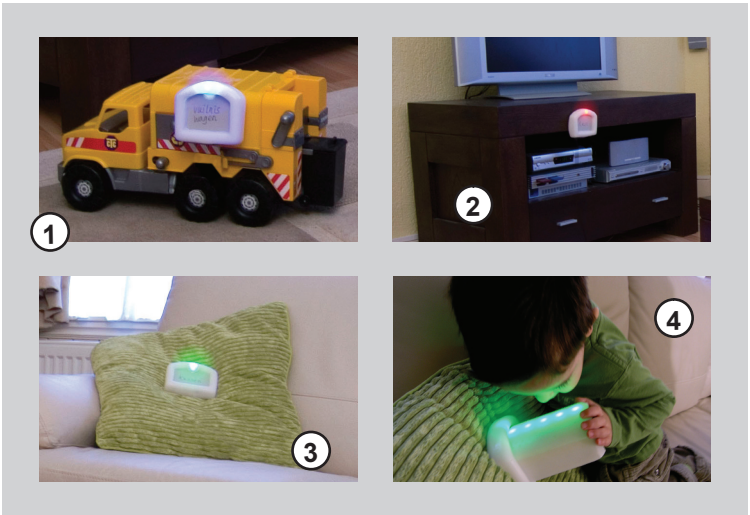
After a link with a speech-o-gram, the block stays alive for some time and 'remembers' the sound. By linking this block to other blocks, the sound moves from one block to another. After each move the receiving block plays the sound and becomes alive, while the sending block falls asleep.

A child links blocks and thereby makes the sound move to the other block

LINKX

Speech-o-grams

The speech-o-grams offer structure to the world of an autistic child. All speech-o-grams are identical to prevent children to link words to speech-o-grams instead of objects. The only aspect on which they differ from each other is their LED colour. The block that is linked to a speech-o-gram takes over this LED colour. However this can make children link a word to the colour instead of the object, it helps the children to remember where they got a word from. To invite exploration, the block fits into a speech-o-grams as if it is a puzzle.



Speech-o-grams attached to objects: (1) garbage truck, (2) cabinet, (3) pillow, and (4) a child connecting a block to a speech-o-gram.

Parents can add a sound, text, or a drawing (e.g. pictogram) to speech-o-grams. In this way parents make the speech-o-grams fit their child's needs. With some children added text or pictograms improves learning, while with others not.

parents write with a marker on a card that fits in a speech-o-gram

Blocks

The blocks let children explore their vocabulary in a playful way. Linking blocks together and with speech-o-grams makes them communicate: a sound travels through. Only one way of linking results in communication between blocks. This way of linking is depicted below. The shape, line of LED's, the linear pattern of holes in the rubber for sound, magnetic force, and different material stimulate the child to link blocks in this way. The shape is an extruded two-dimensional face. The top is curved to discourage upside down positioning. Upside down learning is not stimulated, because light and sound are blocked. The bottom is flat to stimulate stable positioning. A translucent white silicon rubber cover protects blocks and gives a nice touch. The LED's shine through this. On top of is a linear pattern of holes through which sound can travel. The bottom has four metal pins to enable sliding. Just rubber would be too rigid on many surfaces.

Three linked blocks: in a moment the sound will move.

The connection sides are flat, hard, and have magnets to stimulate a correct link. A hard material (PETG) makes the child feel the magnetic force better. It clicks!

4.3.2 Play and learn

An important aspect of LINKX is that blocks reward the child for links that results in language learning. The diagram on the right shows how LINKX rewards by means of operant conditioning. Learning starts with attention (1). The coloured lights in speech-o-grams attracts the child. When a child makes a meaningful link (2), the block rewards this. This reward (3) reinforces the child to behave like this again. There are three main actions that result in language learning: a link between a block and speech-o-gram, a link between at a living block with another block, and speech production near a living block. On these moments a block rewards the child with light and sound to stimulate active play. On overview of the rewards in time before, during, and after making a meaningful link is given below.

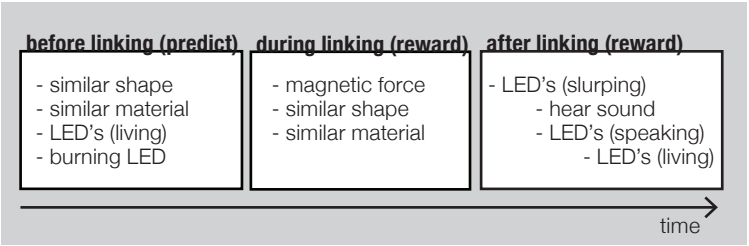


Diagram of how LINKX rewards in time before, during and after linking

1. Linking blocks to speech-o-grams

The meaning of a word is best learned when a child links a block to a speech-o-gram, since the word's reference is close. When elements are about five cm away from each other, connecting is stimulated by magnetic force. After a link, the sound moves into the block. This is visualized with LED's emitting light in the colour of the speech-o-gram. After that, the block plays the sound. After each link with a speech-o-gram, a block stays alive and remembers the sound for limited time. This is visualized with breathing LED's. In time this breathing intensity lowers and eventually the lights extinguish. The child can go back to a speech-o-gram to retrieve a new sound over and over. This

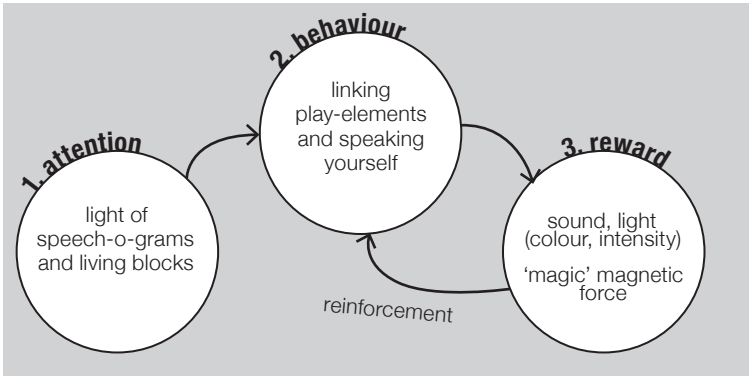


diagram of how LINKX rewards the child, and thereby how it conditions language learning play behaviour in the child

stimulates language development.

2. Linking blocks

When blocks are linked, the sound visible moves from one block to another. After each movement, the receiving block plays the sound and becomes alive, while the sending block falls asleep. Every time a child makes a sound move, the lights move and sound is played. This repetition stimulates learning. Moving lights trigger the child to link. While linking, children feel the magnetic force. A child can make more blocks alive at the same time by linking to speech-o-grams. When living blocks are linked, the most recent living block 'wins' from a less recent one. The winning one slurps all energy from the losing one, and keeps its sound. This choice has a pedagogic background. The child remembers of the most recent retrieved sound probably its reference best. After this 'battle', the winning block plays its sound and remains alive, while the losing block falls asleep.

3. Speaking yourself

When a child says the word that matches the sound in a living block, this block plays its sound with maximal volume as reward. When other blocks are linked as well, these blocks play this sound as well. A word travels automatically without asking for a new link. After recognizing speech, the (last) block lives with maximal intensity again. Producing speech gives the blocks new energy.

4.3.3 Presentation movie

an introduction movie to LINKX: explains how sound travels from play-element to play-element

4.3.4 LINKX inside: hardware

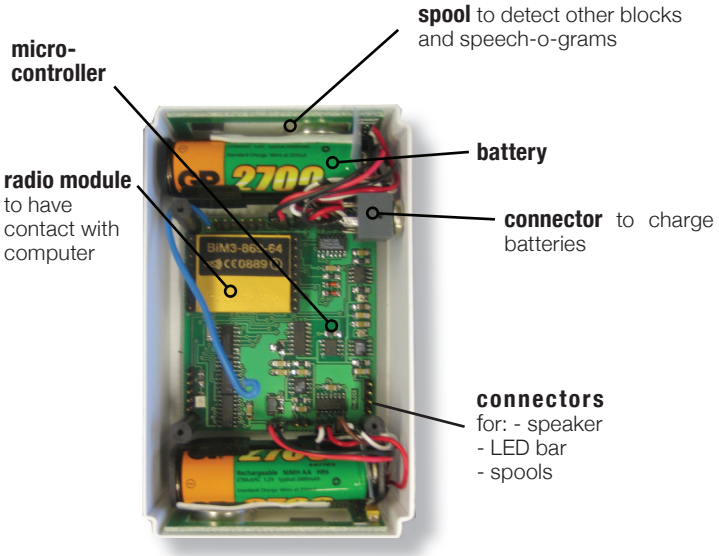
The blocks and speech-o-grams contain hardware, to make the blocks react as desired on the links of a child. This hardware, consists of sensors and actuators that are connected to a print with a micro-controller, memory, and a radio-module. On the right is an overview of all components.

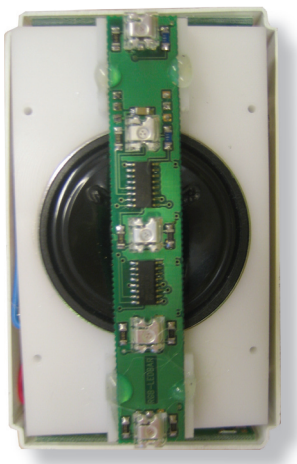
Before playing with LINKX, you upload sounds to blocks by means of a radio transmitter attached to a computer. These sounds are stored in the memory of all blocks. Although it looks like a sound jumps from e.g. a speech-o-gram to a block, the sound is actually already in there and only needs to be activated.

The blocks play sounds and light up. Therefore it contains a speaker and a bar with five RGB LED's. These LED's can light up in different colours. Both sound and light are directed upwards, because sound and lights must travel through the rubber on top of blocks. The speech-o-grams only light up. Therefore it contains a RGB-LED. This LED emits light in one colour, belonging to the specific speech-o-gram.

A block needs to detect if other blocks or speech-o-grams are linked to them. Therefore the connection sides of blocks and speech-o-grams contain a spool. The micro-controller sends a signal through the wire of a spool. This flow of electrons results in an magnetic field around the wire that can stretch out to a spool of another block. Electrons begin to flow in this spool when the magnetic field in the first wire changes. In this way blocks and speech-o-grams can transmit patterns of pulses and thereby know which block is connected to them. A magnet on connection sides helps children to position the spools against each other. This results in more correct links and thereby more language learning.

This hardware needs power to operate. Therefore each block and speech-o-gram has four rechargeable batteries. Blocks can be charged by the power connector on the side of a block.



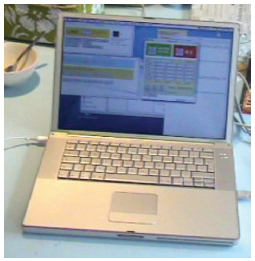


the speaker and ledbar on top of all components

A quick introduction to the electronics in blocks

4.3.5 LINKX inside: software

Software controls block and speech-o-gram behaviour. In the prototype this software runs on an external computer connected by radio. The software was developed with Max/MSP. In this chapter I explain the states of play-elements, which served as basis for software development.



The external computer with software

Energy flow

Another important aspect of the concept is energy. The energy level (E) in a block is maximal when a sound is activated by a speech-o-gram and lowers in time. This level defines the degree of reward by means of light intensity and sound volume. The light keeps the sound's location visual or shows where it goes to. This energy level is not implemented in the prototype of LINKX.

The power point: speech-o-grams

Speech-o-grams are the power point for blocks, and can never become empty. Therefore each speech-o-gram has a LED is burning at all times. The unique colour of this LED helps the child remember the origin of a sound. A speech-o-gram has only one state; it always sends out his unique frequency with its spool.
When attached to a speech-o-gram, a power point, the block plays the activated sound with maximum volume and light intensity. This triggers children to return to the word's reference. Here they can 'slurp' energy into their blocks and listen to a sound, which stimulates language understanding and enlarges the vocabulary.

The energy users: blocks

Blocks carry and use sounds. This costs energy and therefore they live for a limited time. When all energy is used, they fall asleep. The extinguish time is adaptable to the child's needs. When blocks are linked to each other, a sound with energy level can move from one block to another. As explained earlier, I called this energy transition 'slurping'. Next I explain all four states in which blocks can be.

The states and modes of a block

State 1: Sleeping
When a block has no energy, it is asleep. This state is called *'sleeping'*. In this state all LED's are turned off. Nothing happens.

State 2: Slurping
When a sleeping block is linked to a living block or speech-o-gram, it transits to *'slurping'*. Because of the gestallt law of movement, a sound seems to move from one to another. To make this movement look natural, it is important that LED's of blocks emit the same colour light as the speech-o-grams or other block do.

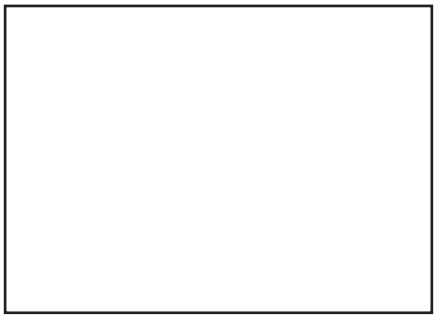
If a child disconnects a block while '*slurping'*, it returns to '*sleeping'*; its initial state. Slurping can only occur while linked. In this way children learn that interrupting slurping results in nothing. It is much more fun to see the blocks slurp and hear them talk.

State 3: Speaking
Each time a block is ready *'slurping'* it transits to *'speaking'*. In this state blocks play the activated sound. At this moment all LED's light up simultaneously with the intensity corresponding with the current energy level. Also the volume corresponds with this level. Hearing the sound again stimulates language development.

State 4: Living
After a block played the sound, it transits to *'living'*. This means the sound is located here. The block shows the location of a sound with simultaneously breathing LED's. By time the energy level and thereby the light intensity decreases and finally the block falls asleep.

4.a Winning or losing blocks
More blocks can be alive at the same time. These blocks always differ in energy level, because it is impossible to slurp energy from more speech-o-grams at the same moment. When this does happen, although it is very unlikely, LINKX chooses.

When linking two living blocks, the block that is most recently activated wins, because this block has the highest energy level. This is chosen, because of this sound the child probably remembers its reference best. To make slurping from a losing to a winning block look natural, the LED's of the losing block first have to chance its colour into that of the winning block. Next the winning block slurps all energy level from the losing block and transits to 'speaking'. The energy cannot exceed the maximum level. By linking living blocks you can make the recent activated sound live longer.



movie of linking two living blocks; one wins and the other loses

Sensitive to speech

Concluding a living block is sensitive to speech. When produced speech matches the activated sound in a living block, the block transits to another mode. I called this mode 'recognizing', or in short 'R'. In this mode the block rewards the child by playing the activated sound once again with maximum volume and light intensity.

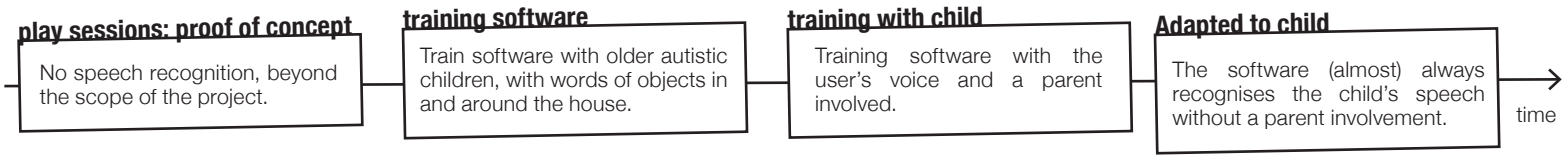
When other blocks are linked to this block in mode 'R' these blocks play one by one once more the activated sound. After speaking the blocks fall asleep except for the last one in the sequence. This block transits to the living state with maximum energy level and remembers its sound. Speaking yourself keeps the toy alive!

Speech recognition

I visited Dr. Drs. L.J.M. Rothkrantz, associate professor of the man-machine interaction group of the TU Delft. He researches speech recognition. Together we discussed how speech recognition can be developed for LINKX. The development of speech recognition is not feasible for the prototype. Wizard of Oz is, but very difficult for this target group. You cannot predict when an autistic child will speak. Therefore speech recognition is left out for now.

In the future speech recognition is feasible. Software needs to train with speech of (older) autistic children, focusing on words of objects and actions in and around the house. Their speech is monotonous and has a lower pitch than 'normal' children. Since the toy only has a small vocabulary at a time, speech recognition is feasible according to professor Rothkrantz. LINKX has only six speech-o-grams, which contain words or small sentences. Therefore isolated speech techniques can be used. LINKX is developed for home use. This means it has one owner; the autistic child. LINKX can learn and adapt itself to the pronunciation of this one autistic child, which is favourable for the reliability of the speech recognition software. Parent involvement is needed for this.

In the memory chip of the blocks sounds are digitally stored. Each block has a microphone and records real time. The micro-controller (with speech recognition software) compares this data stream with the activated sound. When the software recognises a match, the block transits to the recognizing mode. The delay in recognising is equal to the length of word said by the child. Below these needed steps for implementing speech recognition software in LINKX are depicted.



Needed steps for the development of speech recognition software in LINKX

4.3.6 State transition diagram of the blocks

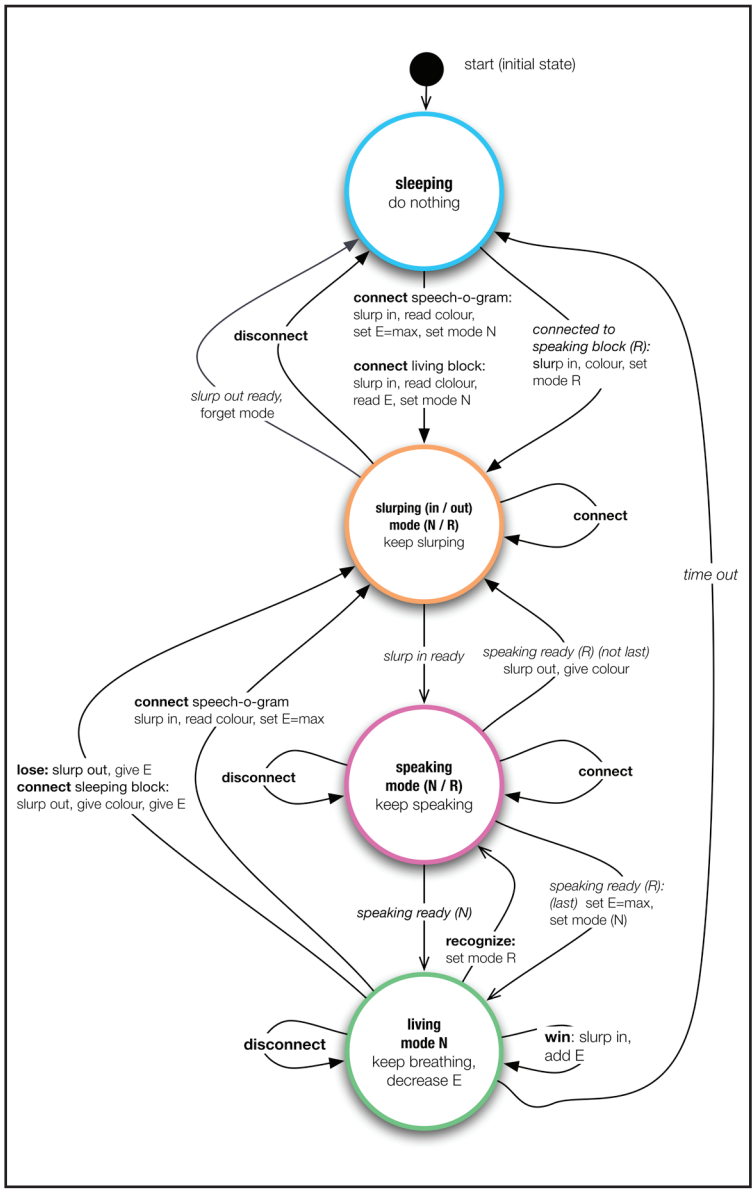
I made a state transition diagram of the blocks that communicates the made choices regarding interaction. State transition diagrams are a standard technique from software engineering (Funge, 1999). This diagram served as basis for LINKX's software.

There are four blocks with equal functionality. These blocks can connect with speech-o-grams and each other. The diagram shows all states and modes in which a block can be. These states and modes are explained in detail on the previous two pages. To transit to another state you need an event. Each event is illustrated with an arrow. The end point of an arrow shows the direction of the transition. An event is initialized by a trigger and results in an action. Triggers that belong to an action of the child are written in bold e.g. (**trigger**, action). Triggers beyond the influence of the child, such as ready or time out are written in italic (e.g. *trigger*, action). Concluding the blocks can be in two modes; normal (N) and recognizing (R).

The table on the right page sustains this diagram by showing all possible events in each state. Each existing state is represented with a blue row. In the first column you can see each trigger. The second column shows whether the block eventually transits to another state as result of this trigger or not. The third column shows the actions a trigger initializes. The last column shows why the toy functions like this.

4.3.5 Conclusion

This concept design is elaborated into an experiential prototype. In the next chapter I present how I tested LINKX in play-sessions with autistic children and what insight I gained from these play-sessions.



State transition diagram of a block

from state	on trigger	to state	performing actions	reason
1. sleeping			nothing happens	(begin state)
	connect speech-o-gram	slurping	slurp in, activate sound, read color, set E = max, set mode = N	reward link
	connect living block	slurping	slurp in, activate sound, read color, read E, set mode = N	reward link
	connected to speaking block (R)	slurping	slurp in, activate sound, read color, set mode = R	reward speech
	connect slurping block			slurping blocks should not be interrupted
	connect speaking block			speaking blocks should not be interrupted
	connect sleeping block			
	disconnect			
2. slurping			show movement direction of sound	slurping blocks should not be interrupted
	slurp in ready	speaking		reward link
	slurp out ready	sleeping	forget mode	reward link
	disconnect	sleeping		disconnect while slurping should not be rewarded
	connect speech-o-gram		keep slurping	slurping blocks should not be interrupted
	connect sleeping block		keep slurping	slurping blocks should not be interrupted
	connect slurping block		keep slurping	slurping blocks should not be interrupted
	connect speaking block		keep slurping	slurping blocks should not be interrupted
	connect living block		keep slurping	slurping blocks should not be interrupted
3. speaking			play sound with volume and light intensity E, keep speaking	speaking blocks stimulate language learning
	speaking ready (N)	living		show location of sound
	speaking ready (R) (not last)	slurping	slurp out, give sound, give color	show movement direction of sound
	speaking ready (R) (last)	living	set E = max, set mode = N	reward speech
	connect speech-o-gram		keep speaking	speaking blocks should not be interrupted
	connect sleeping block		keep speaking	speaking blocks should not be interrupted
	connect slurping block		keep speaking	speaking blocks should not be interrupted
	connect speaking block		keep speaking	speaking blocks should not be interrupted
	connect living block		keep speaking	speaking blocks should not be interrupted
	disconnect		keep speaking	speaking blocks should not be interrupted
4. living			keep breathing, decrease E	Decrease stimulates speech or return to speech-o-grams
	connect speech-o-gram	slurping	slurp in, read sound, read color, set E = max	reward link
	connect sleeping block	slurping	slurp out, give sound, give color, give E	reward link
	connect living block	slurping	*win:* slurp in, add E / *lose:* slurp out, give E	reward link
	recognize speech	speaking	set mode = R	time-outs have no effect during speaking and slurping
	time out	sleeping		reward speech
	connect slurping block		keep living	slurping blocks should not be interrupted
	connect speaking block		keep living	speaking blocks should not be interrupted
	disconnect		keep living	

Table of states and events (block behaviour)

5. Play-sessions with LINKX: testing with autistic children

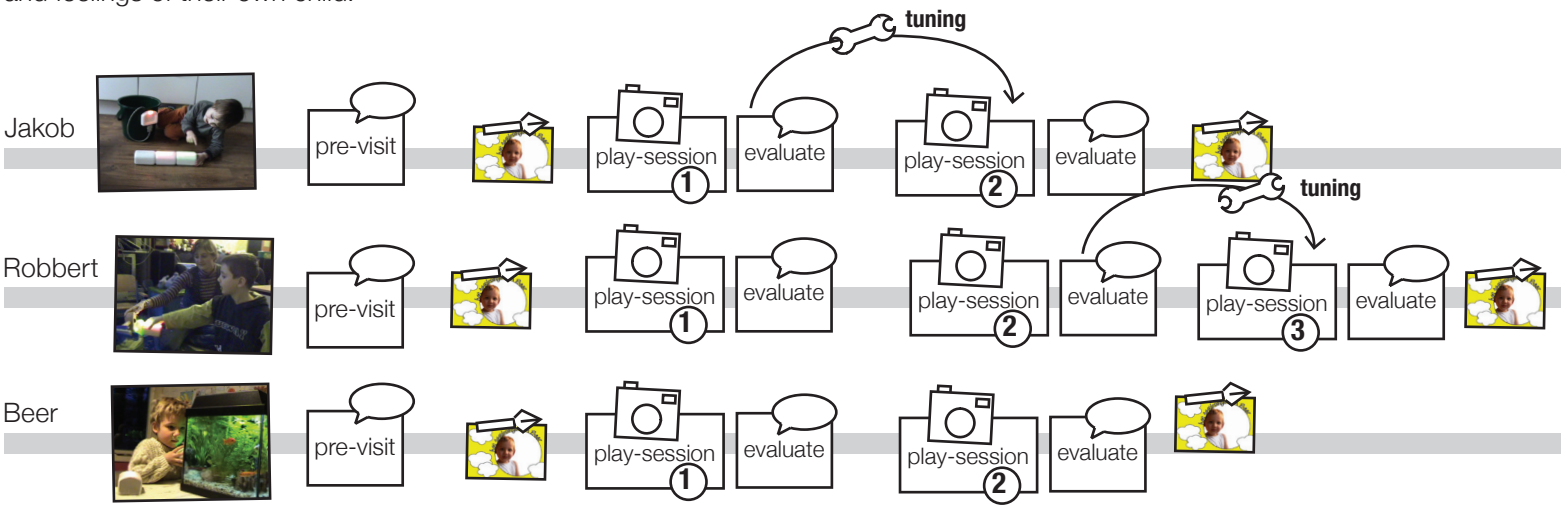
In a time-span of two weeks, I tested the prototype in seven play-sessions. The three autistic children that play a leading role in my process, participated in two or three of these sessions. I realise that these three children do not represent all children with autism, but results can give a good hint whether this specific concept fits the needs and feelings of children with autism in general. Since not all participating children can verbally express their opinion about the concept design, their parents were actively involved in this phase and played an important role.

5.1 Set-up user tests

Jakob and Beer participated in two play-sessions with LINKX and Robbert in three. One play-session took approximately thirty minutes and served as reference for evaluation. Parents had the role of co-researcher, because they are expert on the behaviour and feelings of their own child.

The figure below shows an overview of the process and used techniques. These techniques provided insight in what the children explored, how they did this and why. What and how came to light by means of observing the children during the play-sessions. Evaluating this afterwards with parents and the completed evaluations booklets of parents answered why the children played in this way. Improvements (tuning) for a next session or the future (recommendations) came to light as well.

Each line corresponds with a participating child. It starts with a pre-visit in which speech-o-grams were appointed to objects and corresponding speech was recorded. By means of going through the setup of a play-session, goals of parents (co-researchers) and me (researcher) were tuned to each other. In evaluation booklets, represented with the 'yellow booklets and a pen', parents wrote down personal expectations at forehand. In the end parents completed these booklets with questions about their child, themselves and LINKX. This booklets stimulated parents to take on the role of co-researcher. After each session I directly evaluated the results with parents to see whether goals and expectations were met. In a next session we could tune (e.g. slurp intervals) LINKX to the preferences of the individual child.



Overview of the process during evaluating with used techniques

Research questions

I formulated the following three research questions that can be answered by means of observation, evaluation with parents and evaluation booklets.

1. Does the interaction with LINKX (regarding play and learn) fit the needs of the individual child (on motor, cognitive and emotional level)?

2. Does the interaction with LINKX (regarding play and learn) or the needs of the individual child (on motor, cognitive, and emotional level) change over time within an individual child?

3. Does the interaction with LINKX (regarding play and learn) differ in between the participating children or has it developed differently in between them?

Operation of the prototype

Blocks were able to recognize speech-o-grams and other blocks. This made them able to 'slurp' in the correct colour and direction. When a block was 'speaking', their sound came out of an external audio source instead of the block itself. Pulse modulation needed for breathing during 'living' hindered the radio connection and thereby recognizing. Therefore blocks did not breath with decreasing intensity. Instead they had all five LED's turned on without any elapsing time involved. A block was either sleeping or living. Finally speech recognition was not implemented. The play-sessions focused on linking elements and what this resulted in (slurping, speaking, and living).

Presumptions

My presumptions regarding these research questions are described below. I divided them into motor, cognitive and emotional match. I describe which behaviour I expect from each individual child, and in which way their play probably differs from each other.

Starting to play

I expect that the children will not understand the functionality of LINKX without help from their parents. Probably children will not link blocks to speech-o-grams intuitively. Blocks are more likely to be linked, but without making one alive first, they will only discover the magnets, not sound and light. Especially Beer is expected to research blocks regarding shape and material properties. After children have seen how to make lights and sounds operate, they are likely to imitate this. Jakob did this also with the light box in the exploration phase. I think that when Beer has discovered sound and light together with his mother, he is more likely to explore this than the block's material and shape.

Motor match

I expect all children physically capable of playing with LINKX. Although the blocks are a bit heavy due to necessary components inside, I expect that all children are able to lift and link them. Magnets are expected to make linking easier. I do not expect motor differences between these three children.

Cognitive match

The cognitive match is the degree in which children understand how they can play with LINKX. Linking elements results in direct effect, first slurping, than speaking, and finally living. I expect that this cause and effect will be understood by all children. In the test this understanding is proved when a child repetitively links a block and speech-o-gram together. In the tests we can observe whether the children understand that 'living' is something special. When children connect living blocks more often to other blocks than sleeping blocks to each other, they proof to understand that living blocks are 'special'. I expect Robbert to understand that a living block involves action earlier than the other children. I do think that the other two children will also understand this eventually.

Finally children can repeat the sounds. Although the prototype does not do something with their speech, I expect Robbert to repeat the sound. I do not expect Beer to repeat the toy. Since Jakob speaks a bit now, he could be repeating the sound. Because the toy does not do something with this at the

moment, I do not expect them to keep producing speech.
According to their parents all children's language skills improved over these couple of months. Robbert' language skills are most developed. He speaks in sentences of five words. Although these children are a bit older than this project's target group, they can still give a good indication. Whether they understand LINKX and enjoy playing with it is more important than learning language, because actual language learning cannot be tested in two or three play-sessions.

Emotional match
I expect that all children like to play with LINKX. The way of playing is expected to match their desires, because it facilitates two dimensional play and linking results in (almost) direct results. LINKX reacts sometimes a bit slow. I expect this to be possibly difficult for the children and can lead to frustration.
Robbert likes a reward in sound better than light. I expect Beer to research materials. I am not sure whether the rewards with lights, such as slurping and continuous shining are enough. Maybe more compliments need to be added such as 'great!' and 'wow!'

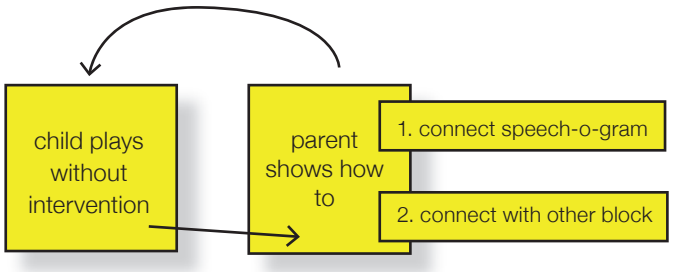
Set up of the play-sessions

Goal of the play-sessions was to get insight in the children's reactions on LINKX. In this way we could see whether the interaction with the toy fits the individual child.

Roles in the play-sessions

Researcher. I had the role of researcher. I observed what the children did with LINKX and facilitated their play. Of course I was also the designer. This made me able to come up with recommendations during play as well.

Co-researcher. Parents had the role of co-researcher. They are best at interacting with their child, and therefore can bridge between me and their child. First we let the child react on LINKX without intervention. After this the parent showed how to connect a block with a speech-o-gram (1) to let it play a sound, and connect blocks (2) to let a sound jump to another block.



Set up of the play-sessions; indicates how and in what order parents should help the child in its play with LINKX

Player. The child had the role of player. He could play in the way that suited him.

Camera man. There was a camera man that made video and photo material.

Research environment

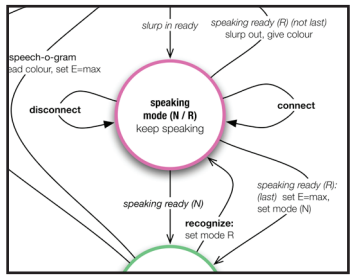
The play-sessions took place at the children's home; their natural environment. It is very likely that the camera man and me are not even noticed as a result of their autism.

Set up of the play-evaluations with parents

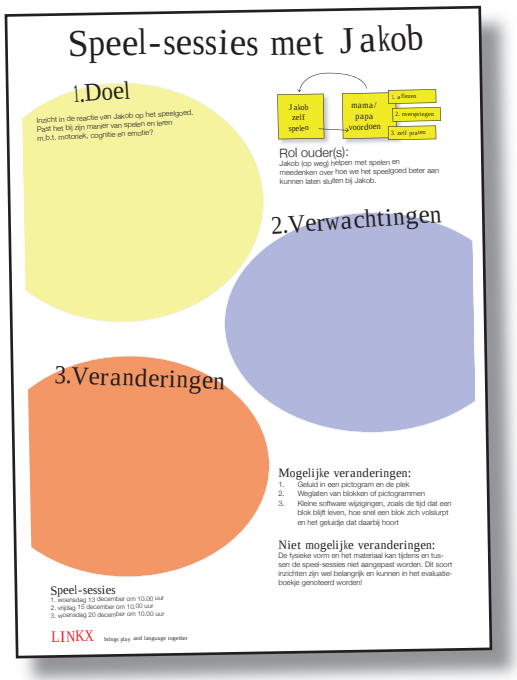
After each session I evaluated with parents how their child played with LINKX, and why he played in such a way. Goal of these evaluations was to bring to light whether LINKX met the goals and expectations we had at forehand. We could steer their play in between play-sessions. To facilitate this conversation, I prepared a laminated poster, on which we wrote down goals, alter expectations and needed changes with a whiteboard marker. The poster was aimed to recorded all changes. After each evaluation I took a picture, because the poster stayed at the parent's house.

Steering the child's play in between and during sessions

The different play-sessions made it possible to fine tune the software of LINKX. For example time interval of slurping can be changed easily. Another thing we can do to alter the child's behaviour is leaving out elements. When something is not there, the child can simply not play with it. Finally we can change sounds that match to speech-o-grams. It is important that parents; the co-researchers, are informed about these possibilities. Therefore these possible adjustments are described at the evaluation poster as well.



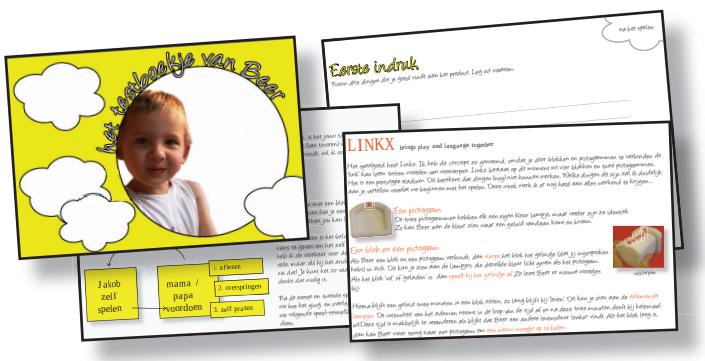
fine tuning software is possible in between sessions



Poster to guide the conversation with parents

Set up of the evaluation booklets

Finally evaluation booklets are used to inform and involve parents, but also get more insight about aspects that cannot be changed in between play-sessions, such as materials and shape. The first pages explained the setup of the play-sessions, the people involved, and asked about their expectations. The questions that need to be answered after playing were sealed with a small yellow sticker. After the first play-session this sticker was removed. At that moment questions about LINKX are revealed. The evaluation booklets are enclosed on this CD.



Some pages from the evaluation booklet of Beer

5.2 Results of the play-sessions

In general all children succeeded linking the elements in such manner that resulted in slurping and playing the sound. It was amazing to see that after only one example, the children pushed a block into a speech-o-gram. The slurping lights caught their attention and made them laugh. Repeatedly blocks were made green, blue, red, and after that blue and red again. Also linking blocks together was enjoyed. On the right is a movie included that gives an impression of how the children played with LINKX druing the play-sessions.

It was interesting to see that all children had their own way of playing. For example Robbert prefers to make a collection of blocks in one colour that next all become another colour. Beer however reserves his blocks for one specific colour. Linking blocks was enjoyed and understood as well. In what way and how often blocks were linked differed much more per child.

With trial and error the children discovered what results in action. They were visibly researching the possibilities of LINKX. I expected Beer to research the shape and material of the blocks extensively, but he did not. He enjoyed lights and sound more.

All children were in charge of their play. When a parent tried to let them explore something new, they 'told' us by means of speaking or screaming they were in charge and did not like any interference.

The blocks triggered language as well. Especially Robbert, who did not know any of the words at forehand, repeated the block immediately the very first time he linked a block with a speech-o-gram. He liked to learn new words with LINK. The other two children did not speak that extensively, but said sporadically a word or sentence. Beer however did repeat a word once! I guess the children did not recognize the voice of their parent, although Beer's mother expressed that she thinks Beer likes the toy because her voice is in it.

Robbert's eye for detail was evident when he was asked how many 'green' he saw. While all adults were counting the three green blocks, Robbert said five. His mother reacted as if he was wrong, but when he started to count explicitly we realized he was correct; he counted the five shining LED's on a block.

5.2.1 Overview of the play-sessions

On the next pages a made an overview of each child's play-sessions with LINKX. Each overview contains movie clips of interesting moments. Click on them to see what happened.
After these overviews I evaluate results of the play-sessions.

An impression of how children played with LINKX

The play-sessions with Jakob

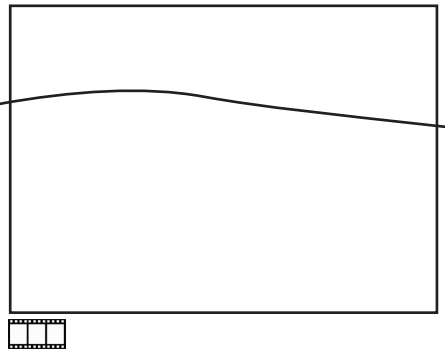
keukenkastje

emmer

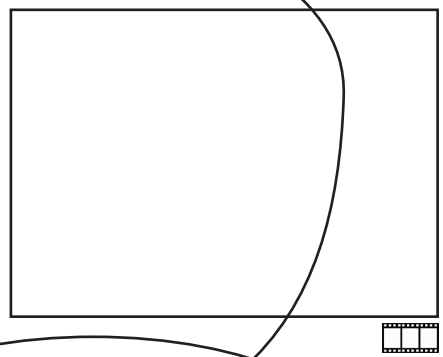
vloer

Session 1

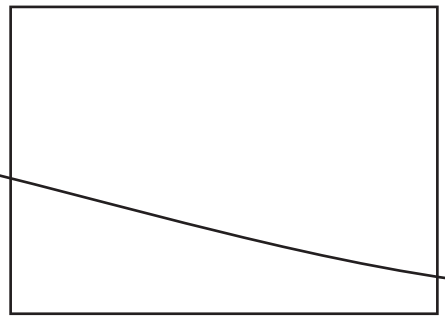
I was cycling around, while my mom showed me how to link a block with a speech-o-gram and another block. There was a smile on my face, I got off my bike, grabbed a block and walked towards the kitchen cabinet. With one hand I linked the block to the speech-o-gram, and next to another block. I like it!



Next my mom showed me the red speech-o-gram on the bucket. When she links a block to it I said: 'red'. I love the different colours of light. For me the prototype was not functioning correctly when lights did not react properly. My mother said I did not focus on sound yet. I am preoccupied with colours. I spoke during playing. I said: 'green wall' and 'red commode'. For me it is important that the colour of the object matches the LED colour.

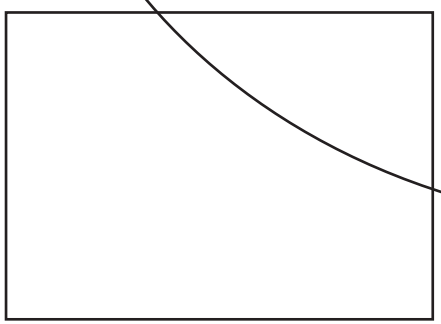


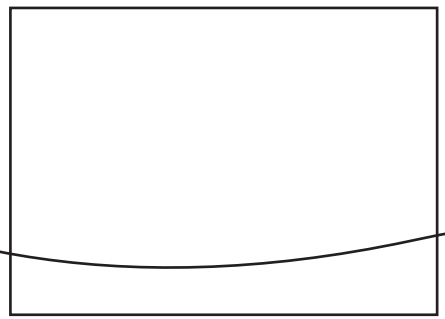
After 15 minutes the blocks started to act funny. They did not work the same as in the beginning. The green speech-o-gram became red, and the red became green. This was unacceptable for me. I cried and couched. When I realized this was permanent, I quit. On my bike it was fine again. No unpredictable blocks for me!



Session 2

My sister lucy played with me during the second play-session. There was a new blue speech-o-gram laying on the floor. I showed Lucy how to link a block with a speech-o-gram. I checked what the three speech-o-grams did and named their colour again. LINKX was not unpredictable today.





Lucy and I played differently. I like to hold one at a time, while Lucy likes to make collections. "All red ones belong together" she said. She linked a lot more and used them for other purposes as well. Because Lucy showed me I started linking more as well. I did research what kind of things would lead to slurping lights. After a while the phone rung, mom went away and so did we. End of play!

end

The play-sessions with Robbert

- keukendeur
- vloerkleed
- loopfiets
- kattebak

Session 1

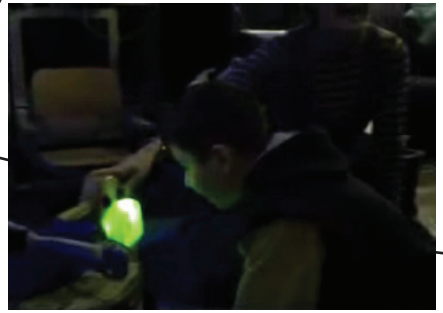
I waited till everything was installed. With a hint in words I linked a block to a speech-o-gram by myself. I repeated the word coming out of the blocks right away. I liked it and did it for many times.

My mom asked me what this word (loopfiets) is. In this way she checked if I referred the word to the object. I linked the word to 'mister'; my father who recorded the word. After naming the chair, I understood that this word referred to the object.

I made the researchers laugh by talking into a speech-o-gram.

The other speech-o-gram on the cat's box proofed that I now understood the principle. The pronunciation of cat's box (kattebak) is difficult, but I learned it!

I liked playing with LINKX. The next day I asked if I could play with it again.



To: van Rijn
Cc:
Subject: blokjes
Attachments:
View

Hoi Helma,

Vanochtend vroeg Robbert of hij weer "met de blokjes met de meneer" mocht spelen. Hij zei "meneer zegt loopfiets en kattebak" . Leuk hè! Ik heb 'm verteld dat je dinsdag weer komt. .... Robbert vroeg "en dan nog een keer????" . Daar heb ik maar geen antwoord opgegeven.

Session 2

I remembered the word and its colour after it's gone. I also still remember the objects of last time their colour, and the gender of the voice.

Session 3

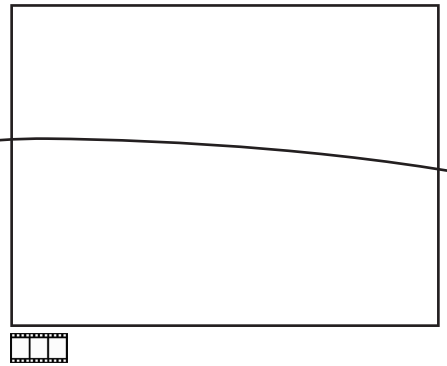
My dad showed me how the blocks can give 'a kiss to each other' and thereby let another word disappear. I did that a lot!

The play-sessions with Beer

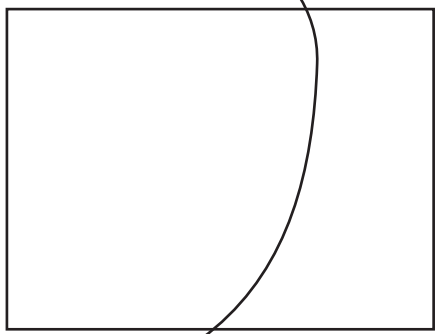
- vissenkom
- raam
- bank

Session 1

Mom showed me how to link a block with a speech-o-gram on the fishbowl. I walked away, but the sound and the slurping lights draw back my attention. I asked for the block that just slurped. I now linked this block and the speech-o-gram on the fishbowl again and again and a smile appeared on my face.

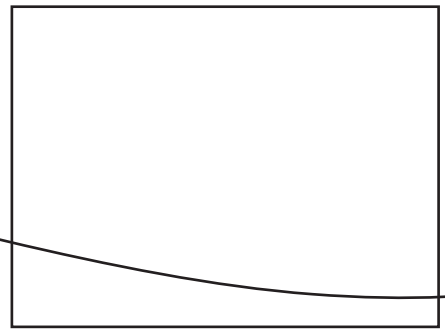


My mom showed me the other block could become red with the speech-o-gram on the window. She showed this block could become green again, and that you could link two blocks together. I had to laugh real hard and run from fishbowl to window to let the blocks slurp in different colours. The blocks stayed close to 'their' speech-o-gram. A green block must stay green, a red block red.



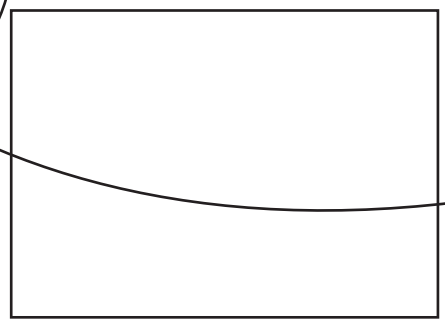
Session 2

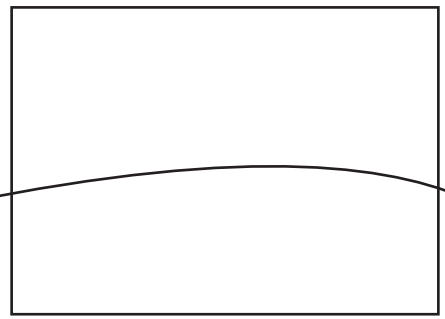
After LINKX was turned off, I put a block into the speech-o-gram of the fishbowl. Unfortunately it did not work, but I showed I understood and liked the concept.



While not everything was installed yet, I noticed the speech-o-grams. I walked towards them and carried one towards the fishbowl. First Helma had to attach speech-o-grams to the objects. We now put one on the couch. I got a bit impatience and therefore the speech-o-grams were not attached properly. Especially the one of the fishbowl felt off a lot. But I did not mind, I put it back on myself. The couch was my favourite this time. I could push real hard and laugh.

Abruptly I had enough and walked to my trampoline. They tried to seduce me with some new objects in my playroom, but I prefer to jump!





End

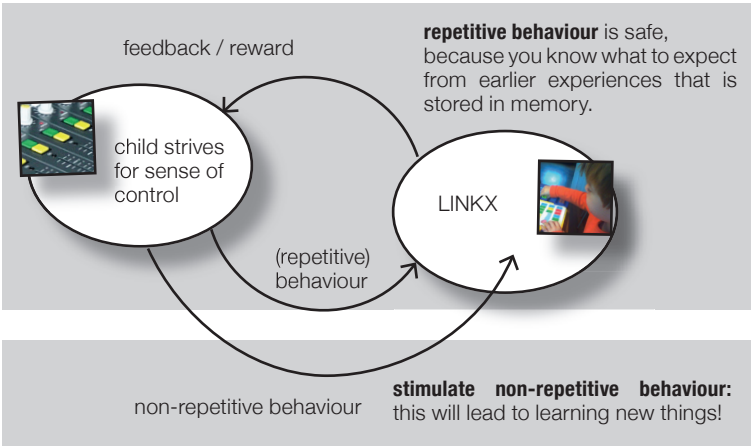
End

6. Evaluation of the results

This project resulted in (1) a design framework with knowledge on play and learning of children with autism and (2) a design build on this framework that aimed to stimulate the language development of autistic children in a playful way. This design, LINKX, is tested in several play-sessions with autistic children. Knowledge gained from these play-sessions tells both something about the validity of this framework and the design itself. In this chapter I evaluate the results of this project on generated knowledge (what I learned), scientific (what I designed), and society (what others can do with these results).

6.1 Knowledge - evaluation of the design framework

My result from exploration, a design framework for autistic children (chapter 3.7), served as basis for conceptualising. LINKX fits this framework and thereby serves not only as final concept design, but also as tool to evaluate this framework. I start with evaluating the knowledge I gained regarding language learning.



Design framework with important interaction characteristics for autistic children

Language learning

In my vision I explained that children with autism should start with *labelling* physical objects with words. Therefore the speech-o-grams in LINKX were appointed to objects. Not only promises this to sustain language comprehension, it can structure the world of a child as well. When offered in a consistent way, spoken language can help the child to understand the world around him.

Robbert was the only participating child that spoke small sentences on a communicative basis. This enabled me to 'have a look into his brain'. Although speech-o-grams were attached to objects, he referred the sound to 'mister', his father who recorded the word. After an explanation he learned this sound referred to the object. Proof that he understood the concept can be found in that he named the cat's box (the second discovered speech-o-gram) correctly right away. Together with his mother he learned to pronounce this word. With this example you see how difficult it is for autistic children to learn something, even when it seems obvious to us.

Compilation of moments that gave insight in language learning with LINKX during play-sessions.

Beer said ‘fishbowl’ (vissenkom) once when he walked towards the fishbowl. Whether he referred to the speech-o-gram or to the fishbowl is hard to check with him. However when we thought he was only playing with the lights repetitively, by saying the word showed that he (subconsciously) stored the word.

Jakob said only the colours of the speech-o-grams. He named objects that had the same colour, such as ‘green wall’ and ‘red bag’, but not the ‘green bucket’. I am convinced that the reference would have gone better when the colour of the object was said in the recording (e.g. ‘green bucket’, ‘white kitchen cabinet’) and this colour had matched the object’s colour as well. Using one LED colour can be a good solution for Jakob as well.

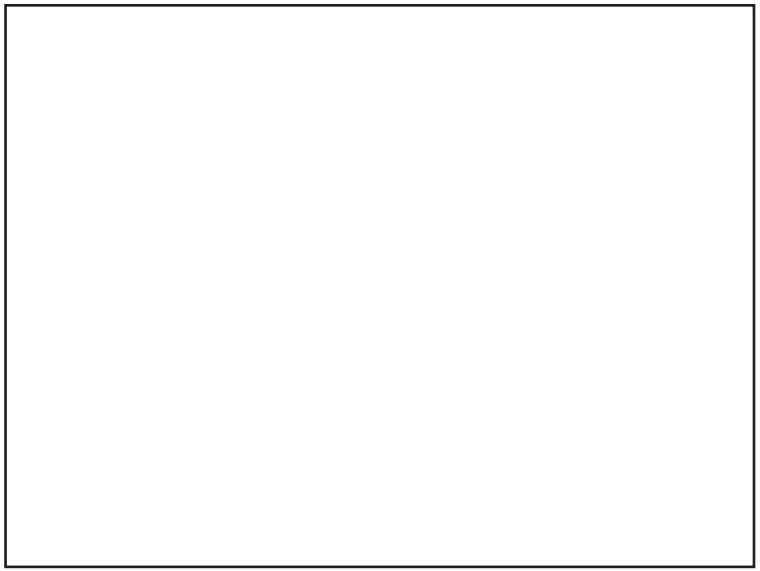
With all encounters regarding referring correctly is proofed that naming physical objects is the only way for these young children to learn new words. Even like this, these children can make a mismatch. The movie on the left page shows how LINKX triggered their language development.

Giving sense of control

During the play-sessions I noticed that the children indeed enjoyed the control they had while playing with LINKX. The toy has clear ‘cause and effect’ and therefore is predictable. The children were in control, because they knew what would happen as reaction on their own behaviour. Because LINKX’s software was not operating stable in the first play-sessions, I gained great insight in the importance of ‘sense of control’ for the participating children when control was taken away.

In the first play-session Beer preferred linking blocks with speech-o-grams over linking blocks together. He preferred this, because at that moment these links operated most stable. A predictable interaction gave Beer most sense of control, and this is what he enjoyed most. When a speech-o-gram link did not result in ‘slurping’, he went to the other speech-o-gram to get rewarded anyway and proof himself he was in control.

All children showed that they liked to be in control of their play as well. When we tried to help them, or let them explore something new, they ‘told’ us by means of speaking or screaming they were in control and did not like interference. Jakob firmly holds his block when his mother asked if she may link with it. When his sister Lucy grabs a block he was playing with, he got angry. Robbert said in words ‘no, Robbert is playing’, when his mother asked him to try something else. Beer screamed when we tried to help him. He likes to do what he has in mind.



Compilation of moments that gave insight in the interaction characteristic ‘giving sense of control’ with LINKX during play-sessions.

How much control is enjoyed can be seen when LINKX does something unexpected and thereby takes away control. When the colours of speech-o-grams interchange due to a software bug, Jakob panics and eventually quits playing with LINKX. An unpredictable toy is no fun to play with for children with autism. In the movie above these ‘moments of control’ are brought together.

Giving direct feedback

Children with autism have trouble processing stimuli. Therefore feedback should be given directly, and be redundant. Feedback is their reward. Feedback shows they have done it correctly, which makes them feel in control. As expected this interaction characteristic is very important.

In the play-sessions I noticed that every child perceived the same feedback differently. While Jakob seemed to be preoccupied with the colours of the LED's, Robbert was focusing on the sounds LINKX made. Beer seemed to be preoccupied with the light, but when he said 'fishbowl' during the second play-session there was proof he did store this word in his memory. The prototype sometimes did not give slurping LED's and other moments it did not play the sound. For Jakob and Beer the prototype was experienced as non-functioning when lights stayed out, while for Robbert this was the case when sound stayed out. It was fun to see that Robbert gave himself verbal compliments like 'very good Robbert!' as result of expected feedback.

Feedback can also easily be misinterpreted. Example of this is Beer's linking roughly in the second play-session. Blocks give feedback on every link, no matter if it's done roughly or gently. Beer however learned at a moment that linking roughly works best. Afterwards Beer linked so roughly that the block's often reset themselves and transit to 'sleeping' state (the blocks were not that shock-proof and reset as result of a shock). At that moment it was difficult to teach him he could also link gently, which has a better result.

On the right you can see how Beer links the blocks roughly.

When roughly linking results in slurping, Beer learned this is the way to do it

Enabling repetitive behaviour

Children with autism learn from repetition. Repetition is safe and makes them able to cope with the world. Therefore LINKX facilitates repetitive play, simply because they enjoy it. During the play-sessions it was clear the children liked the possibility for repetition in LINKX. Children linked elements over and over. Robbert began with making all blocks green. After that he made them all red. He kept this kind of play for a long time and it was difficult to let him do something else. Beer had one block for red and one for green and played like this the whole time. Jakob preferred to explore all the coloured speech-o-grams around him with a block. It was amazing to see that children exhibited such different play with the same functionality. The movie below shows how Beer makes the same link over and over.

Beer likes to link a block with a speech-o-gram over and over

Stimulating non-repetitive behaviour

Although children with autism learn from repetition, non-repetitive behaviour should be extra stimulated. Often they repeat behaviour to be in control, but this does not result in learning new things.

In the play-sessions we could see that LINKX itself does not extensively stimulate non-repetitive behaviour, because it keeps giving equal feedback on the already explored interaction. Stimulating non-repetitive play was done by the parents. They were assigned to show their child the functionality of LINKX in the two play-sessions. This functionality consisted of linking blocks with speech-o-grams and linking blocks together in different ways. This was difficult, because the children preferred to make links from which they were sure it results in success. Although the children repeat links a lot, their play grew during the sessions. By showing other options they eventually discovered the whole functionality of LINKX. Nevertheless, some combinations stayed favourite.

Facilitating their memory

Because Robbert spoke on a communicative basis we could check his memory regarding LINKX. We tested what he remembered from previous sessions by asking questions such as “what colour was on the bike last week?”. He remembered and also remembered the gender of the voice from last time. He could choose between ‘mister’ and ‘misses’. He let colours disappear by linking a block with another LED colour to it. He remembered the disappeared colour and word and what was still present. Jakob remembers which colour is on which object as well. This was evident when the colours of speech-o-grams interchanged. Beer remembered the position of a speech-o-gram from the previous play-session. While I was preparing LINKX for the session, Beer noticed the speech-o-grams lying on the table. He walked towards them and carried one to the fishbowl. All children remembered what to do and started without any help the second time I came by. As explained in the framework, children with autism have an excellent memory!

Conclusion

In general the play-sessions with the prototype of LINKX gave me great insight in whether this framework sustains the design process for autistic toddlers. Sense of control by means of feedback (reward), facilitate repetitive behaviour and stimulate non-repetitive behaviour as well as facilitating their memory indeed appeared to be important. In the next chapter I evaluate the concept LINKX.

Compilation of moments that gave insight in the interaction characteristic ‘facilitate memory’ with LINKX during play-sessions.

6.2 Scientific - evaluation of LINKX

My aim was to design a toy, both playful and educational, which stimulates development of language of autistic toddlers. This toy should grow with the capabilities of the children and trigger them to explore and learn. In this chapter I evaluate whether LINKX meets its goals.

In general LINKX fits the individual needs (on motor, cognitive-, and emotional level) of the children. Although each child played differently, they all liked the interaction with it. Over time their play became more diverse. They started only with speech-o-grams, but in the end they were familiar with all aspects of the concept. The lights and the sounds that the blocks produce were enjoyed by all.

LINKX promises to learn language to autistic children. For sure Robbert learned four new words (loopfiets, kattebak, vloerkleed, keukendeur). Beer once said the word (vissekom) that was stored inside a speech-o-gram. This encounter surprised me, because I did not expect Beer to speak at all. Since Jakob did not repeat what the blocks played we do not know whether he also did not hear the word. It could be that it led to language understanding, but not production.

The differences in way of playing and learning level of the children made me realize adaptivity is needed for such a toy. The open system of LINKX regarding sound enabled parents to adjust the toy to the language level of their child. Therefore LINKX can grow with the capabilities of the child. Parents can start with easy words, and next choose more difficult ones or record small sentences.

The elapsing time was not implemented. Although I expect that understanding the concept of elapsing time is difficult on short term, on long term time can give an extra dimension to play. For the children it is probably exciting to keep the toy alive.

Another not tested aspect of LINKX was speech recognition. I expect this to have large effect on their speech production. When the toy does something with their voice input, they are more likely to speak themselves as well.

Now I first discuss the results on motor-, cognitive-, and emotional level. After that I give my recommendations.

Starting to play

It was not difficult at all to get the children play with LINKX the very first time. After showing what happens when a block is linked to a speech-o-gram, the children immediately repeated this. Robbert even made his first link just with a verbal hint. After making successful links, the children kept doing this.

Jakob (1), Robbert (2), and Beer (3) linking a block to a speech-o-gram for the first time.

Motor match

As expected all children were physically capable of playing with LINKX. Jakob lifted the blocks often with one hand. Although he seemed to experience it as a bit heavy, Jakob's mother said the weight was positive for him. Weight gives extra feedback and pressure, which the children enjoy. However, a next version of LINKX should be made a bit lighter.

Cognitive match

The children understood and remembered what to do after they had seen their parent's example. Although feedback did not always come as immediate as desired, this was surprisingly not a big issue. It is most important to them feedback eventually comes. This tells them they were right. The children learned real quick they had to wait a few seconds to activate the lights and the sound. A good example is the learning process of Beer with LINKX. In his first seconds of playing with LINKX he learned he had to wait a little while before action appears.

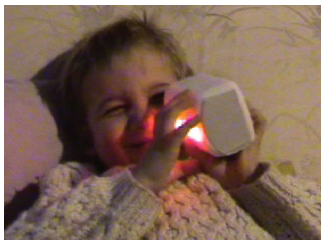
After showing the children that a sound can move through blocks, the children linked blocks as well. Because they first learned how to link blocks to speech-o-grams, they preferred to do this in the beginning. In the next sessions the children linked blocks more and more as well.

As expected Robbert repeated sounds a lot. Beer said the sound once and thereby proved he did store something. Since Robbert can speak we discovered he made a mismatch. Whether the other children understand that a sound is linked to the object is hard to check. They can also link the sound to the speech-o-grams. Jakob said the colours, not the words. Unfortunately speech recognition was not implemented. However I do expect that a reaction on spontaneous speech can make them conscious about speech production. I think the children will understand that LINKX reacts on their 'correct' production.

The best proof for understanding is that the children knew what to do the next time I came to play with them. In the end of the first play-session, Robbert showed his father, who just came home, the full functionality of LINKX; linking blocks to speech-o-grams and linking blocks together. In the first play-session, Beer came back after we turned off LINKX. He put a block into the speech-o-gram of the fishbowl. Unfortunately it was not operating at that moment, but we had proof he liked and understood the concept. Although Jakob had a bad experience in the end of the first play-session with LINKX acting unpredictably, he knew what to do the second time I came by. Although I expected him not to play with it any more, he surprised me by starting to play immediately.

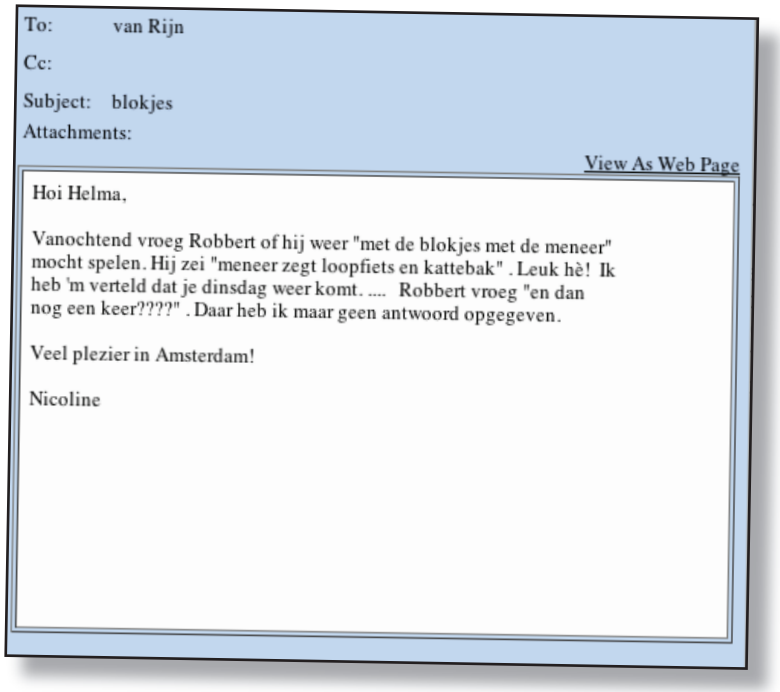
Emotional match

All children liked to play with LINKX. The feedback with lights and sound made the children feel in control and this was clearly enjoyed. While Beer (see below) and Robbert showed this explicitly with laughter, Jakob had a content smile on his face.



Beer is satisfied after a succesfull link

The first sessions with the children, I was surprised by their enthusiasm. Beer crawled from laughing. Robbert explicitly asked the next morning whether I came back, so he could play with the blocks again. In time you could see that the first session they liked to play longer with it than the second one. To keep it interesting on long term, parents should change words, and maybe be able to add other sounds as well, such as music and verbal compliments. The lights however were very much enjoyed. Especially interesting is that a child with typical development that played with LINKX nearly showed any interest for the moving light and played sound. The interaction with LINKX seems to fit autistic toddlers much better than toddlers with typical development.



To: van Rijn

Cc:

Subject: blokjes

Attachments:

View As Web Page

Hoi Helma,

Vanochtend vroeg Robbert of hij weer "met de blokjes met de meneer" mocht spelen. Hij zei "meneer zegt loopfiets en kattebak" . Leuk hè! Ik heb 'm verteld dat je dinsdag weer komt. .... Robbert vroeg "en dan nog een keer????" . Daar heb ik maar geen antwoord opgegeven.

Veel plezier in Amsterdam!

Nicoline

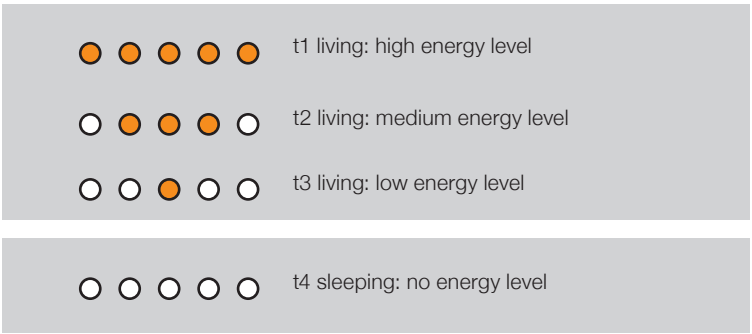
The email I received from Robbert's mother the morning after the first play-session with Robbert: she expressed Robbert's wish to play with the blocks again.

Recommendations

In general, the interaction with LINKX fits children with autism. Many redesigns are possible, but to my opinion, the strength of the concept lies in its simplicity. That makes it clear and thereby enjoyable for autistic children. Of course in reality, sound should come out of the blocks instead of an external audio source. Children did expect sound to come out of blocks, because they hold them against their ears. I am certain that the vibrations of sound will be enjoyed as well, not only the word. A vibration motor would be a good additional reward as well. Further, LINKX should function absolutely reliable in real. This will take away frustration during play. During the play-sessions I discovered also some other aspects on which LINKX can be improved. These aspects are described below.

Another way of living

I realize now that elapsing time communicated with light intensity is too complex. I think it is best when the energy level is shown in discrete steps. I recommend that when time is maximal, five LED's are burning. After some time two turn off, and the middle three stay on. The last stage is one burning LED in the middle. In the end all turn off and the block transits to the 'sleeping' state. Discrete steps fit the cognitive skills of the children.



The discrete steps (t1, t2, t,3, and t4) for another way of living.

More blocks and other shapes

In the future other shaped blocks can make play more diverse; a sound could for example go around the corner. I do advise to stay in the two-dimensional plane with making links.

LINKX & adaptivity

Parents were very much involved in their child's play and asked for much customizing, such as specific sounds or lights. I learned that adaptivity is needed for educational toys for autistic children. A device that helps parents to set LED colours, record and appoint sounds (not only speech), can make LINKX useful in many settings.

Setting LED colour

For Jakob the colours were a drive to play with LINKX, but it hindered his language learning. When parents can set all colours to white the focus can shift to sound instead of colour.

More sounds is more fun!

Blocks can be more rewarding when they play music or compliments as well. Parents should be able to record and set compliments or select a happy music for their child. This 'personal' recording is experienced as positive by parents. Beer's mother expressed Beer really likes LINKX, because he hears her familiar voice. Whether this is true is difficult to check, but the mother is convinced at that is important as well.

Games with LINKX

When children know the words they get bored and ask for new objects. By learning the other way around their play can have more depth. A nice game is 'Where is?' A block can ask for an object, and after that the child searches the correct speech-o-gram. A correct match can give a compliment or a music. In that way the child learns some turn-taking as well.

Speech recognition
After seeing that parents were so much involved in their play, it would be a good idea that their 'device' enables them to reward their child for talking. Automatic speech recognition never meets the recognition of parents and they like to play with their child. However a parent can not always accompany their play, so for individual play it would still add value.

6.3. Society - toys for autistic children for now & later

Interactive toys that stimulate language development of autistic children are scarce at this moment. Children with autism could really benefit from toys such as LINKX. They love being in control, and computers facilitate this. They are much more predictable than human beings. Moreover they learn easier from a voice coming from an external audio source than a human being (Frith, 1989). With the rising technological possibilities of tagging objects in the environment for example by means of precision location sensors or RFID-tags, toys can become much smarter in the future. By using technology (language) learning of autistic children can be facilitated in a way they enjoy.

LINKX gives you a feeling of what toys for these children should be like. The framework I made can inspire other designers as well in their design activities for these children. Parents were very enthusiastic about the design and really hope it will be further developed. Not only in home situations LINKX can be used; speech therapists or schools can use it as well for example.

On long term I hope that further research can give more certainty about the whereabouts of autism and what can be done to facilitate the learning process of these children. For now I hope that many designers will be inspired to design for these special children who surprised me often with their smart and inventive way of playing.

7. Evaluation of the process

Key aspect of my process is involving 'autism experts' into my design process. I never involved users this intensively in my process before. I enjoyed it a lot and learned it adds great value. Empathy with the children and their parents helped me to design something that fits the needs of autistic children better. The children surprised me with their unexpected behaviour. I realize that parents invited me into their life which was sometimes very personal. But I am convinced that I could not have made this design without being part of the experiential world of these children. Therefore the phases of exploration and play-sessions were my favourites.

7.1 Exploration

During exploration I could use knowledge from my previous project 'Contextmapping in East Asia'. In this project I learned a lot about contextmapping techniques and discovered I like doing human centred design research. Since I already used existing techniques, and designed some tools myself, I had contextmapping basis for this project. During my graduation I could use techniques in a way that suits me, because decisions are easier made when you have experienced it before (e.g. setting up a contextmapping session, preparing sensitizing material). However, I could not have a conversation with these children I also observed them a lot. Since these children exhibit such particular behaviour, I enjoyed that a lot as well. I realize my strength surely lies in involving people, and structuring results into a framework.

7.2 Conceptualizing

During conceptualizing I sometimes had difficulties to keep things going. I wanted a concept that both fits their special way of playing, but also learning, and this led to some struggling sometimes. During concept development it took quite some time before all components were ordered. If I had been more explicit to others I think I could have saved some time here. Although I am good at involving people, I seem to have trouble to 'ask' for someone's help. But everything turned out okay after all, even the rubber moulding. Although I did not manage to implement everything (wizard of Oz for speech recognition, breathing, etc), I am glad I kept my time schedule. At that moment I sometimes felt it was not enough yet, but during play-sessions I realized the main concept could be tested and that is most important. On most important functionality (the linking) a lot of insight could be gained already.

7.3 Play-sessions

The play-sessions were most fun of all. Although it was quite a job to prepare LINKX over and over (e.g. charge batteries, reset) it was really worth it. Playing with the children went okay, the parents were enthusiast about LINKX, and the children liked it. The way of evaluating afterwards did not work as expected. During play we discovered a lot, both me as the parents. We spoke about these encounters right away. The poster afterwards was difficult to use, because the child was walking around and asked for attention. The booklets gave information, although most was already discussed during the play-sessions.

7.4 Conclusion

Autistic children are for sure 'difficult to reach' and this made me to my belief learn more on the area of user involvement than I would have when designing for a target group that is 'easier to reach'. Now things needed to be explicitly discussed with parents and pedagogues, because the world of an autistic child differs that much from my own. Although especially during conceptualizing, I was sometimes desperate about what could help these children, I am happy with my result. I hope more educative toys will be become available for autistic children, because I learned that they can really benefit from it. I enjoyed doing this project and liked to cooperate with all people involved. Thanks!

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Enclosures

The CD included in the cover includes a digital version of my master thesis. In this version you can play movies. The CD also includes a presentation movie of LINKX.
I included in between results from my process as well. Booklets from parents and pedagogues can be found as well as collages from the contextmapping session with pedagogues of my process during exploration. The evaluation booklets of the parents are included, even as the movies of the seven play-sessions with the participating children.