Robot-enhanced therapy for autistic children

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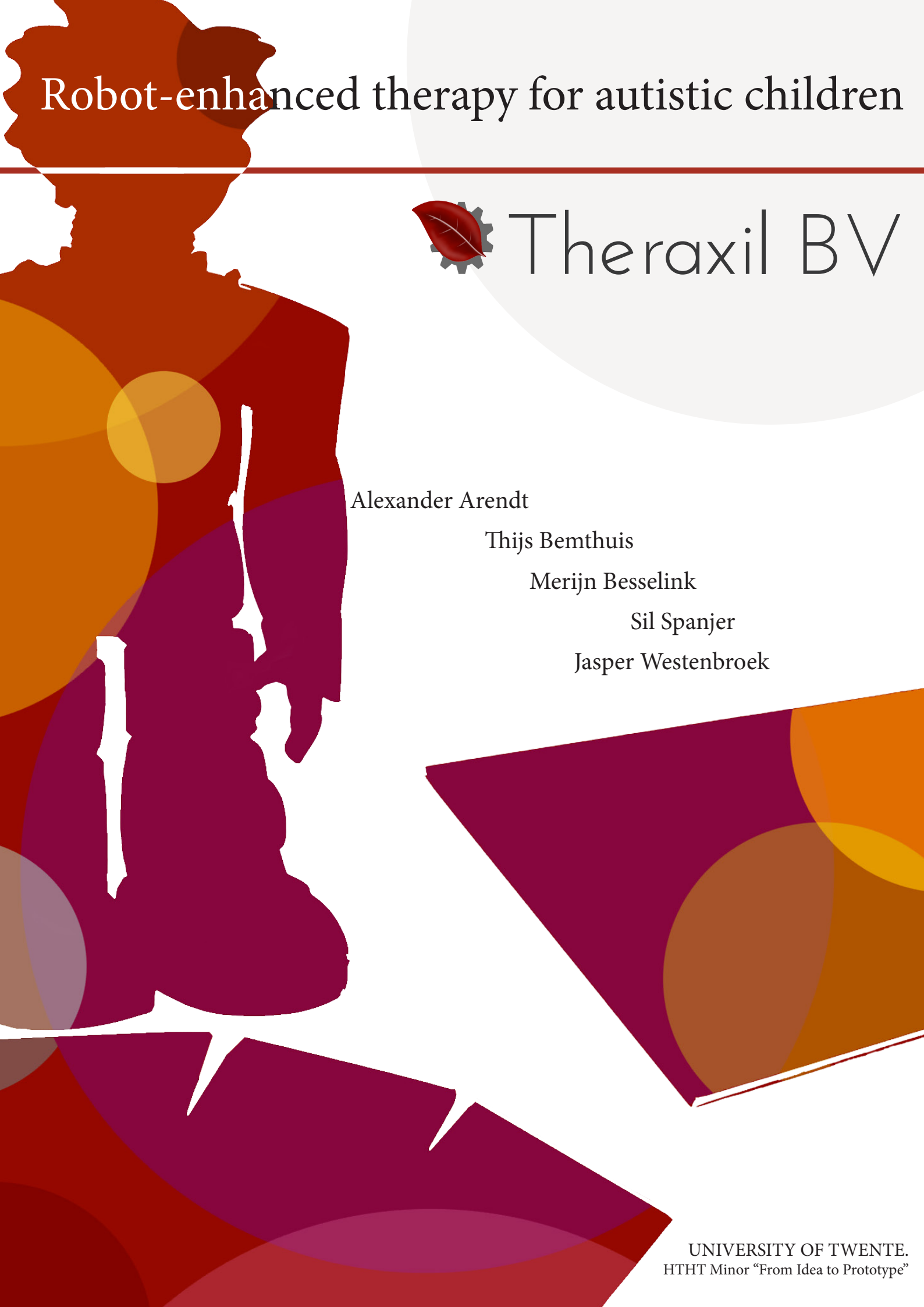

UNIVERSITY OF TWENTE.
HTHT Minor “From Idea to Prototype”

Theraxil BV |Group 5|

This rapport, written by the authors below, is part of the High Tech Human Touch Minor “From Idea to Prototype” of the year 2015-2016 at the University of Twente.

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The aim of this minor is to evolve a broad idea into a lifelike prototype, by simply starting from scratch. This is exactly what happened in our group. At the beginning of the project, none of the team members was familiar with each other or the subject that we have been working on for the weeks that followed.

The proverb ‘A good start is half the battle’ could perfectly be pasted on our group. At the beginning no one knew each other and everyone was a stranger to the subject. We had the luck that from the start and first acquaintance there was directly a good atmosphere between every group member. This was very beneficial to get a good start of this project and to gain our focus and interest in the subject.

At the end we have created a well-underpinned therapy and application for usage with the Zeno robot technology, with a special focus on increasing the emotional recognition abilities of autistic children.

This project would not be possible without the cooperation and support of our main stakeholder and tutor, Ms. Charisi. We want to specially thank her for her support, advise and cooperation during this project. We also want to act our special thanks to Mr. Davison, for his time and support with the Zeno robot. At last we want to thanks the minor coordinators, mr. Bruinsma and dr. Kulyk, for making this minor possible.

Enschede, October 2015

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Introduction

The world is continuously evolving and innovations are every day's business. Previous research has shown that children with Autism Spectrum Disorder (ASD) have a preference for objects over people and the researches emphasize the usefulness of humanoid robots in both the diagnostic as well as the therapeutic phase of ASD (Cabibihan, Javed, Ang & Aljunied, 2013, Dautenhahn & Werry, 2004, Robins, Dautenhahn, Te Boekhorst & Billard, 2005, Scassellati, 2007). The humanoid technology is constantly evolving and on the current market multiple robots, with a special focus on usefulness for children with ASD, are available. These well-designed robots can mediate and facilitate the development of children's social and emotional skills (Werry, Dautenhahn, Ogden & Harwin, 2001).

The positive effects humanoid robots could have on autistic children creates a lot of possibilities for application of these technologies in real-life situations. Currently a lot of these humanoid robots are used for testing and research as they are not yet suitable for the therapeutic market. In this design we will focus on creating an application and therapy for a humanoid robot, with focus on the usage for autistic children in therapy.

There are different humanoid robots on the market. In this design we have chosen to use the Zeno Robot technology to work with. This humanoid robot is designed for the usage for therapy for children with ASD and therefore suitable for our situation and research. To goal of this research is to design a child-robot-therapist interaction for children with ASD. In other words, we will investigate and create possibilities to make the Zeno robot more usable in therapeutic sessions with Autistic children. From this goal the guidance design question can be extracted and it is stated as follows:

How can the Zeno robot technology be effectively used in therapeutic sessions for autistic children.

The results of this design could have a positive influence on the therapy for autistic children. Currently, the Zeno robot is only used for testing and researching purposes (Ranatunga, Rajruangrabin, Popa & Makedon, 2011). With this research we want to create a new therapy approach, which makes it possible for the therapist to control the Zeno robot in a user-friendly way and make the autistic children benefit from all the positive influences the Zeno could have.

Problem Analysis

Problem statement

In the past multiple researches concluded that humanoid robots could have a positive influence on children with autism. The term autism refers in this design to Autistic Spectrum Disorder (ASD). This disorder consists of different stages, degrees and varieties. Autism is a lifelong development disorder that characterized itself by the difficulty in social interaction, communication and forming relationships, according to the National Autistic Society (NAS, 2014). People with autism are struggling to interact successfully with others on an emotional and social level (Scassellati, Admoni, & Matarić, 2012). This includes making little reciprocal use of eye-contact, experience difficulties in understanding verbal and non-verbal communication, especially facial expressions, and therefore are struggling with understanding other people's feelings, mental states and intentions (Robins & Dautenhahn, 2014).

The reasons for this disorder are unknown and a cure for is yet to be found. Currently the only way this disorder could be handled is by educational and therapeutic approaches. A problem which occurs here is that every child is unique. Autism has multiple degrees and not every therapeutic or educational approach is as effective for every person with autism (Dautenhahn & Werry, 2004).

Humanoid robots could fulfil a mediator role in the therapy for autistic children. Children with autism prefer objects over people (Cabibihan et. al., 2013) and, like most of the children, have an affinity towards robots and technology. Next to that humanoid robots could be programmable and therefore predictable for those children (Dautenhahn & Werry, 2004).

The technology is available to implement the humanoid robots to its fullest in the therapy for autistic children. This could have huge benefits for the autistic children. Despite all the possibilities, these technologies did not reach their full potential and a lot of children with autism could not yet benefit from all the positive influences it could have.

This gap between the technology and the possibilities of the technology lead to the following problem statement:

The therapy methods for humanoid robot technology are not yet used to its fullest potential by therapist in the benefit for children with autism.

This problem statement gives opportunity to conduct a sustainable solution which is implementable for the usage of humanoid robot technology and make it possible for therapist to use the humanoid robot technology to its fullest potential for the therapy with autistic children.

Problem Analysis

Research proposal

In the current situation there is a gap between the possibilities the available humanoid robot technology has and the usage of it in therapy for autistic children. In this research we will design a solution for this gap, with the focus on creating possibilities for therapists to use this humanoid robot technology to its fullest potential.

The current technologies offer different kinds of humanoid robots. For this research we have chosen to use the available Zeno robot technology. This robot is designed and created by the RoboKind company in Dallas, USA. A picture of this Zeno robot can be found in the appendix (page 72). This is a leading company in the robotics industry and they focus on creating the most lifelike robots in the worlds, especially by focusing on the facial expressions of the robots. According to RoboKind the Zeno robot improves children's social and behavioral skills and lets them gain the confidence they need to succeed academically and socially. These specifics are especially useful for autistic children and therefore this robot is a suitable robot to conduct this research with.

The goal of this research will be to fulfil the gap mentioned above, by using the available Zeno robot technology. This gap can be fulfilled by designing a therapy and application for the Zeno robot, which could be used by therapists in the therapy for autistic children. From this child-robot-therapist interaction design the following design question could be extracted:

How can the Zeno robot technology be effectively used in therapeutic sessions for autistic children?

The Zeno robot technology is already available and in use in therapeutic ways of research (Ranatunga et. al., 2011). Our design question is based on improving the available technology and designing a new therapy method to improve the abilities of the Zeno robot in therapy for autistic children. With this improving therapy methods for the Zeno robot, we want to make this humanoid robot more user-friendly for the therapist and thereby aim to decline the gap between the technology and the practice.

This design wants to increase the value of the humanoid Zeno robot technology for therapist involving in autism. With our therapy design we want to make it easier for therapists to use the Zeno robot and therefore increase the benefits it could have for the autistic children.

Value proposition

Our design and this research could have a great value for the potential customers. The goal of this research is to fulfil the gap between the available humanoid technology and the usage of it in therapy for autistic children. This gap can be filled by designing a therapy and application for the Zeno robot, which could be used by therapist in the therapy for autistic children. This robot technology could have an increasing value for both the therapist, as the child involving.

Old-fashioned therapy sessions are not always even effective for every autistic child. The humanoid technology makes usage of the fact that autistic children prefer objects over people (Cabibihan et al., 2013) and that most autistic children, like every child, show a general affinity towards robots (Robins, Dautenhahn & Dickerson, 2009) Because of these aspects of humanoid robots, different researches concluded the effectiveness of these robots in the therapy for autistic children (Dautenhahn & Werry, 2004, Robins et. al., 2005, Scassellati, 2007).

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In the following Value Proposition Canvas, the value of our design will be further explained.

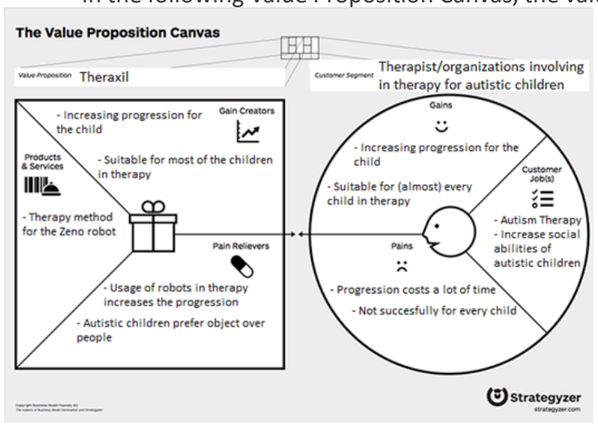


Figure 1 - Value proposition canvas

Our research is based on designing a therapy method for the therapy for autistic children. Our potential customers are therapists/organizations who are involving in the therapy for autistic children. On the right side the pains, gains and jobs of our potential customers are stated. Our customer is involving in the therapy for autistic children, with the focus on increasing the social abilities of autistic children, this is the customer job and our design is focused on this aspect. The pains our potential customer has are the time it costs to achieve some progression in the therapy and that not every therapy is even successful for every child. The gains our potential customer is searching for in a new technology of therapy method is the ability to increase the progression of the therapy and make the therapy methods more suitable for (almost) every child.

On the left side of the Value Proposition Canvas our company can be found. We will design a therapy method for the Zeno robot technology. This therapy method has some pain relievers for the potential customer; different researches concluded that the usage of humanoid robots could increase the social abilities of autistic children. Therefore this pain reliever solve (partly) the pains of the potential customer. This pain relievers are also involving in the gain creators of our design. The therapy method could increase the progression of the child and could be more suitable for more children, because of the aspects that children prefer objects over people and are in general more interested in robots.

Theoretical underpinnings

Autism

Autism spectrum disorders are disorders which first have been described as stand-alone disorders by, independent of each other, Hans Asperger (1944) and Leo Kanner (1960) during world-war II. Whilst first being identified as a symptom of schizophrenia in 1911 it soon became clear that the symptom of autism can occur without any other indicators of schizophrenia (Andreasen, 1989). Until today, there is no cure for autism spectrum disorders (ASDs) (Myers et al., 2007) and behavioral therapy alone has not been proven effective (Weinmann, 2009).

Diagnostically, one talks about Kanner-syndrome, starting in early childhood, and Asperger-syndrome, which becomes apparent after the third year of life (Asperger, 1944; Kanner, 1960). Yet, scientifically it is preferred to see autism as one disorder which runs on a spectrum of seriousness (APA, 2013), hence ASDs.

One of the main problems of ASDs is the poor social behavior. This occurs due to people with ASD are not having a theory of mind. In other words, they are having difficulties or simply cannot grasp that every person has different beliefs and knowledge, hence the trouble understanding emotions that do not coincide with their own emotions and problems with communicating, for example mixing up personal pronouns (Baron-Cohen, 2000). It adds to that the way people with ASDs perceive the world is so different from a healthy person that they struggle to communicate visuospatial information (Happé, 1999).

A newer approach is to view ASDs not as cognitive deficiency but as a cognitive style (Happé, 1999). This means that, besides the aspects people with ASD are having problems to deal with, they are having certain strengths, often in one area of knowledge, skill or science (Treffert, 2009).

It is hypothesized that, by helping children with ASDs acquiring a theory of mind, much of their poor inter-social behavior can be improved, as the children might learn to change their perspective and understand that other people are indeed other people. It is, though, important for people with ASD to have a dedicated structure in everything they do, as this does not surprise or overstrain their perception and information processing (Whitaker, 2001).

Robotics

The development of robot technology dates from back in the mid and late 20th century. Though the description of robotics and robot-human interaction comes from way back in the past, for example Da Vinci's 'mechanical man' (Goodrich & Schultz, 2007). But it was not until 1958 that real robots were introduced in the car industry. In this year General Motors introduced the "Unimate", which was a robotic arm that aided in the assembly of automobiles (Hockstein, Gourin, Faust, & Terris, 2007). After this development the robotics made a jumpstart in different sectors like the aerial industry, the military and deep sea exploration. According to Hockstein and colleagues (2007) all robotic interventions are aimed to duplicate human functions in hazardous, difficult or restraining situations.

In the health sector, assistive robots have been introduced to aid people in need of physical help. Robots can help a patient perform repetitive therapeutic motions just like a physical therapist would (Kwakkel, Kollen, & Krebs, 2008). Assistive robot design typically focuses on precision of motion, repeatability, and reliability. These are all important because of the physical engagement with humans. Another type of assistive robots are the so called socially assistive robots (ASRs), which are used for helping people on a social level rather than a psychical one (Feil-Seifer & Matric, 2005). This rather new approach on robotic usage in health covers approximately a decade in research so far (Scassellati et al., 2012).

The latest developments in socially assistive robotics are the humanoid robots focusing on human behavior. In 2010 the company Robokind has developed the "Zeno" robot. The Zeno is a humanoid robot that can express humanlike expressions and mimic emotions. The robot is developed for aiding children with autism with social limitations. In this research the Zeno robot will be used for teaching autistic children social skills.

Theoretical underpinnings

The Zeno robot

For the project the Zeno robot is used. The Zeno robot is a humanoid robot developed and produced by the Robokind company, with model number r25. The Zeno robot is designed to be able to express emotions and further is can move its arms and legs. To perform these emotions and movements the Zeno robot has a couple degrees of freedom (DOF's) which will be addressed shortly in the next section. The Zeno robot also has an onboard speaker, touch screen and webcam. The Zeno has a height of about 40cm, has an internal battery which last around the 10 minutes in full use. It is delivered with a charger and to control the robot from an external source the robot has to be connected to WiFi.

Degrees of freedom

The Zeno robot is equipped with a couple of DOF's. Each DOF has at least one actuator to be able to perform controlled motions in the desired DOF. Robokind deliverers a animation software package with the robot to specify the motion paths the actuators will follow in a user defined sequence. Each actuator gives feedback over its position to the control program and therefore the control software is able to make the actuator follow a user specified path in time.
The available DOF's are listed below:

1. Shoulder Roll. The shoulder roll DOF is located between the torso and the arms of the robot. This joint makes the robot able to roll its arms half a circle.

2. Shoulder pitch. The shoulder pitch DOF is located in the arms between the upper arm and the shoulder, where the arms makes a 90° angle, see figure 2. The robot is able to perform a 180° roll in this joint. This joint is posiioned with a 45° angle to the shoulder, this means that the robot is able to roll its arms from vertical to horizontal.

3. Elbow. The Elbow DOF is located between the upper and the lower arm and is positioned at a 45° angle to the rest of the arm. The robot can perform a 180° roll in this joint. This means that the lower arm of the robot also can roll from horizontal to vertical.

4. Wrist. The wrist joint is located between the lower arm and the hand of the robot. Because of the wrist DOF the robot is able to roll its wrist 45°. The 0° position is when the robot has the flat of his hand directed toward his torso and the 45° position is when the robot has the flat of his hand is directed forward.

5. Grasp. The grasp joint should theoretically make the robot be able to make and release fists, but practically this feature did not work well.

6. Legs. The robot has wheels under his feet and is able to lift his legs and therefore he can imitate the walking movement. This part of the robot was not controlleble with the animation package so it is, from this point on, let out of the description.

7. Corners of the mouth. The robot is able to move the corners of its mouth to display for example a smile. This motion is performed with two actuators and therefore it should also be two DOF's, but Robokind connected the actuators to each other and therefore the actuators are not separately controllable and is therefore referred to as one DOF.

8. Mouth. In the mouth of the robot a actuator is placed to open and close the mouth, all the positions between open and close are also available.

9. Eyelids. The eyelids of the robot are, just like the corners of the mouth not separately controllable. Through the eyelids DOF the robot is able to adjust the position of the eyelids. Therefore the robot is able to blink and for the expression of emotions it is also necessary.

10. Eye's pitch. The pitch of the eyes is also connected. The robot is able to rotate its eyes.

11. Forehead. The forehead DOF makes the robot able to raise and lower his forehead. The actuators are positioned that when in low position the robot displays a frown and in high position it raises its eyebrows .

The DOF's of the arms are double, in the head several DOF's are coupled and the wrist are not useful, this makes a total of 13 controllable DOF's.

Figure 2 - The Zeno Robot see appendix page 72

Impact on society

Autism is a frequently noticeable mental condition in the current society. According to studies of the central statistical bureau of the Netherlands almost 3% of the children between 4 to 12 years has, according to their parents or caretakers, autism or a similar mental condition like Asperger's or PDD-NOS (CBS, 2014). These 3% correspond with almost 43.000 children in the Netherlands alone. This condition has therefore a noticeable influence in the Dutch society, like in the education and health system. The improvement of the therapy for the autistic children can make it possible to increase the social capacities of those children and therefore make it possible to increase the participation in the society. The improved therapy has by means of different stages an indirect influence in the society as a whole.

The model

The modified therapy has an indirect influence in the society. For the good understanding of the impact in the society it is important to distinguish the different stages of the influence of this therapy before it impacts in the society. The different stages are shown in figure 3.

Figure 3 – From therapy to society

In figure 3 there is a systematic overview given of the different stages which an adjustment in the therapy flow before it hit society. Every stage has an effect on the next stage. It all begins in the first stage; the therapy stage. This research is about implementing new ways to improve the social skills of autistic children, with special use of existing humanoid robots. The question that will be answered in this stage is how the adjustments will affect the existing ways of therapy. The next stage is all about the effect this modified therapy has on the patient; the autistic child. The question that will be answered in this stage is how the modified therapy will affect the patient. The next stages will built on the answer of the stage before them; for example the indirect and direct surroundings are affected by the patient which is involved in the modified therapy and the society is affected by the (in)direct surroundings of the patient.

Table 1
Questions on how each stage will affect society

Stage	Questions
Stage 1: The therapy	How will the adjustments affect the existing ways of therapy?
Stage 2: The patient	How will the modified therapy affect the patient him/herself?
Stage 3a: The direct surroundings	How will the patient involved in the therapy affect his/her direct surroundings? (e.g., family or school)
Stage 3b: The indirect surroundings	How will the patient involved in the therapy affect his/her indirect surroundings? (e.g. neighborhood, therapist)
Stage 4: The society	How will the direct and indirect surroundings of the patient affect society?

The stages

In this project, research will be done to provide technology that will improve the way therapy is given to children with ASD. This technology will be evaluated when implemented. Therefore it is currently not possible to answer the questions of the different stages by fact. Although the questions cannot be answered by fact, it is possible to answer them by hypotheses based on assumptions and literature. These hypotheses will be the current answers to the questions. When the project is finished and the results are evaluated, these hypotheses will be checked and the answers will be corrected when needed. For a short display of this concept, see figure 4.

Stage 1: Therapy:

How will the adjustments that will be made affect the existing ways of therapy?

Old-fashioned therapy consists of the interaction between an autistic child and the therapist. One of the aspects of autism is that children with this condition are struggling with human contact. With the implementation of a humanoid robot a third player is assigned. This robot will fulfill the function as a mediator between the child and the therapist.

Impact on society

The stages

Stage 2: The patient:
How will the modified therapy affect the patient?
The new way of therapy will be given with a robot as a mediator between the child and the therapist. Different studies confirm that children with ASD prefer objects above human interaction. With the implementation of a robot mediator it is possible for the child to recognize human emotions in a better way and absorb these emotions.
Stage 3a/b: The (in)direct surroundings:
How will the patient involving in the modified therapy affects it (in)direct surrounding (e.g. family, school)?
With the appliance of this new therapy the autistic child can recognize human emotions better and therefore can handle and process those emotions better in its direct surroundings. The effect it has is that the child can get along with his or her classmates. Will take less time for the parents or caretakers.
Stage 4: The society:
How will the direct and indirect surrounding of the patient involving in the modified therapy affect the society?
The patient can get along better in his/her surroundings, therefore can participate more in the society as a whole. If the therapy works well, the patient will proceed better, less therapy is needed and so it will costs the society less money.

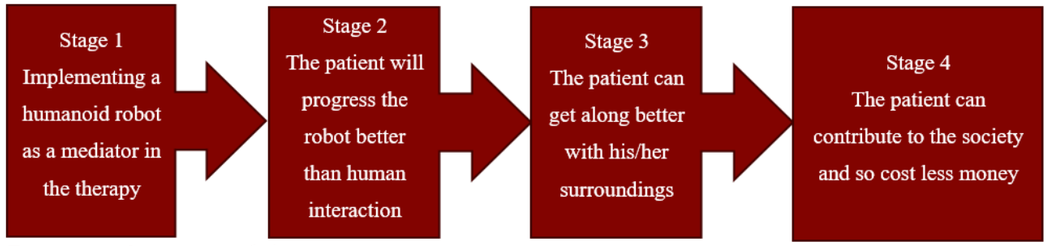


Figure 4 – Summary of the concept

External input by specialists

Before the generation of ideas two professionals have been consulted. Mrs. Marjolin van Klink, a specialist in the work with children and children with psychological disorders who runs the kindergarten at the University of Twente, gave advice on how to cope with autistic children and added some considerations to the project. These considerations were that one cannot design one solution for all the autists in the world as there is a great difference between single children with ASD. They are as diverse as any other children. She also mentioned that it was very important to have some kind of structure in the therapy to avoid surprises and children throwing a tantrum.

The second specialist that was involved was Mr. Daniel Davison, a PhD-student at the University of Twente who promotes in the field of Human Media Interaction (HMI). He instructed the structure and use of the programs behind the Zeno robot so changes could be implemented without his help. This led to the use of a Java-GUI and the Flipper- Yarp- and Asap-structure. The HMI-faculty used this program for their own research and it has not been made by Mr. Davison alone. The changes made to this existing program will be explained later on.

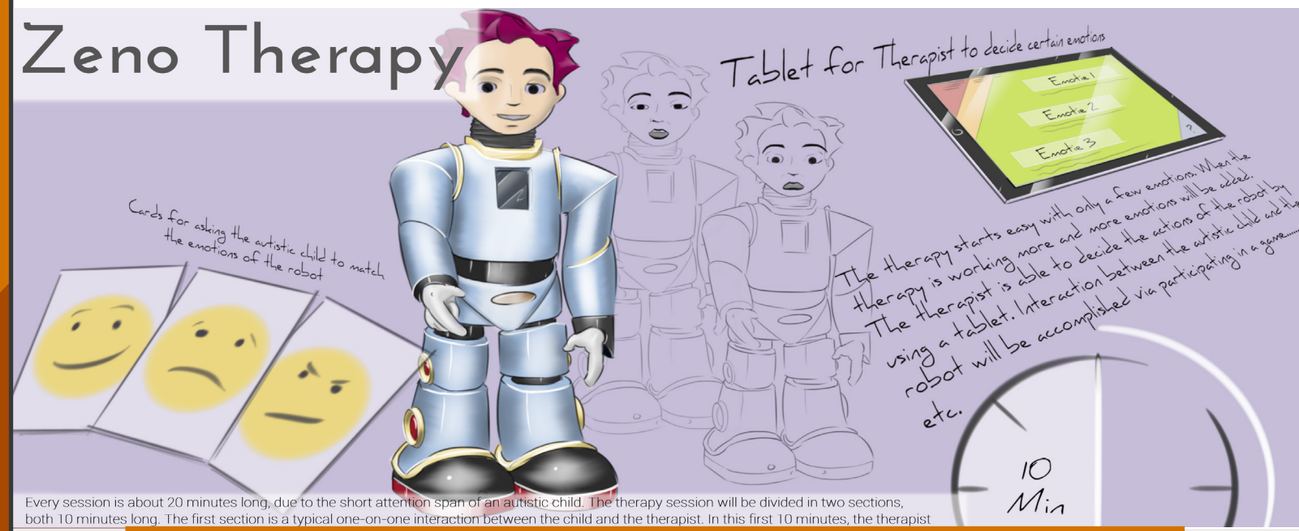
Final concept description

Every session is about 20 minutes long, due to the short attention span of an autistic child. The therapy session will be divided in two sections, both 10 minutes long. The first section is a typical one-on-one interaction between the child and the therapist. In this first 10 minutes, the therapist discusses various topics of the child's interest, e.g. daily activities, school activities, interaction with known and/or unknown people. In the last 10 minutes, the setup will be changed to a child, therapist, robot situation. This session has three levels. The child will get cards with different pictures of emotions. The therapist will choose an emotion with the controller that will be expressed by Zeno. In the easy level the zeno will express the emotion and will ask the child which card fits his expression best. Zeno will ask the child to choose the emotion card that matches Zeno's expression. In the easy level only the most basic emotions are displayed, these are happy, sad and angry. In the medium level the Zeno will express the emotion and asks: "What is the name of this emotion?" In the medium level the most basic emotions are used plus one emotion extra emotion specified by the therapist. In the hard level the Zeno asks:"How do you feel when you look like this?" In the hard level all six basic emotions are used. These are happy, sad, angry, surprise, disgust and fear. When the child answers correctly, Zeno will be enthusiastic and says something like: good job! The therapist also gets the opportunity to choose an extra enthusiastic response. The performance of the child will monitored so the therapist can pay extra attention to the emotions the child has problems with.

Results / Prototype

The prototype consists of a certain amount of sub results. These results together are what makes the product a whole. The results of the prototype are the therapy, the cards, the program for the robot, the interface and its design, the reward- and the difficulty-system. For the prototype to work, all of these parts had to be conjoined.

Figure 5 - Concept Board (see appendix page 73)



The therapy

For the prototype it has been focused one part of the concept. In the schematic overview below, the prototype session is marked in purple. The first therapy with the robot starts with an introduction, to see if the child is comfortable with the Zeno. The child can see, touch and even smell the robot to get familiar with it. Then the Zeno gives an introductory speech, in which he tells the child that his name is Zeno and what they are going to do in the session. If the child is comfortable, the therapist will be able to start with the easy session. If, on the other hand, the child is not comfortable with the robot, the session will end and the therapist will continue with the therapy as usual.

There will be three emotion cards displayed on a table in front of the Zeno robot in the easy session. The therapist will choose a particular emotion, for example happiness, and the Zeno will start acting. The Zeno says: "I feel happy, can you choose the card that reflects my emotion?" At this time the Zeno has a happy facial expression and the child has the opportunity to choose the happiness card out of the three cards that are laying on the table. If the child picks the right card, the therapist will click the 'right answer' button. The Zeno will then approve of the child's choice. This process will be repeated with the other two emotions that have been chosen by the therapist for this particular therapy session.

If the child picks the wrong emotion card, the therapist will click the 'wrong answer button' and Zeno will say that it was not the correct answer and asks the child to try again. Should the child not be able to pick the correct card after a couple of tries, the therapist will intervene and say which card would have been correct. At a later session, the card with which the child had difficulties will be rehearsed. During the sessions the therapist will control the robot by using the "Wizard of Oz" method. This means that an actual person is controlling the robot, but this fact must be oblivious to the child to create an illusion of an autonomously acting robot.

Results / Prototype

The therapy

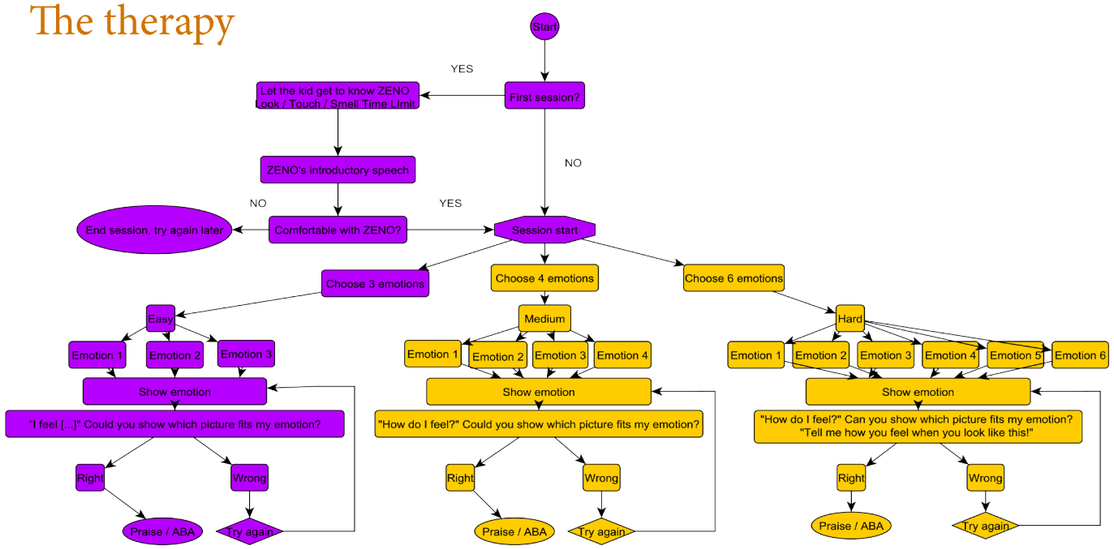


Figure 6 – Therapy structure (see appendix page 69)

The therapist has a choice of three difficulties, which differ in the degree of storytelling and the amount of different emotions that Zeno will show. Easy employs a maximum of three emotions, medium four and hard, respectively, six, which then covers all basic facial expressions of emotion. With the easy difficulty, Zeno will tell the child how he is feeling, with medium he will ask how he is feeling and with hard he will ask the child to tell him when it feels this way. So, after Zeno showed the emotion, the child has to show a card. The therapist can then choose if it was right or wrong, making Zeno elicit different responses, for example “That was not right, try again!” for a wrong answer or “Correct! Well done!” for a correct answer. After ten minutes the session is over and Zeno will farewell the child.

Difficulty system

The therapy which is used in this design consists out of three different difficulty levels. In the easy level, a maximum of three different emotions can be chosen for the session. The Zeno robot tells the child which emotion is shown and asks it to choose the emotion card that reflects the shown emotion. At the medium level there will be a maximum of four different emotions. Zeno will ask the child how his expressed emotion is called and will also ask it to choose the matching emotion card. The final level, hard, consists of six emotions and the child will have to say which emotion is expressed, choose the matching card but also tell a story about a time where it felt or expressed that way. In the prototype only the easy level has been programmed, due to time constraints. In a later stage, the other two steps will be included in the prototype.

The robot/program

The Zeno robot is controlled by a couple of inter-cooperating programs. Four of these programs have been used to program the prototype. These programs are “Asap”, “Yarp”, “Flipper” and a Graphical User Interface (GUI) which has been programmed specifically for this prototype.

Flipper

Flipper is the program that controls the flow of the dialog. The input of Flipper are input ports from Yarp. The backbone of the Flipper structure is the easeldialog_config.properties file. In this file it has been specified which files are used as scenario and as data sources. The data source file is the file which converts the input of Yarp to the database used in the scenario. The scenario contains all the text and the motions the robots performs during the therapy session. These text and motions are grouped in templates and each template has certain preconditions, effects and behaviors. The preconditions can be things like compare if a value in the database is equal to a given value or compare if a value in the database is greater than a given value. When the preconditions of a template are met the effects are performed. The effects can create, modify, erase and replace values in the database. In the behavior section the actual actions of the robot are specified. The motions are specified in xml files which are send to Asap.

Yarp

Yarp is the program that connects the GUI with Flipper. Yarp sets up a server that listens to input on output-ports and connects them to a user specified input-port. It is important to notice that the direction of the ports are specified from the other programs, which means a input port in Yarp is a port which sends out data to a program. The connections between the input and the output of Yarp are specified in a connections-file and controlled in Yarp manager. The advantage of this system is that the GUI and Flipper do not have to be on the same system, as long as they are on the same internet network. It is therefore possible to set up a configuration with a host pc and a tablet which runs the GUI.

Asap

Asap is the program that controls the robot. The input of this file comes from flipper. Asap reads the incoming xml motion files and adds the motions so multiple animations can be acted out simultaneously. Asap also limits the motions of the robot to what is physically possible. After adding and filtering Asap translates the files to a format the robot can understand and sends the data on to the robot which performs the actions. Asap also has a text to speech sections which translates the incoming text commands to sound and movement of Zeno’s mouth.

Graphical User Interface

A Graphical User Interface (GUI) is programmed in Java to allow the user to control the flow of the conversation. The GUI controls the flow by sending out bottles of information to Yarp. The program can, therefore, run therefore from the other programs.

Results / Prototype

The interface / design

The therapist remains a significant personage in this therapy. He or she chooses the emotions that the child needs to recognize. To employ the “Wizard of Oz”-method, the therapist needs a Graphical User Interface with which he can control the robot without touching him. A tablet with an user interface is implemented. The interface consists of screens which take the therapist through the session. It has been made sure that the interface is somewhat user friendly and easy to use. This is important because the therapist must be able to move through the menus with ease and must be able to do it in a fast fashion. The picture below shows the designed interface and its options.

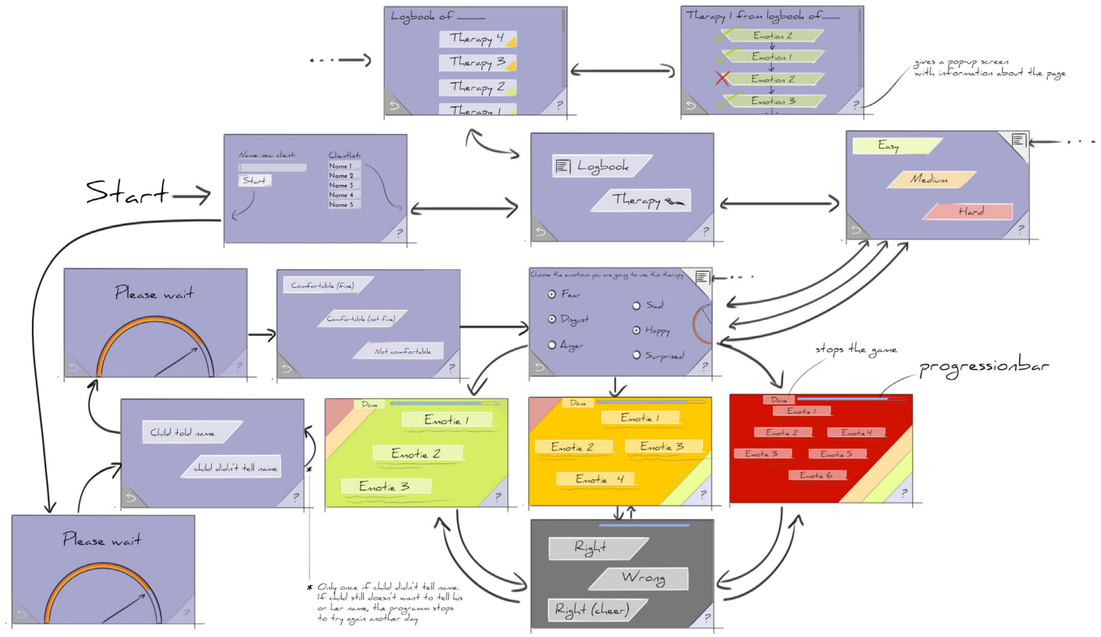


Figure 7 - Design interface (see appendix page 70)

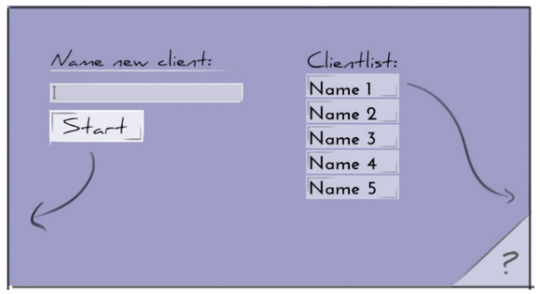


Figure 8 - Startscreen

In the picture on the left the first screen of the application can be seen. In this screen the therapist can choose to start the therapy with a new client or with one he or she already had a therapy with. Once the first therapy has been finished a name will be saved into the database. This name will appear in the list of clients shown on the screen.

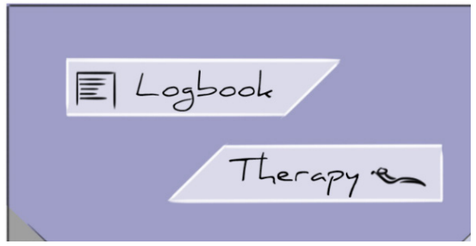


Figure 9 - Logbook/Therapy screen

When the therapist has chosen to see the logbook this screen will appear. The therapist can scroll through the different therapies the client has already had. The colored triangle in the corner of each button shows the difficulty that has been chosen for that particular session.

Once the therapist has chosen a client from the list this screen will appear. Now the therapist can choose to start a new therapy or check the logbook of this client. Every screen has a clickable question mark and a return button. When the question mark is pressed, additional information to the current screen will be shown.

Figure 10 - Logbook of therapies

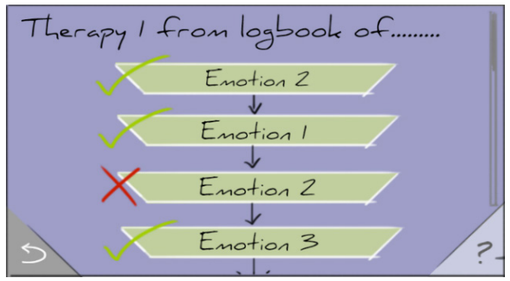


Figure 11 - Logbook of a therapy

When the therapist opens a therapy he or she can see the progress of the child. This screen shows the correct and wrong responses per emotion. This way the therapist knows which emotions need to be repeated for the child to better recognize a certain emotion.

When the therapist chose to start a therapy he can choose which difficulty the session will have. In the top right the therapist can choose to go to the logbook in case he forgot what kind of session they did last time and how the autistic child performed in that session.

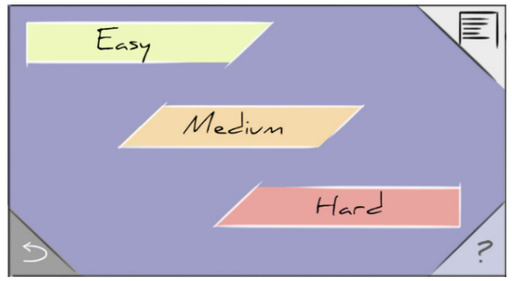


Figure 12 - Difficulty screen

Results / Prototype

The interface / design

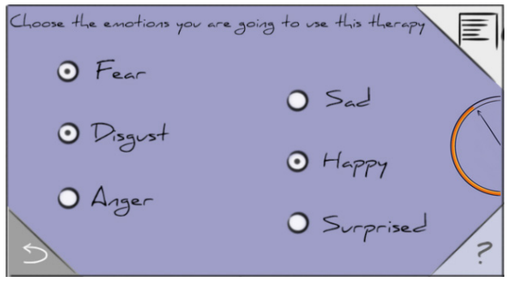


Figure 13 - Emotions for therapy screen

Once the therapist has chosen how difficult the session will be he must choose the emotions for the upcoming game. In this period the robot is talking with the child. Once the therapist has chosen the emotions and the robot is done talking the program will move on to the next step.

he game has started. Depending on the difficulty one of these three screens will appear. The green one for the easy difficulty, the orange screen for the medium difficulty and the red one for the hard difficulty. The therapist can choose the emotions the robot will show, but the therapist can also end the session by pressing “Done”. A progression bar shows the therapist how much time is left until the ten minutes are over.

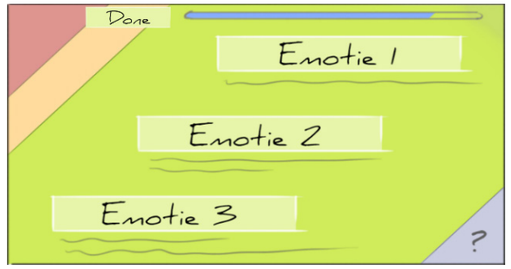


Figure 14 - Easy screen

Figure 16 - Hard screen

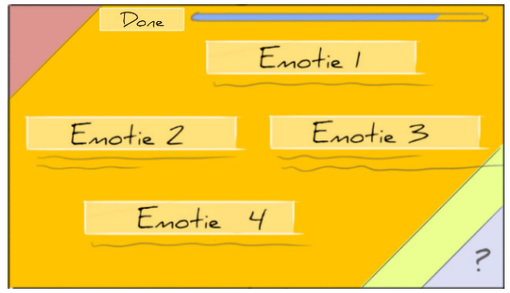


Figure 15 - Medium screen

The therapist chooses if the child gave a correct answer or not. This way the program knows how the child is performing. When the therapist chooses right, the robot will tell the child he did a good job. However if the therapist thinks the child is performing great he or she can choose “right cheer”. This will trigger a cheerful reaction of the robot to let the child know he has to continue his good behavior.

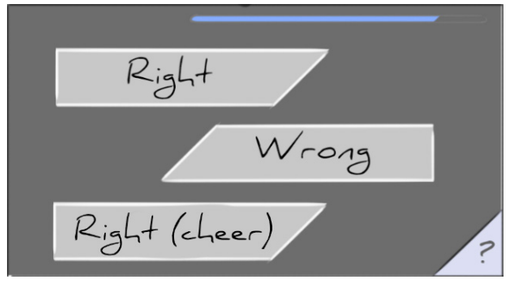


Figure 17 - Right or wrong screen

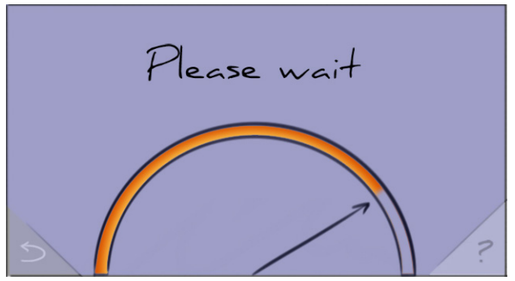


Figure 18 - Waiting screen

The please wait screen is meant to tell the therapist to wait a second. These screens occur when the robot is talking or expressing an emotion. An animation will show how long the therapist will have to wait.

If it is the child’s first session and the therapist filled in the name of the client this screen will appear. The robot just asked the child to tell his name. If the child told his name the conversation can move on. This is when the robot will ask the child how he is feeling. If the child is not comfortable with talking to the robot the therapist can choose the option “not comfortable”. This option tells the system the child is not ready for the therapy with a robot yet. The therapist can then try again next time. If the child is, indeed, comfortable and told how he is feeling the robot will react and explain what will happen and that they are going to play a game.

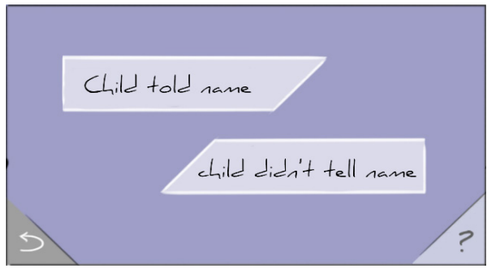


Figure 19 - Child told name screen

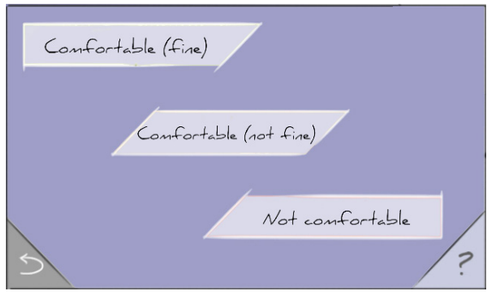
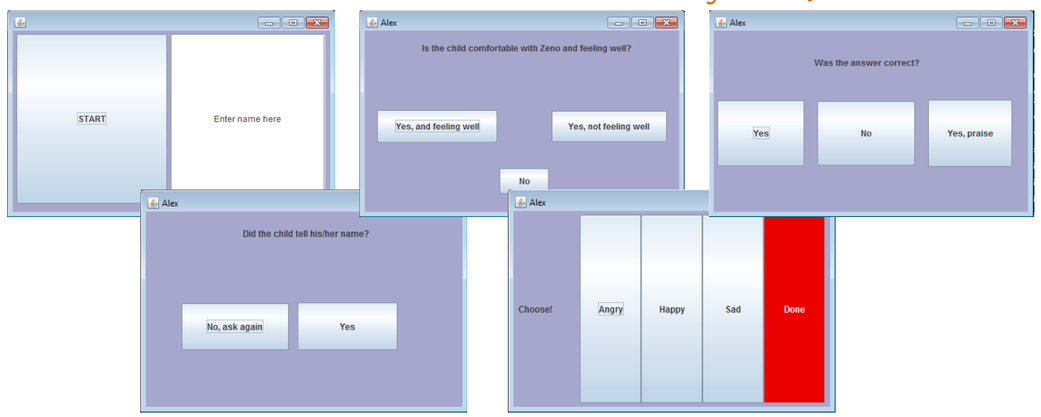


Figure 20 - Child is comfortable screen

However, it was not possible and needed to implement all these screen in the prototype. The interface used in our prototype does not yet need the logbook and the medium and hard sessions. The pictures below represent the interface of the prototype.

Figure 21 - Java interface screens



Results / Prototype

The cards

To play the game of the scenario cards were designed. These cards display the six basic emotions of humans. These emotions are, namely, happiness, sadness, anger, disgust, surprise and fear. Two sets of cards were designed: one for the easier sessions and one for the harder sessions. The set for the easier sessions has drawings of faces. The drawings are simplified versions of real faces. The most important aspects of an emotion are shown in these drawings without as less noise as possible. The set for the harder session however, has pictures of real people. This way the child will recognize emotions through pictures of existing people.

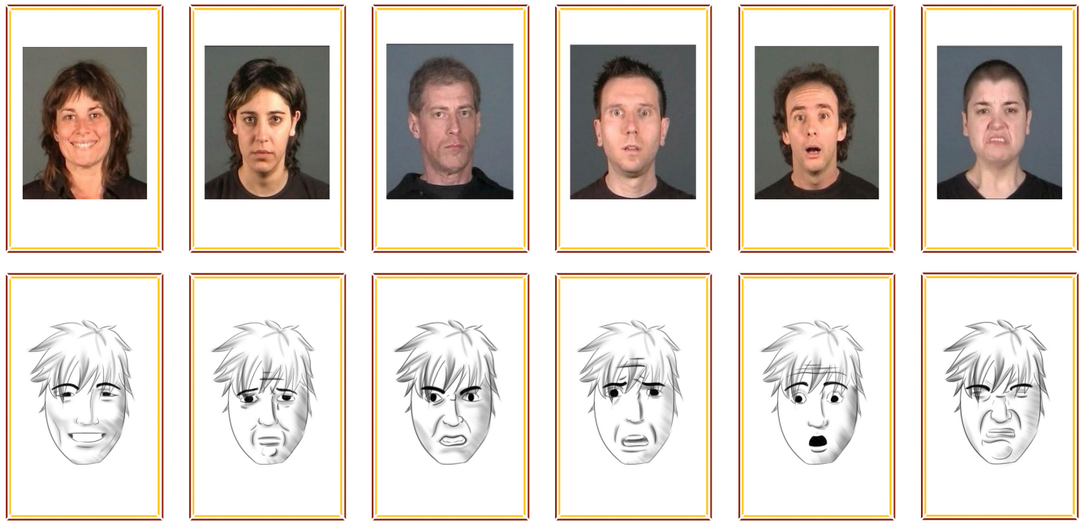


Figure 22 – Game cards

Because in the prototype only the first session is programmed, only three cards of the easier set are used. The cards used for our prototype are “Happy”, “Sad” and “Angry”. These emotions were chosen because they differ strongly and they make first session the easiest session of all.

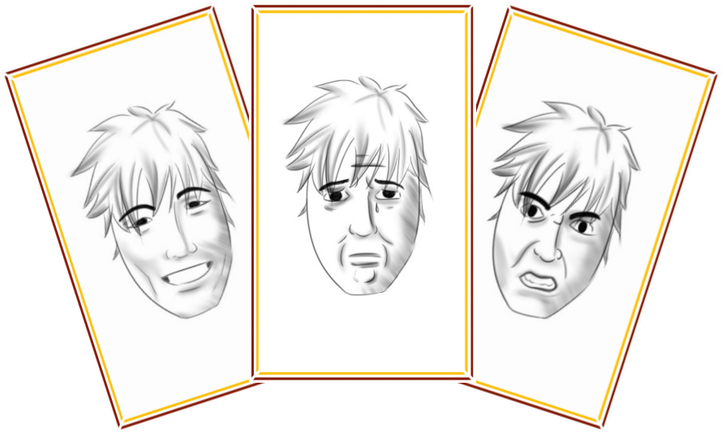


Figure 23 – Cards for the prototype

The rewarding system

The prototype has the function to praise the child when it does a good job. However, this is not enough to teach emotions to the child. A rewarding system has been implemented into the therapy, which is supposed to work better than appraisal. Through giving the child candy or letting him play with his favorite toy the child is taught that it is doing a good job. However this is not implemented in the structure. The therapist knows best when the child deserves his reward. As the skills of a therapist can generally be trusted this freedom has been given to him or her.

Technical details

flipper structure

The flipper structure is an easy overview of the programming of the robot. (The whole overview of the structure can be found in the appendix page 71.) You can see this map as the short term memory of the robot. This memory is somewhat divided into cognition and knowledge. For the program to work you can call upon his 'knowledge' and 'sensors' in a certain way. If the button (sensor) 'done' is pressed you can take this from the tree by using: $sensory.buttons.tree. This way the system knows what happened. This structure makes it easy to understand how the robot works and how it must be programmed. The structure consists of 3 different parts (the database, the precondition-effect-behaviour tables and the scenario structure)

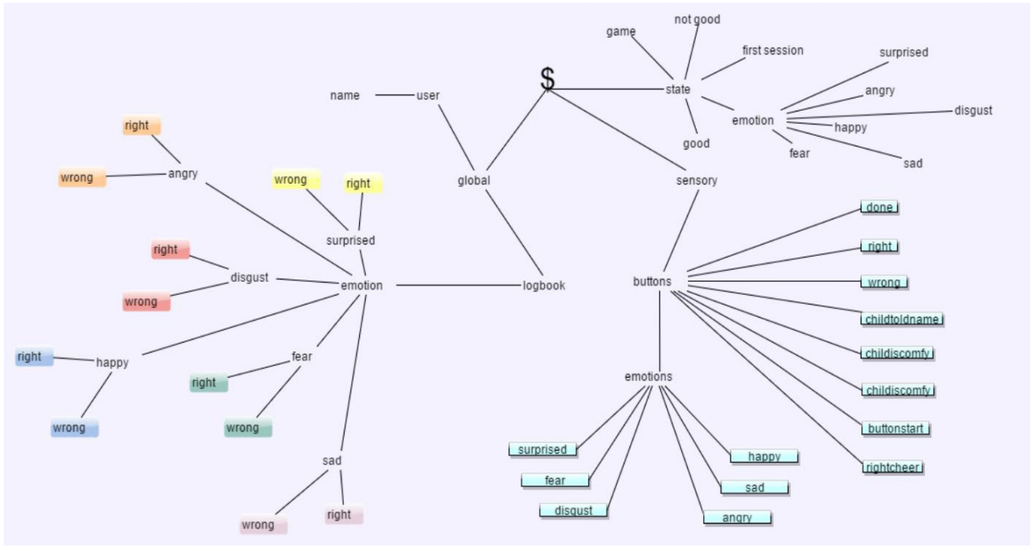


Figure 24 - Database

The above figure is the database of the robot. Basically it is a tree where each branch represents a button or something that happens internally. The states can tell the robot in what part of the therapy they are. With states the robot can take different actions at certain moments. Buttons are pressed by the therapist and tell the robot what happened. If a button is pressed the robot takes some actions. This if-statement is called a precondition. When a precondition is met, an effect and the robots behaviour will be triggered.

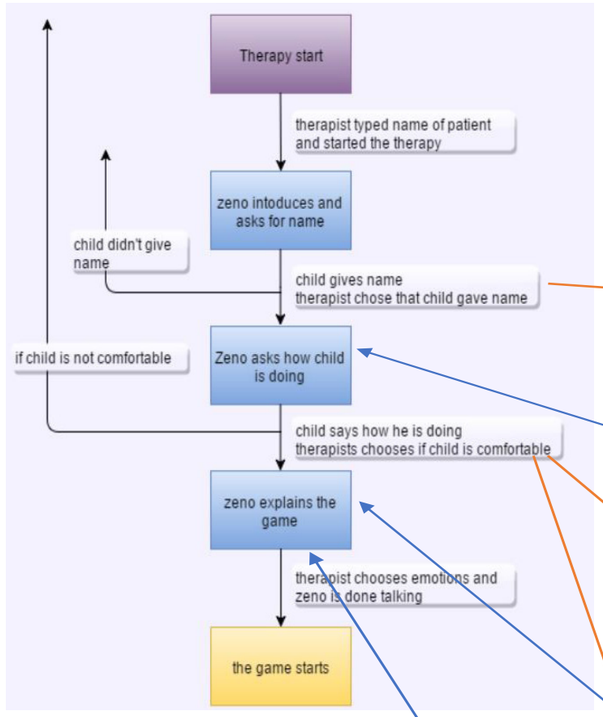
These preconditions, effects and behaviour actions can be sorted in a table of sorts:

preconditions - $sensory.buttons.emotions = "happy" - $state = "game"	**preconditions** - $sensory.buttons.emotions = "angry" - $state = "game"	**preconditions** - $sensory.buttons.emotions = "sad" - $.state = "game"
effects - $state.emotion = "happy"	**effects** - $state.emotion = "angry"	**effects** - $state.emotion = "sad"
behaviour speech(ik ben blij, kun jij mij zeggen welk kaartje bij mijn emotie past) expression(happy)	**behaviour** speech(ik ben boos, kun jij mij zeggen welk kaartje bij mijn emotie past) expression(angry)	**behaviour** speech(ik ben verdrietig, kun jij mij zeggen welk kaartje bij mijn emotie past) expression(sad)
preconditions - $sensory.buttons = "right" - $state.emotion = "happy" - $global.logbook.emotion.happy.right != 3	**preconditions** - $sensory.buttons = "right" - $state.emotion = "angry" - $global.logbook.emotion.angry.right != 3	**preconditions** - $sensory.buttons = "right" - $state.emotion = "sad" - $global.logbook.emotion.sad.right != 3
effects - $global.logbook.emotion.happy.right = - $global.logbook.emotion.happy.right +1 - $global.logbook.emotion.happy.wrong = - $global.logbook.emotion.happy.wrong - 1 - $state = "game"	**effects** - $global.logbook.emotion.angry.right = - $global.logbook.emotion.angry.right +1 - $global.logbook.emotion.angry.wrong = - $global.logbook.emotion.angry.wrong - 1 - $state = "game"	**effects** - $global.logbook.emotion.sad.right = - $global.logbook.emotion.sad.right +1 - $global.logbook.emotion.sad.wrong = - $global.logbook.emotion.sad.wrong - 1 - $state = "game"
behaviour speech(goed gedaan ik was inderdaad blij)	**behaviour** speech(goed gedaan ik was inderdaad boos)	**behaviour** speech(goed gedaan ik was inderdaad verdrietig)

Figure 25 - Tables with preconditions

These tables represent the code. They consist of the branches from the database. Every table describes input and output. Preconditions are the input of the robot and the affects and behaviour are its output. The scenario has certain points where input will be given to the robot. The first stage of the scenario looks like this:

Figure 26 - Scenario tree



The text fields beside the arrows are actions of the therapist. He or she presses buttons on a tablet or something similar which induce the robot to act. These actions are seen in the blue text fields.

The tables fitting to this blue text fields are:

preconditions - $sensory.buttons = "childtoldname" - $state = "first session"
effects
behaviour speech(hoi dennis + verhaaltje over hoe het gaat en vraagt hoe het met het kind gaat.)

preconditions - $sensory.buttons = "childiscomfygood" - $state = "first session"
effects - $state = "good"
behaviour speech(verhaaltje over hoe het spel gespeeld word en wat er gaat gebeuren.)

preconditions - $sensory.buttons = "childiscomfynotgood" - $state = "first session"
effects - $state = "not good"
behaviour speech(verhaaltje over hoe het spel gespeeld word en wat er gaat gebeuren.)

Figure 27 - Tables fitting to scenario

The arrows explain the connections between the two different structures. In order to make the prototype work it is needed to take into account a lot of possible actions the autistic children can take. For example, the therapy can't start if the child is not comfortable with the robot. The therapist needs an option to quit the therapy and try again another time. The templates are essentially the same thing as an if statement. The template consists of three parts: preconditions, effects and behaviour. If a preconditions is met the robot will act (its behaviour). Effects however work a little different than behaviour. Effects change certain items in the $map/database. You won't notice these changes first hand, but they can be used as preconditions in a different template. So if a preconditions from another template would be: "state="first session"" ? Then this template won't start as long as the state is not a "first session".

Technical details

The game in the structure

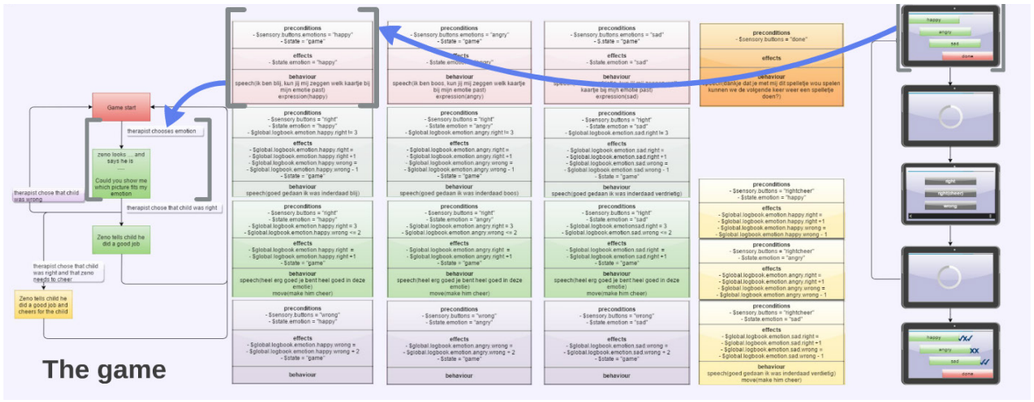


Figure 28 - Flipper structure for the game

Here you can see the many options the system comes across during the game. You can also see the connections between the screen, the table and the scenario. As you can see when a button is pressed a precondition is met, which will trigger an effect and the robots behaviour. In the scenario you can see these actions taking place (the first green text field is a behavioural action). As mentioned before effects won't be noticed first-hand. If you take a look at the first row of three green tables you can see a lot of effects happen. These effects will count the childs progress. When the child chooses correctly he will get a point for the correct answer but the system also counts one down for the wrong answers. This way the child gets a bigger "reward" for correct answers, since wrong answers only count points (2 points) for wrong answers. Counting like this makes the robot act extra cheerful when the child does a good job.

The programming

As discussed in a previous section of the report, the programming behind the zeno exists of four elements: YARP, Flipper, Asap and the GUI. The programming of the prototype consisted for the main part of defining a scenario in Flipper, programming the GUI and linking the parts together. The GUI is programmed in JAVA and uses aditional YARP packages to add actions that send bottles to YARP in case of certain events. These bottles are transferred through YARP to Flipper where they are linked with input ports. In the scenario of Flipper templates are defined. These templates links input ports to actions. In the next section two examples of templates are explained.

```
<template id="Happy" name="Happy">
    <preconditions>
        <compare value1="$wizard.action.v1" value2="Happy"/>
        <compare value1="$isglobal.started" value2="TRUE"/>
        <compare value1="$isglobal.gamestarted" value2="TRUE"/>
    </preconditions>

    <effects>
        <!--always clean this value immediately -->
        <update name="$wizard.action.v1" value=""/>
        <update name="$isglobal.emotion" value="Happy" />
        <update name="$isglobal.recentanimation" value="dynamic_smile"/>

    </effects>
    <behaviour class="nl.utwente.hmi.zenobehaviour.BMLTemplateBehaviour">
        <argument name="templateFilename" value="complexBehaviour"/>
        <argument name="id" value="Happy"/>
        <xmlcontent name="content">
            <![CDATA[
                <sze:animation id="animate1" animation="dynamic_smile" start="1"/>
                <sze:speak id="speak1" text="Which card fits my expression best" start="0"/>
            ]]>
        </xmlcontent>
    </behaviour>
</template>
```

Figure 29 - Happy code

In figure 29 the template for displaying the happy emotion is shown. The precondiotions of this template are met when the values of $isglobal.started and $isglobal.gamestarted are TRUE, and the value of $wizard.action.v1 is equal to Happy. The value of $isglobal.started is updated to TRUE the moment the therapist hits the start button in the GUI. The value of $islobal.gamestarted is updated to TRUE when the therapist confirms that the child is comfortable with Zeno and is feeling well. The value $wizard.action.v1 is linked to the button Happy in the GUI, when the therapist hits that button, the value will be updated to "Happy". The effects of this template are erasing the value of $wizard.action.v1, and updating the values of $isglobal.emotion and $isglobal.recentemotion to respectively Happy and dynamic_smile. The value of $isglobal.recentanimation is used for when the child gives the wrong answer, then the same animation is displayed again. $isglobal.emotion is used for the score system.
In the behavior section, between the xmlcontent elements, is specified what the output to Asap is. The outputs of this template are displaying the dynamic_smile animation and speaking " which card fits my expression best".

Technical details

The programming

```
<template id="idle_blink" name="idle_blink">
    <preconditions>
        <compare value1="$TIME.value" comparator="greater_than" value2="$isglobal.time.value"/>
        <compare value1="$isglobal.started" value2="TRUE"/>

    </preconditions>

    <effects>
        <update name="$isglobal.time.value" value="$TIME.value+60" />
        <update name="$isglobal.blink.started" value="started" />

    </effects>

    <behaviour class="nl.utwente.hmi.zenobehaviour.BMLTemplateBehaviour">
        <argument name="templateFilename" value="complexBehaviour"/>
        <argument name="id" value="RightHappy"/>
        <xmlcontent name="content">
            <![CDATA[
                <sze:animation id="animate1" animation="blink_long" start="1"/>

            ]]>
        </xmlcontent>
    </behaviour>
</template>
```

Figure 30 - Blinking code

In the prototype the blinking reaction is programmed. This is done to make the Zeno look more alive. The animation of the blink reaction is 60 seconds long and contains blinks of the eyelids on a random interval. When the program is started, the value of $isglobal.time.value is set to 0 and the value of %isglobal.started is set to TRUE. Under the section preconditions is this value compared with $TIME.value. $TIME.value is the total runtime of the program. When the runtime is greater than 0 and when the game is started the blink animation will be sent to Asap. This means that the moment the therapist hits the start button the preconditions of the blink reactions will be met. When the preconditions are met the value of $isglobal.time. value is updated to the value of $TIME.value plus 60. When the preconditions are met also the arguments in the behavior section will be performed. In this case its only output is animation blink_long. The moment the effects and the behaviors are performed the program will check the preconditions again. The preconditions will not be met until the value of $TIME.value has increased with 60. At this point the blink animation will be finished and will be started over again. This creates a seemless repetition of blink animations.
This methodology works in practice nicely, however it has one disadvantage. This disadvantage is that the only way to end the blink reaction is closing the FlipperDialogStarter. The FlipperDialogStarter is the program responsible to link the scenario to the input and output ports. When the therapist clicks on " Done" in the GUI this program is not closed. The advantage of this methodology is that the programmer is able to tweak the blink animation exactly how he wishes.

The rest of the templates used for the prototype are built in a similar way to the previous two exampe.

Theoretical underpinnings

Emotions

In everyday life emotions can be found everywhere. People are smiling and laughing on the street, looking afraid when they are going to the dentist or are proud that they have passed an exam. The basic idea of emotions are the facial expressions which occur when someone is, for example, sad or happy. An emotion is more than just a facial expression. Emotions play an important role in organizing, motivating and sustaining behavior (Izard, 1971; Izard, Bartlett, & Marshall, 1972; Leeper, 1948; Mowrer, 1960; Rapaport, 1942; Schachtel, 1959; Tomkins, 1962, 1963). An emotion is not just a smile, it is information that is given about the current physical and psychological state of a human being. Therefore is it necessary to understand what kind of emotions there are, what information they provide someone with and how this can be influenced. When a good understanding of emotions is available, it is possible to implement these emotions in new ways of therapy.

What are emotions?

As mentioned in the above introduction, an emotion is not just a facial expression. It is a whole package of connections and information that is given about the current state of a person. According to the James-Lange theory (Lang, 1994) an emotion is a complicated response which is formed in the mind and consists of three different aspects: a subjective experience, a physiological response and a behavioral or expressive response. The formulation of an emotion is shown in the figure 31.

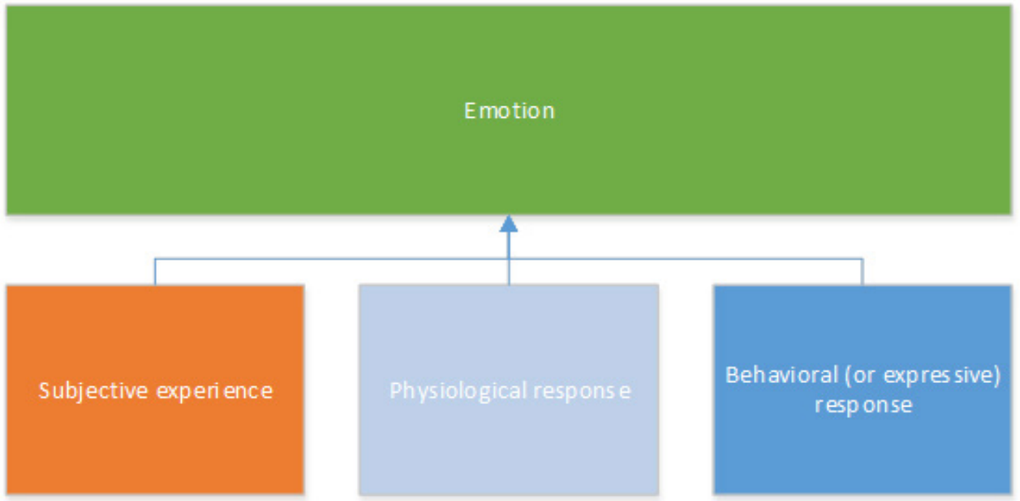


Figure 31 - Components of emotions

As seen in figure 31, an emotion consists of three different components, namely;

- Subjective experience

Every person is different and therefore every person can experience an emotion differently. Although research has shown that there are a few universal basic emotions (Ekman, 1993; Ekman & Friesen, 1971), other researchers concluded that the experience of these emotions are very subjective. (Plutchik, 2001) that emotions are something intimate and is often not even comprehended by people themselves, which is mostly owed to the fact that more than one emotion can occur at once. For example, people could be nervous and afraid at the same time. Next to that persons can also experience different stages of emotion. Someone could be very angry, on the other hand someone could be a little angry, but they are both angry.

Theoretical underpinnings

Emotions

- Physiological response

Different emotions could give a different physiological response. If you are afraid your heartbeat could increase, if you are nervous you could get sweaty hands.

- Behavioural (or expressive) response

The behavioral (or expressive) response is the most noticeable part of the emotion for the outside world. This response is the actual expression of the emotion, mostly known as the facial expression someone has, but also the body language is important. During a day you are continually reading the expressions of everyone around you. This is a huge source of information about someone's wellbeing and current emotional state. In the psychology the reading and understanding of the expressions is better known as "emotional intelligence". Ekman researched that many of the facial expressions are universal around the world, and he made a list of basic emotions.

The emotion recognition

In the above theory the different parts of an emotion are separated. An emotion consist of three components; a subjective response, a physiological response and a behavioral (or expressive) response. The first two responses are mostly appointed to the person who has the emotion. The outside world cannot recognize directly what kind of subjective response or what kind of physiological response a person has on a certain emotion. The last response is the behavioral (or expressive) response. This response is noticeable for the outside world and include information about the physiological and subjective response, and therefore gives information about the emotion someone is feeling, as seen in figure 32. By far the most extensive body of data in the field of human emotions is that on facial expressions of emotion (Oatley & Jenkins, 1992).

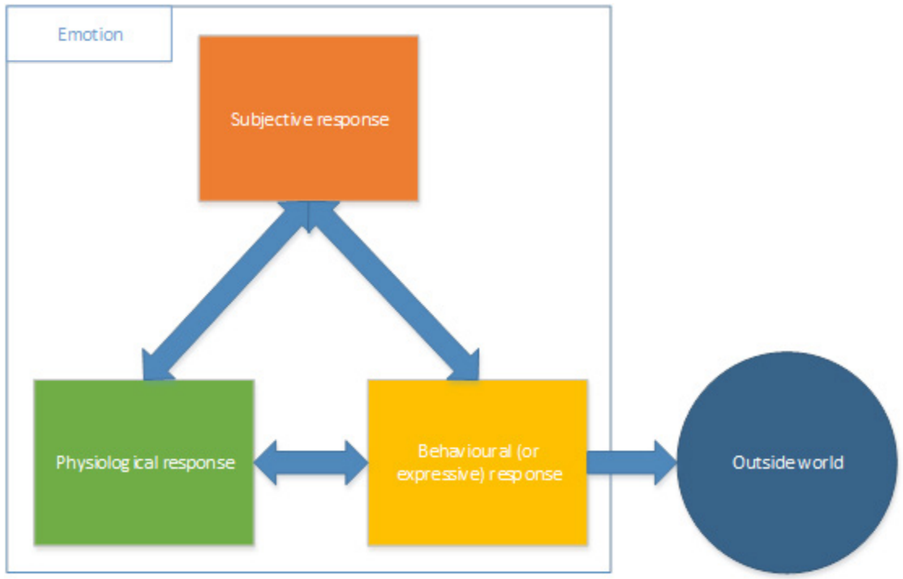


Figure 32 - Emotions and the outside world

In figure 32 it is displayed that all the three different responses of an emotion are connected with each other. The subjective response has an effect on the physiological response and the behavioral response, and vice versa. To recognize an emotion of someone you crystallize the behavioral (or expressive) response of someone. This means the facial expression and/or the body language someone has. This response gives you information about the different parts of the emotion and so over the current physical and psychological state which someone could have. In this research we want to teach autistic children this emotion recognition part, starting at recognizing the emotions themselves and later be able to comprehend the feelings behind the emotion.

Emotion & facial responses

By far the most extensive body of data in the field of human emotions is that on facial expressions of emotion (Oatley & Jenkins, 1992), therefore to recognize the emotion on people's face, it is necessary to identify the facial expression. These facial expressions are the movement of mimetic muscles in the face. These muscles receive impulses from the brain, and when a person is in some kind of emotion, the brain activates these muscles and this is what we understand as the facial expression of an emotion.

People, regardless of race or culture, have the ability to express some emotion in the exact same way through their faces (Darwin, 1872). Darwin considered some emotions as basic, and this research was furtherly conducted by Ekman, Friesen, and Ellsworth (1972). Ekman an his colleagues concluded that there were six basic emotions, which are the same, regardless of race or culture. These emotions are anger, disgust, fear, happiness, sadness and surprise as seen in figure 33.

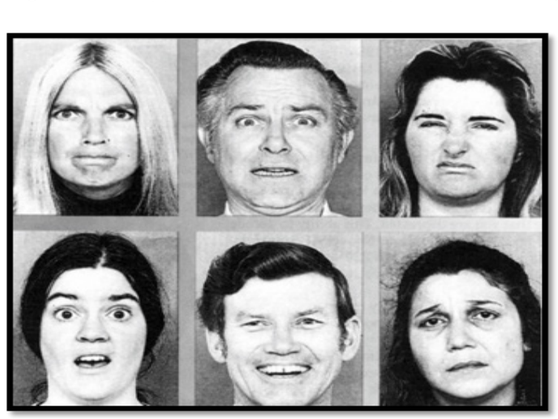


Figure 33 - Facial Expressions of basic emotions by Ekman (1972)

The face consist of different muscles, and every emotion has different muscles involving. These muscles that are involved in certain emotions, could be coded according to the Facial Action Coding System (FACS) (Ekman & Friesen, 1978). This system describes the facial expressions that are connected with a certain emotion. These facial codes could be summarized to a formal description of an emotion. The emotions and their descriptions of the facial expressions are shown in table 2.

Theoretical underpinnings

Table 2

Emotion	Description
Anger	- Nostrils raised - Mouth compressed - Furrowed brow - Eyes wide open - Head erect
Disgust	- Lower lip turned down - Upper lip raised - Expiration - Mouth open - Spitting - Blowing out protruding lips - Clear throat sound - Lower lip - Tongue protruded
Fear	- Eyes wide open - Mouth open - Lips retracted - Eye brows raised
Happiness	- Eyes sparkle - Skin under eyes wrinkled - Mouth drawn back at corners
Sadness	- Corner mouth depressed - Inner corner eyebrows raised
Surprise	- Eyebrows raised - Mouth open - Eyes open - Lips protruded

The above descriptions of the facial expressions are connected to the emotions and are the same among cultures and races (Ekman et al., 1972). In other words: every person connect the same facial expressions to the same emotions. In our research to conduct the facial expressions on humanoid robots, it is necessary to simulate the exact same facial expressions, as researched by Ekman et al. (1972).

Effect of the emotions

The facial expression on somebodies face and the body language includes a lot of information about the current physical and psychological state of someone. Emotions play an important role in organizing, motivating and sustaining behavior (Izard, 1971; Izard et al., 1972; Leeper, 1948; Mowrer, 1960; Rapaport, 1942; Schachtel, 1959; Tomkins, 1962, 1963). Effect of emotions could be split in to the effect on the person who feels the emotion and the effect the person with the emotion has on its surrounding.

Effect on the person with the emotion

The person who experience the motion loops through the three different aspects of an emotion as mentioned above (e.g. subjective, physical and behavioral expressive). For example, if someone have been passed for an exam, his subjective reaction is that he is happy, but he expected it, so he is not exited. His physical response is a higher heart beat and his behavioral expressive is that he has a smile on his face.

Effect on the surrounding (e.g. person who interact with the emotional person)

A person who interacts with the person in question, sees the expressed behavior. He noticed a smile by the other person and connects this smile to the emotion of happiness or excitement. He could empathize with the person and change his behavior to fit the emotional state of the other person.

Emotion in therapy

Autistic children are struggling with recognizing the facial expressions and thereby cannot empathize with another person. A person without autism could empathize with other persons, because he could read their emotions. This link is missing in autistic children as shown in figure 34. In this research we want to teach these children to recognize the basic emotions and therefore could increase their possibilities to empathize with other people. With this increased empathy, they could increase their social participation in the society.

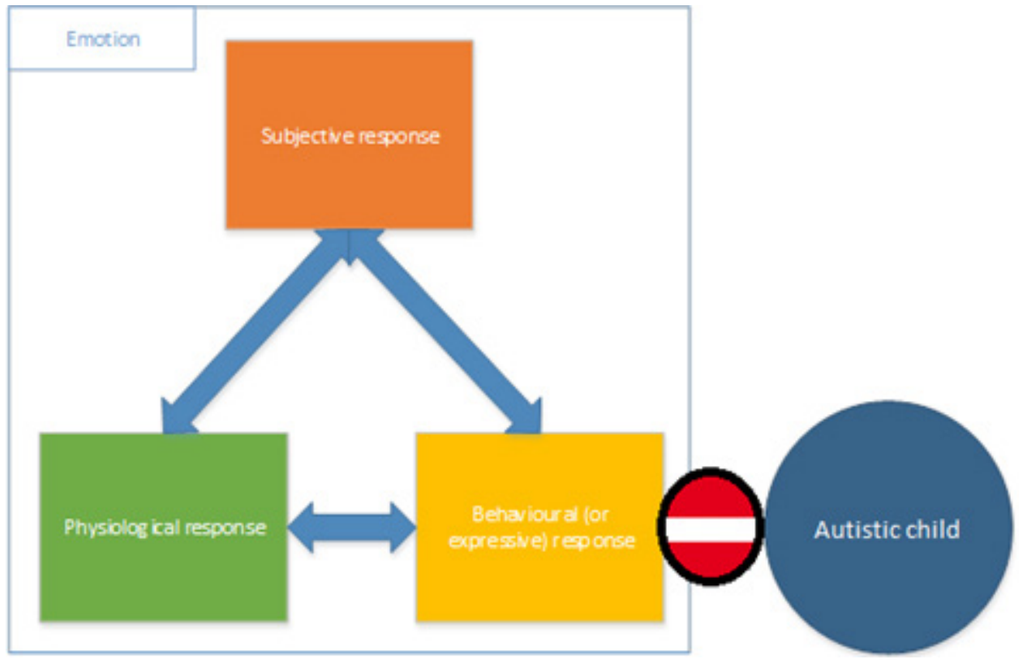


Figure 34 – Emotions and aurism

Theoretical underpinnings

Game-aspect: Choosing cards

In this design physical cards are being used instead of digital ones, because of the freedom for the therapist. When laminated cards are being used, the therapist can decide which emotion will be expressed by Zeno. The therapist is, thus, more flexible in using the card recognition system, by choosing which emotion will follow the preceding emotion. It is also preferable because of the social nature of the therapy, so that there will be an interaction between the robot, the child and the therapist. If you only let the child interact with the robot through a tablet, the social aspect of a traditional therapy will be lost, as research has shown that autists tend to strongly focus on technological devices and overall like touchscreens a lot (Alves, Marques, Queirós, & Orvalho, 2013). It is not guaranteed that the patient will not shut out the therapist completely. If the robot is controlled by the therapist, the therapist can discuss the different emotions more easily with the child. All in all, in this design physical cards are being used to not rob the therapist of his freedom when conducting therapy.

Rewarding

To motivate an autistic child to proceed with the session, it is important to keep in mind that they experience less reward from social interactions and more from non-social objects (Schultz, Chevallier, & Kohls, 2012). Thus, using candy or a favorable toy are probably more effective as a reward than, for example, appraisal. There is evidence that the use of child-preferred, or intrinsic, reinforcements leads to improvements in social engagement (Paul, 2008). When a social reinforcement is chosen, the use of non-verbal and verbal appraisal is very important. The therapist can choose to sing a child's favorite song or praise it by saying, in an enthusiastic way, that it did a great job. (Koegel, Koegel, Harrower, & Carter, 1999).

Using a reward chart could also help to motivate an autistic child. If the child completes a task successfully, he or she will earn a point. If a certain amount of points is obtained, the child will obtain a reward. This can be an edible treat or something the child really likes to play with. The problem with using toys as a reward can be the moment that you have to take the toy away from the child. When you suddenly take away the toy, the child may feel a high level of frustration and general distress (Bradley, Summers, Wood, & Bryson, 2004; Brereton, Tonge, & Einfeld, 2006) This can cause a meltdown, a physically aggressive outburst, or a tantrum, a loud vocally defiant protestation (Jang, Dixon, Tarbox, & Granpeesheh, 2011; Matson & Nebel-Schwalm, 2007).

In this therapy the rewards edible treats, appraisal, thus social reinforcements, and toys will be used. The rewards can be combined in different ways. For example, when the child recognizes the right emotion of Zeno, the therapist can give the child a treat while he tells the child he or she did a great job. Eventually the therapist has to decide what rewards suit the child the most, due to individual differences. When the reward chart is used, the therapist can decide that the child gets a reward if he or she successfully recognizes all the emotions in the session. This can be used if the child is not allowed to get a lot of edible treats because of dietary wishes of the parents or the risk for bad teeth.

The therapist can decide by himself when Zeno will express appraisal. For example if the child has to recognize three emotions, only the therapist will appraise the child the first two correct answers. Only when the child completes the whole task successfully, the therapist can make Zeno praise the child too. This is because of the importance of personal contact between the child and the therapist. If Zeno is used for appraisal with every task, the effect of the appraisal may decrease.

Storytelling

In recent studies (Salvador, Silver, & Mahoor, 2015) it has been found that by using a Zeno humanoid robot, children with ASD did not have more difficulties in recognizing emotions than their typically developed peers. The only deficit between the two groups of children was the difficulty of autistic children of recognizing the emotion fear.

New to this therapy is the introduction of storytelling. Storytelling is the process where the child explains the deeper meaning and understanding behind a certain emotion. In other Zeno therapies, the mimic of the robot was only being used for recognition and teaching of different emotions. In this study the Zeno will not only show the specific emotion, but also asks the child: "How do I feel? Can you tell me when you look like this?". By asking when the child itself looks like the example given by the robot, for example happy, the idea is that the child is motivated to find the meaning of an emotion by reflecting it to his or her own life. In this therapy it is important to improve the social and emotional skills of an autistic child. The expectation is that if the child is able to reflect the robot's emotions to his own, he or she will develop a greater understanding of the meaning behind an emotion.

Business plan

This business plan is written for a company to commercial distribute the designed therapy method. In this business plan multiple assumptions are made about our key partners and the potential revenue streams, to make this therapy method commercially more interesting. The current research we have done till now, the therapy is not ready to market. In this business plan we assume that this therapy is ready to market and therefore this business plan is future prospective.

Executive summary

Theraxil Inc. is a start-up company which offers a therapeutic service which is based on the Zeno robot technology by Robokind. The focus of this service is based on the niche market of autistic children between 6 and 10 years old. The service we will offer is not just therapy software for the robot, but rather, a whole package of different aspects. We have designed a new way of therapy for usage with the robot and will offer different applications and information about this therapy. Currently we are in the first stage of developing and testing our service and we want to be an established enterprise within the next two years. Currently we are focused on the Dutch therapy market and after we established there, we will expand our business further into the European Union.

The way we want to do this business is by implementing a push strategy to inform different organizations and therapists around the Netherlands about the opportunities our service offers. Next to that, we are going to assign health and governmental organizations about our services and also try that way to push the services into the therapy market. All this will, of course, cost money. Within the social content which we are doing research in and the possibilities of society, we want to assign for a financial support by the European Union for further research. Next to that we want to bring up a cash flow by offering an extra service to our client. We will not just offer a license for our applications and therapy, but also the possibilities to lease or buy the ZENO robot and the matching insurance policies. We are all doing this with a highly motivated group of five students, which all have a different background. We all have in common that we want to make the world a better place, by starting to increase the social participation of autistic children in the society.

Our business goals are to acquire the first 10 clients within a year from now. After two years we want to acquire at least 100 clients and after five year at least 175 client. These 175 clients could generate a potential revenue stream of more than €316.000 in the most positive case. To get a foothold in the Dutch market a financial investment in our company is needed. The therapy is almost ready, but for the marketing aspect a funding is needed. To get a foothold in the Dutch market we need to have an investment of €50.000, to acquire the first clients and make it possible to invest in new technologies and new ways to acquire clients. According to our market prospective we will make a sustainable revenue after the first year and will grow further the years after that.

Enschede, November 2015

The company

Theraxil is a fresh start-up company which implements the latest technology and most revolutionary designs for application in the therapy for children with deficits in their inter-social and emotional development, with a special focus on the therapy for autistic children. Our goal is to break down all the social obstructions people with Autistic Spectrum Disorders (ASD) will meet in our current and future society. This goal will be achieved by a highly educated and multidisciplinary team of employees, who are highly motivated to create the best therapies and implementations of technology for autistic children.

Our goals and motivation are the basis of our company and can be found back in our mission and vision of the world of tomorrow.

"Theraxil Inc. is dedicated to increase the social participation of children with Autistic Spectrum Disorder, through technology and design" – The mission of Theraxil Inc.

Our employees and our company are driven by the thought that the purpose of living is to pass on the world and therefore the society, in a better way then you received it. This driving force could be found back in our goals and summarize the vision of our company.

"Theraxil Inc. will work for a society where Autistic Spectrum Disorder will be no obstruction for a fully participation in the society" – Vision statement of Theraxil

The business model canvas

This business plan can be summarized according to the following Business model canvas.

<table>
<tr>
<td rowspan="2">Key Partners
- RoboKind company
- Allianz Insurance
- MediaMarkt</td>
<td>Key Activities
- R&D
- Installing software
- Licensing
- Marketing
- Mediator
- Supporting</td>
<td rowspan="2">Value Propositions
- Latest technology
- Leasing options
- Acquiring options
- Academic researched therapy method</td>
<td>Customer Relationships
- Long term relationship
- Trust
- 24/7 support</td>
<td rowspan="2">Customer Segments
- All therapist and organizations which are involved in the therapy for autistic children</td>
</tr>
<tr>
<td>Key Resources
- Zeno robot
- Application for the Zeno robot
- Contracts with external partners
- Lattice culture</td>
<td>Channels
- Direct sales reps.
- Website
- Field sales
- Tradeshows
- Conferences</td>
</tr>
<tr>
<td colspan="3">Cost Structure
- Marketing B2C
- Developing costs
- Installating costs
- Supporting costs</td>
<td colspan="2">Revenue Streams
- Licensing of the application
- Mediator fees
- (Potential) subsidy</td>
</tr>
</table>

Figure 35 – The business model canvas

In this canvas all the important issues of the business are addressed. In the following pages the business plan and this business model canvas will be further explained.

Business plan

The products

The world is always spinning and never stands still. The same applies for our company and our employees. We are always working to implement the latest technology and try to better ourselves day by day.

The basis of our company is the revolutionary therapy which we are going to try to change the world of tomorrow with. Our current service is built around the already available Zeno Robot. The Zeno robot is a humanoid robot made by the RoboKind company in Dallas, USA. This company is a specialist in humanoid technology and the implementation of it for educational and therapeutic purposes. We have acquired this company as our partner through contact with the Human Media Interaction faculty at the University of Twente, Enschede, and are continually in contact with them to implement the latest innovations into our services.

Different academic research papers have proven that humanoid robots have positive effects on autistic children and the possibilities are numerous. In the current situation there is not a service available for therapists to have a user-friendly interface to control the humanoid robot that fulfils all the desires of the therapist and is focused on autistic children. Therefore we have designed an all-in one solution for therapists and organizations to implement in the therapy for autistic children.

The all-in one solution

We do not just offer a therapy for a humanoid robot; we offer a whole service package for our clients. We want to take care of all the measures that are necessary to acquire and implement the therapy for our clients, so that they can focus on their main goal; giving therapy to autistic children.

We offer a broad service of customized packages to our clients, so that every client gets the optimal solution for their situation. Every client is unique and therefore we think we have to focus on the differences between our clients to offer the most suitable service for their situation. Our basic service includes an application for the Zeno robot and a tutorial for implementing it in the Zeno Robot. Within this service we also install the software on the already available Zeno Robot and Tablet. Next to that we offer the possibilities to follow seminars about the implementation of the software and the robot and the possibilities that it offers.

If a client is not already in the possession of a tablet and/or Zeno robot, we offer the service to buy or lease a Zeno robot or tablet by our company. We have a contract with the RoboKind company and have arranged the possibilities to offer this service in the Netherlands through this company. We are a mediator in this service and we, thus, bring a small amount in debit by our client.

We also offer a possibility for our clients to acquire an insurance policy. We do this in contact with Alliant insurance company Ltd.

All the above services are offered to create an optimal solution for our clients and take care of all their concerns with the product.

What do we offer?

As written above, we offer a broad scale of services to offer the optimal solution for every client.
Our basic package consists of:

- An application for iOS/Andriod/Windows, based on JAVA;
- A license for the above application for a certain time span;
- Manual of the therapy;
- 24/7 support though the internet;
- Seminar for the client for usability of the robot.

Next to the above basic service package, we offer external services for our clients to fit their needs;

- Buy or lease of the Zeno robot (in cooperation with the RoboKind company);
- Buy or lease of a tablet (in cooperation with MediaMarkt Netherlands);
- Different insurance policies (in cooperation with Allianz insurance Europe).

The market

Our service is specifically designed for the therapy for autistic children between 4 and 12 years of age. According to the Central Statistical Bureau (CBS, 2014) of the Netherlands, around 2,8% of the Dutch children between 4 to 12 years old have (a kind of) autism, according to their parents. This includes both standard autism, Aspergers and PDD-NOS. This 2,8% 43.000 children. Although our service and therapy is made for the therapy for autistic children, not every child could have a positive effect through our therapy. Every child is unique and the therapist has to decide if he or she thinks that it could benefit the child in question. So our current focus does not have to be on the autistic children, but on the therapists and organizations who working with autistic children.

In 2014 the Central Statistical Bureau (CBS) has written down a health survey about so called ‘diagnose-treatment combinations’ (DBC’s) in the mental healthcare. In this survey they paid attention on the question how many treatments are currently going on for autistic children. The results where clear; in 2014 around 26.000 treatment programs were taking place, involving children between 4 and 12 years old.

The trend that is seen in the therapy of autistic children is the shift from normal therapy to therapy which includes the usage of humanoid robots. Different studies concluded that the usage of humanoid robots has a positive effect on autistic children, and therefore more and more organizations and therapists begin to see the usefulness of this modern way of therapy.

These trends are positive for our future success and the whole group of 26.000 treatment programs could be our possible target group for the future. We could fit and change our services to the optimal form for different kinds of autism, to serve the whole target group an optimal solution. Not all of these 26.000 treatment programs are independent of each other, so the possibility exists that one robot could be used for around 10 different treatment programs. If we assume that one therapist treats 13 children and that every therapist has his or her own Zeno Robot, this could be a possible market of around 2.000 services that we could offer in the Netherlands alone.

The customers

Our service is especially designed for the usage in therapy for autistic children between 4 and 12 years old. In this case we focus on the people behind the therapy; e.g. therapists and organizations involving therapist. These organizations will be the end consumer of our service and will implement it in the real society. Our customer segment will therefore be the therapists and organizations who are involved in the therapy for autistic children between the 4 and 12 years old.

Business plan

The value proposition

Our product and services could have an increasing value for the potential customers. This product is especially designed to fulfil the gap between the available technology and the usage of it in practice. Our product and service could have an increasing value for not only the therapist, but also for the child in therapy.

Old-fashioned therapy sessions (without the usage of technology), is not always effective for every autistic child. The humanoid technology makes usage of the scientific observation that autistic children prefer objects over people (Cabibihan et al., 2013) and that most autistic children, like every child, have interest in robots. Because of these aspects of humanoid robots, different researches concluded the effectiveness of these robots in the therapy for autistic children.

In the below Value Proposition Canvas, the value of our product and services will be explained more profoundly.

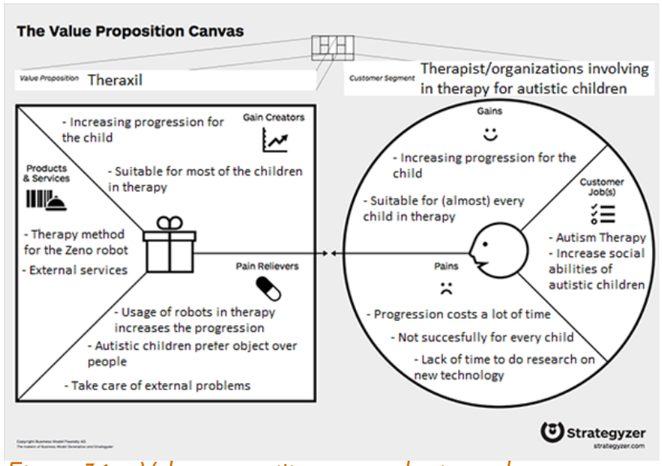


Figure 36 – Value proposition canvas business plan

Our product and services are especially designed to meet the pains and gains of our potential customers. Our therapy method is focused on increasing the social abilities of autistic children and therefore our potential customers are the therapists/organizations who are involved in the therapy for autistic children, with the focus on increasing the social abilities of them. The current pains of these therapists are that the progression costs a lot of time and every child reacts differently on therapeutic methods. Next to that, most of the organizations and therapist simply do not have the time to take care of all the business that come with implementing new therapy methods or technology. Our company will offer painkillers for these pains. We offer the therapy method for the existing Zeno robot, but next to that we will also offer external services, which could take care of the lack of time the therapists and organizations have. Next to the pains, our potential customers also has some gains. These are the gains the potential customers require from a new product or service. Our therapy and method is based on creating gain for our potential customer and therefore increasing the progression for the child in therapy.

The competitors

The market of therapy for autistic children is very niche. We will focus on the therapy for children between the 4 and 12 years old. Within this niche market, there are different kind of therapies available. Most of these therapies the therapist has learned during his or her education or through different courses. With our service we push ourselves in the therapy market. We have to compete with already existing therapies and have to distinguish ourselves from them with our competitive advantages.

As written above, our main competitors are already existing therapies for autistic children. A lot of therapists who have been in the business a long time have to adapt to new forms of therapy; for instance humanoid robots. The main strengths of already existing therapies are that the therapists are familiar with it and they have proven to some extent that they work. With technology the therapists have to learn a new way of working, which could bring up skeptics among therapist. Our advantage on this side is that a lot of research is done on the side of autism and humanoid robots. Every single research concluded that humanoid robots could have a positive effect on the already existing therapy. Our goal is to convince therapists about the broad range of possibilities that this new technology could offer.

Next to the already existing 'old-fashioned' therapies, other technological therapy tools have found their way to the market. We offer a service who is completely designed for usage with the Zeno robot, next to the Zeno robot there are other different humanoid robots in the market, which could be used for autistic therapy, for example the NAO robot. The Zeno robot is the most advanced robot in the market and is especially designed to be used on a broad scale of autism therapy. It is affordable and user friendly.

The SWOT analysis

The above information about the market and the company, can be summarized into strengths, weaknesses, opportunities and threats. This SWOT analysis can be found in the table below:

Strengths	**Weaknesses**
All-in-one solution for therapists and organizations Knowledge of programming Academic research at hand	Specifically only for autistic children Needs to have the Zeno robot
Opportunities	**Threats**
Well defined market niche Interest shift to technology Costs reduction for therapy sessions Specific solution for autistic children	ial new entrants in the niche Old-fashioned therapies Potential newer technologies in period of time Potential budget cuts in the therapeutic world

SWOT THERAXIL

Figure 37 – SWOT analysis

Business plan

The SWOT analysis

The strengths of our company are the all-in-one solution we offer to our clients. Next to that we employ programmers, so we could constantly update our services. Next to that our therapy method with the usage of humanoid robots has a background of academic research. The weaknesses of our services are that they are specific for the niche market for autistic children. This makes the market not very broad and also has limited our revenue streams. Our therapy is based on the Zeno robot. It will not work on other humanoid robots and so the potential customer has to acquire this particular one.

On the external field, the niche market of autistic children also offers opportunities. Because this service is especially designed for one market, we could closely observe this particular market and offer the best services. In this market, the shift from old-fashioned to new technology is visible. More and more organizations and therapists are increasing their interest in implementing the latest technology in their sessions. Our service and therapy could increase the progress of a child, therefore it would be possible that a cost reduction will take place. The specific niche market also offers some threats for our company. There are not many players in this market, so it would be possible that new entrants will come into this market and will compete with us. Next to the possibility of new entrants, the old-fashioned therapy methods could slow down our market share. Therapists have to be convinced about the positive influence our service could have above the already existing old-fashioned therapy methods.

Another threat is the technological improvement. Our service is designed for the use with the Zeno robot. Innovations never stand still and over a period of time it is possible that our method is old-fashioned and a newer technology is available. Therefore we will keep our business up-to-date with the latest technology to offer our clients the latest services at any time. And the last threat in our external environment is potential budget cuts from the government in the treatment programs. Our potential customers receive money from insurance companies and governmental organizations. When the government decides to cuts the budget for therapy, it would be possible that less therapists and organizations will acquire our service.

The marketing

The faith that the product will be an added value to the current situation is the first step in the marketing plan. We firmly believe that our service will change the way therapy is given to autistic children, and therefore we are confident that therapists and organizations from all over the Netherlands will see the usefulness of our service. The way we want to do this is by a push marketing strategy.

The marketing plan

We assume that organizations do want to implement the newest technology but lack the time or the resources to do so. Therefore we have set up a marketing plan that involves a push strategy and we are going to take the product to the customer. We believe that the best way to show the benefits of our service is to bring them in practice at the potential customers. This will include different trade show promotions, face to face promotions and customized products. We will approach organizations and therapists personally to inform them about our service and the benefits it could have on their own business.

Next to the organizations and therapists, we will take a step up in the bureaucratic ladder and will also focus on the insurance companies, interest groups and governmental organizations. To address these kind of groups, we do not make direct sales, but if these organizations see the benefits of our service, they could persuade other organizations and therapists to acquire our service.

The management

The current team of Theraxil Inc. includes five team members, which have all the same influence in the current business planning. Every one of the team has a specific target and we are all working together to fulfil our goals and strategy. In the current state this is working well and we have time to work on the latest innovations to bring the company to the world of tomorrow.

If we look at our potential future prospective, we believe that if we grow any further, it is necessary to set up a more bureaucratic form of organizations, where the tasks will be more crystallized for every member. This because the focus could be more specific and the time could thereby be used more efficiently.

Thijs Bemthuis Director of sales and marketing	Mr. Bemthuis is almost a graduate from the University of Twente (UT), with a specialty in the industrial engineering and management part. He focusses on the business aspect of the company and the possibilities that could be found in the markets.
Sil Spanjer Director of software engineering	Mr. Spanjer is almost a graduate from the University of Twente (UT), with a specialty in mechanical engineering. He focusses on the programming aspect of the therapy and robot and is leader of the innovation board.
Merijn Besselink Director of therapy	Mr. Besselink is almost a graduate from the University of Twente (UT), with a specialty in psychology. He focusses on the psychological aspects of the therapy and the best ways to implement this.
Jasper Westenbroek Director of management and design	Mr. Westenbroek is almost a graduate from the University of Twente (UT), with a specialty in industrial design engineering. He focusses on the management and communication aspects within our team and is in control of the design of the applications.
Alexander Arendt Director of programming	Mr. Arendt is almost a graduate from the University of Twente (UT), with a specialty in programming and cognitive psychology. He focusses on the programming aspect within our team. His psychological background influences design in a positive way.

Business plan

What to do / the future

The world is constantly changing and new innovations are everyday business. The first step we want to take is establishing a well situated company in the branch for autistic therapy. We want to make sure that the organizations in the Netherlands are familiar with our company and the services we offer. If we have established this and our brand recognition is big within this niche market, we will look further and try to enter new markets.

First we are going to focus only on the Dutch market for autistic children therapy. When we have successfully implemented our service in this market, we are going to look further within the European Union and write new software and applications for the usage in the other member states of the European Union. Next to that we will continually keep track of the latest innovations on the humanoid robot area and we will look every day how we can improve our services to our customers, so that we keep it all up to date with the latest technology.

In the current state we are a highly motivated team, with a service to offer. Within a year from now we want to have established our name in the therapy and will have closed our first 10 service contracts with different organizations. In the years that follow we want to conquer the whole Dutch market and at the end of our third year we want to enter the other markets of the European Union. First starting with Germany and Belgium and step by step increase our activity in other European countries. Within five years we want to have activities in more than the half of the member states of the European Union.

Financial plan

Our revenue stream will come from license agreements of our services. We offer license for our basic package for €1499,99 a year for an organization and €499,- a year for an individual therapist. This basic package consist of the following services:

- An application for iOS/Android/Windows, based on JAVA;
- A license for the above application for a certain time span;
- Manual of the therapy;
- 24/7 support though the internet;
- Seminar for the client for usability of the robot.

Next to the above basic service package, we offer external services for our clients to fit the most optimal solution;

- Buy or lease of the Zeno robot (in cooperation with the RoboKind company);
- Buy or lease of a tablet (in cooperation with MediaMarkt Netherlands);
- Different insurance policies (in cooperation with Alliant insurance Europe).

With the buying or leasing option of the Zeno robot we acquire a small fee for our work. We will offer a Zeno robot for €2999,99. This includes a €199,99 fee for our services. Next to that organizations and therapist could lease a Zeno robot for €99,99 a month. We get a 10% share from this leasing agreement, which adds up to €9,99 a month. In the acquiring and leasing agreement, we will work as a mediator between the organizations/therapists and the RoboKind company.

Next to the option to buy or lease the Zeno robot, we will offer the service to buy or lease a tablet. We will do this in cooperation with MediaMarkt and we will only be a mediator in this agreement. We will offer an Apple iPad mini 2 for €299,99. Which includes a 20% share for us. It is also possible to lease this iPad for €29,99 a month, which includes a 10% fee for us monthly.

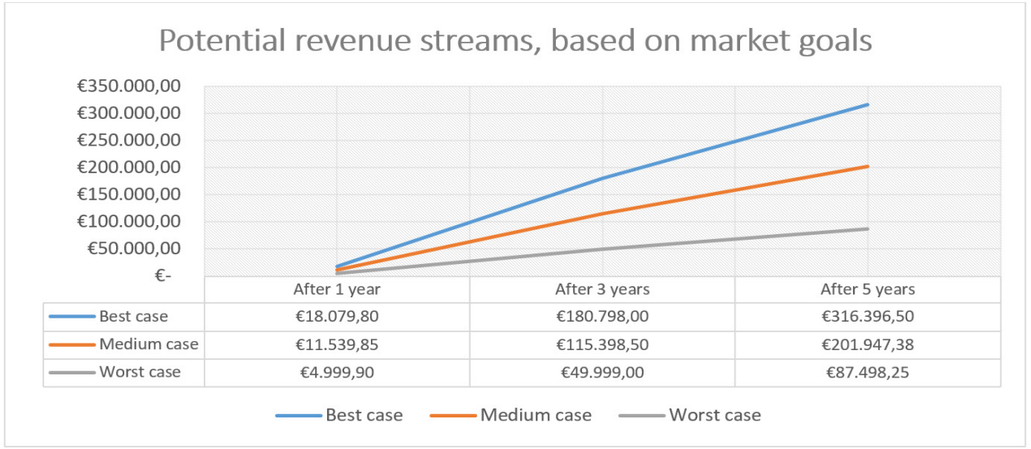
The last external service option we offer is in cooperation with Alliant insurance Europa. We offer the service to our potential customers to acquire an insurance for both the Zeno robot and the iPad. The insurances for the Zeno robot will range from €4,99 to €24,99 a month, and the insurance from the iPad from €1,99 to €14,99 a month. The monthly payment differs from the level of insurance the customer chooses. From every insurance policy we close for our customers, we get a 10% fee.

Product or service	Revenue stream
Basic package	€1499,99/€499,99 (a year)
Zeno robot	€199,99 (acquiring) or €9,99/month
Apple iPad	€60,- (acquiring) or €3,-/month
Insurance policy	€0,50-€2,50/monthly (Zeno insurance) €0,20-€1,50 (iPad insurance)

The different revenue streams that our services will generate are shown in the table above. Our target is to set to 10 service contracts within a year from now. We will focus on selling the whole service packet to our potential clients. So our target revenue stream after the first year will be €14999,90/€4999,90 for the Zeno robot and an extra 0 to 1558,80 from leasing activities or 0 to 2599,90 from acquiring activities and 0 to €480,- from insurance activities. This makes a potential revenue stream after the first year from in the best case from €18079,80 or in the worst case from 4999,90, if we will meet our target from 10 clients after the first year. After the first year we want to increase our market potential in the Dutch market and within the next two years we want to have acquired at least 100 service contracts. Which will generate a potential revenue stream after the third year from €180.798,- based on the best case and €49.999,- based on the worst case.

The best cases are based on the maximum revenue that is possible. This means for the first year that every 10 service contracts are signed by an organizations instead of an individual therapist. Every client acquires a Zeno robot and an iPad from us and they close the maximum insurance policies through us.

In the worst case these 10 service contracts are signed by 10 individual therapist and they do not make use of the external services our company offers. The best and worst case for the revenue streams after the third year are based on the same assumptions. After the fifth year we have set up a goal to have at least 175 clients in the Netherlands and the best and worst cases are based on this progression. In the graph below the potential revenue streams are shown. The medium case is the average of the best and worst case.



	After 1 year	After 3 years	After 5 years
Best case	€18.079,80	€180.798,00	€316.396,50
Medium case	€11.539,85	€115.398,50	€201.947,38
Worst case	€4.999,90	€49.999,00	€87.498,25

We have written a marketing plan to market our product and acquire the first deals. For this marketing plan we need an external funding of €50.000. This money is needed to support this company through the first year. After this year the potential revenue streams will be big enough to keep the company financially stable. For further research on autism and therapy we want to acquire financial support by the European Union. We did not state this in the potential revenue streams, because it is currently not written in stone if we get this funding and within our company we want to keep the commercial aspect and the research aspect separate, because otherwise the chances to get funding will fall.

Evaluation

At the end of this first module there has been made great progress in the development of the therapy and programming of the Zeno robot. In this study the following strengths and weaknesses can be extracted.

Strengths

- There are a lot of possibilities with the Zeno robot for autism therapy. The Zeno can be programmed to fit in almost any autism therapy sessions
- The therapy could easily be adjusted and extended, if necessary. Because the Zeno is relatively easy to program, new aspects can be added or deleted without starting from scratch.
- The therapy is linear, which means that it follows a predetermined script. Because children with autism are in need of structure, it is important that the Zeno does not behave unexpectedly.

Weaknesses

- It is expected that the therapy is not useful for every child. Because of the great variety between children with ASD, it is difficult to develop a therapy with the Zeno that will fit the needs of all.
- When a therapist wants to make use of the Zeno in his or her session, an expensive robot has to be acquired. The cheapest model costs around €2500,-.
- The therapy is linear. Although a linear therapy is an advantage for working with autistic children, it can also be a weakness. If the child suddenly reacts of behaves in a way that does not fit with the therapy, the Zeno cannot react accordingly. For example if the child starts asking questions to the Zeno, the therapist has to answer/intervene because the robot is not programmed to answer.

Future works

1. The therapy still needs pilot testing. At this moment only the development of the therapy and programming the Zeno robot has been done. The most important step for the next module is that the theory has to be tested in practice. This will give important feedback and will show if the therapy works properly or still needs further development.
2. Also the programming of the therapy into the Zeno robot has to be extended. Currently only the “easy” mode is programmed and it still lacks the “medium” and “hard” mode. Especially the last mode is important for this study, because at that stage the unique aspect of storytelling where the child explains emotions, will be implemented.
3. Finally there must come further application development for tablets. Currently the interface is only running on laptops. Because in this therapy one of the goals is to control the robot by using a “Wizard of Oz” technique, where the therapist controls the robot without the child knowing so, a tablet application is necessary. Only with a small device like a tablet the therapist is able to discretely control the robot.

These three points will be covered in the next module to finalize this study.

Iteration Sprint 1

Project Management & Control

Integration management

For the first sprint we used the scrum methodology to integrate, choose and manage the different aspects, objectives and alternatives. The beginning of the first week sprint the objectives were set and the values were assigned to the objectives. Before the first sprint we already investigated what our stakeholders expected from us and what the objectives are. We did this by contacting our tutor and discussing our ideas with her. This was very useful to set up the objectives for the first sprint. Every beginning of a new day the planning is discussed within the project group and current objectives and alternatives are reviewed and new ones are discussed and added to the scrum process when accepted. The scrum master made sure that the objectives of the stakeholder are never forgotten and always in the mind of all the group members, so that with the integration of different parts the objectives of the stakeholder are met.

Scope managment

When the first sprint started we had already done some investigation about the information that is needed for the first sprint, so that we can start the sprint with enough information and information would not pass through a bottleneck. Though, during the first sprint we noticed that more information was needed. We also included the information gathering in the scrum process and assigned some group members to search for new articles and investigate different methods. Next to the search of new information during the scrum process, we also have weekly contact with our tutor.

Our tutor brought us new information and got us in contact with different experts who have given us new information and have pushed us in the right direction. During the first week the information gathering was both part of the scrum process and a process itself. Every day in the daily stand-up we discussed within the group what information is needed and how we can acquire it, so necessary action could be taken.

Time management

Every group member had to be present in the office from nine o'clock in the morning until four o'clock in the afternoon to ensure maximum availability and teamwork. Beforehand, whilst planning the sprint, the tasks were divided by days and per person, so that everyone always had an idea of how to fill his time usefully.

Cost management

No vouchers have been used during the first sprint.

Quality management

To ensure maximum quality there was a daily stand-up. Results have been controlled by at least one other group member or presented to the whole group. By this, we could make sure that everyone was happy with the progress.

Project Management & Control

HR management

During this sprint the two psychologists and the technical business administrator were busy designing the optimal therapy. Research had been done on what the best therapy approaches were and what emotions are the basic emotions and how they are uttered. One of the psychologists also made a structure that could be used for programming purposes and for displaying what the therapy looks like. This has also been transcribed to text for the final paper. The technical business administrator researched the possible impact on society of our product. The industrial designer spent his time designing an interface in collaboration with one psychologist. He also did research on robotics together with the mechanical engineer, who also programmed the first parts of the therapy by programming facial expressions for the robot and gaining insight into the program of the robot. Besides that, the industrial designer made sketches and prepared presentations.

Communication management

E-mails to the supervisor have been sent timely and with some buffer to prevent running out of time. When problems inside the group emerged, the group-internal WhatsApp-group has been used. This was, for example, when somebody had to call in sick and discuss what he, nevertheless, could do at home. In the office everyone sat at one table which facilitated getting in direct contact with the other people working on the project.

Risk Management

As mentioned earlier, the risk of running out of time was handled by frequent and timely communication with the supervisor. Also, ideas from one week were discussed with the supervisor every Friday to ensure that the project goes the right way. The supervisor also offered contacts for an array of problems, be it programming, robotics or psychology. To ensure that we had the right picture of autistic children in mind we had an hour with Marjolijn van Klink, who works with autistic children in the daycare at the University of Twente, Enschede.

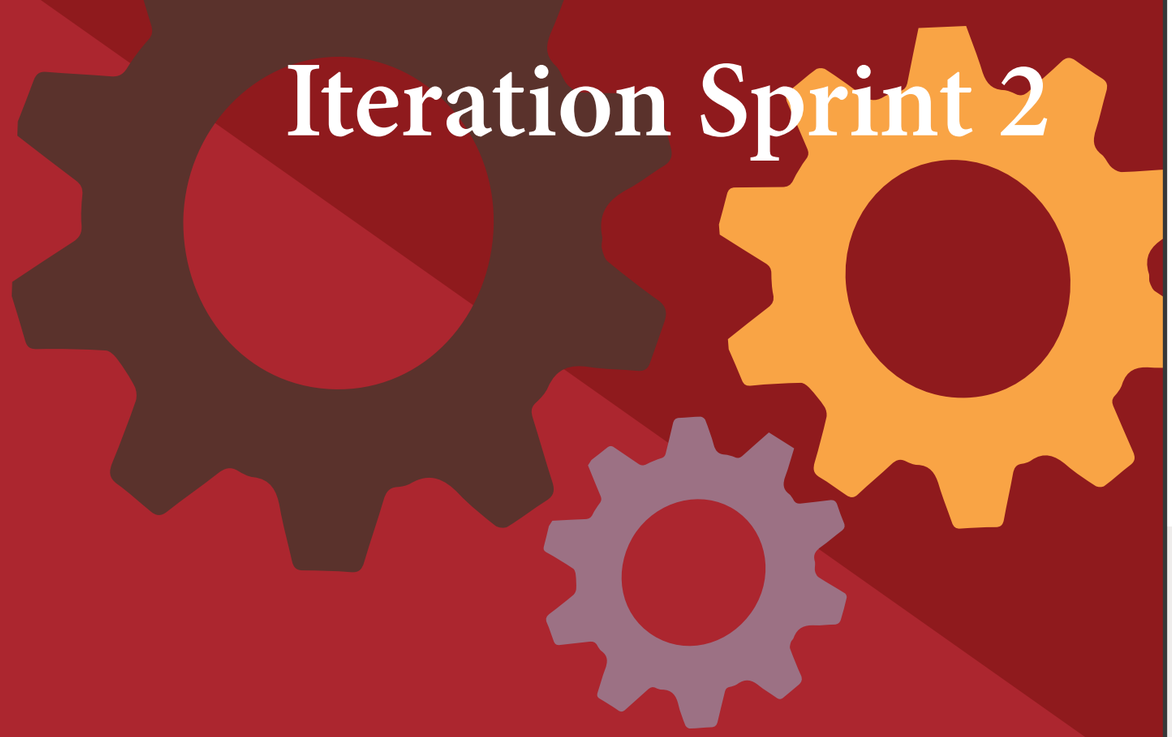
Sprint results

After the first sprint a structure for a therapy has been finished. Also, a vision has been built. Facial expressions were programmed for the robot and the beginning of the final report was finished, thus, the problem was analyzed and a concept made. Sketches for an interface have been made as well. Besides that we acquired a common pool of knowledge by researching journal articles and sharing what we already knew with each other.

Sprint conclusion and discussion

We discussed our collaboration after the first sprint and came to the conclusions that we needed everyone to know what is being done at the moment and that we discuss our ideas more profoundly and with the group. We also concluded that we had to keep the office cleanlier to better the atmosphere whilst working.

Iteration Sprint 2



Project Management & Control

Integration management

To fulfill the wishes of the stakeholder we offered her to visit us during our sessions to observe how everything was going. She did that gladly. Also we always held in mind how autistic children might perceive the elements we build into the therapy session, based on what Marjolijn van Klink told us about the children she knows. Again we used the scrum methodology to assign tasks to every member of the group per day. Small adjustments have been made as necessary. For that, again, the daily stand-ups were held.

Scope managment

In sprint 2 we strongly oriented around having something to show and, thus, the scope was quite narrow. The focus laid more on working towards our product than on generating new ideas. Yet, when new knowledge had been acquired it has been applied to the already made concepts and sketches as well as possible.

Cost management

One voucher has been used for a session with Daniel Davison to explain to us the program they used for controlling the Zeno robot via the Laptop. He described the structure of the program and how each component interacts with the other. Thereby we gained insight in how we can realize our ideas.

Time management

The same means of time management that have been applied in sprint 1 have also been applied in sprint 2.

Quality management

As we were content with the quality of the products from our first sprint we continued the aforementioned quality management. In addition to that, we also now prepared better for the meetings with the supervisor, who also had a look at our products and assessed whether it was good enough.

Project Management & Control

HR management

One of the psychologists was busy doing research on how to reward autistic children best and made a concept of how these principles can be applied in our design. The other psychologist focused on making an interface and started learning the Java programming language. The industrial designer and the mechanical engineer created a concept for the game- and storytelling-aspects of the therapy session and designed the cards. The technical business administrator looked how we could make the design more user-centered and set up a questionnaire which is to be used in the implementation phase of the project.

Communication management

The communication management worked well in the first sprint, therefore the same method has been applied in the second sprint. By now we developed a feeling of trust and reliance inside the group which facilitated communicating problems we had with each other's work or behavior.

Risk Management

In addition to the risk management from sprint 1 compared the products of the first two sprints at the end of sprint 2 to assess how much we stuck to our original idea and if we are still on the right track.

Sprint results

At the end of the second sprint we had an applicable reward system, twelve laminated playing cards whereof six had drawn faces on them and six had photos of real persons and a questionnaire which can be sent to therapists specialized on autism therapy to assess their attitude towards technology and robotics in therapy and how they would like to control such technology. The psychologist who learned Java had acquired enough background knowledge to be able to program an interface and couple it with the robot controller, though, no product emerged from his work in this sprint.

Sprint conclusion and discussion

After the second sprint we discussed our way of working. We concluded that we need to control each other's work even more if we want a higher quality. As we had some problems with the management of files on our Google Drive we designated one group member to manage this, so that one person has the overview and not a situation in which everyone continuously changes something. We also concluded that we should keep up our speed of work and keep on working together as close as we already did.

Iteration Sprint 3

Project Managment & Control

Integration management

As we started making our final product for this module the best way, for us, to integrate this sprint into the overall project progress was to stick as close to our design as possible so we acquire the desired product.

Scope managment

The scope was very clear during the third sprint. We had a picture of how our product should look and received a great deal of hints by Daniel Davison on what parts of our idea we should implement right away and which parts would be nice to have but are not necessary or luxury, like robot-control via a tablet. We also decided to only include three basic emotions instead of six in our prototype so that everything could be finished at the end of the sprint.

Cost management

In sprint 3 we spent two vouchers. One voucher has been spent, again, on Daniel Davison for help with the Flipper-structure. The other voucher was spent by one of the psychologists to get help with Java by Fjodor van Slooten. Both meetings lasted an hour.

Time management

In sprint 3 we had the same rules for being present in the office but we did not divide the tasks per day per person but rather we decided to stay flexible and just concentrate on having the product at the end of the sprint.

Quality management

We controlled the quality by showing our prototype to our supervisor and by assessing whether we used the robot to its full potential. Also we still applied the quality management from the two sprints before.

Project Management & Control

HR management

One of the psychologists applied his Java-knowledge to build an interface which would work with the robot controller (Flipper). The other psychologist worked on the design report and, together with the industrial designer, built the Flipper-structure. The mechanical engineer implemented the animations into the robot and adjusted the given program so that it can run our therapy session. The technical business administrator wrote our business plan and prepared, with help by everyone for their particular part, the presentation for the “Dragon’s Den”.

Communication management

Communication still was held via WhatsApp (group internal) and E-Mail (with the supervisor). Anything else was discussed verbally in the office. Everyone was invited to always ask for help when needed and to tell at what point in their work they were.

Risk Management

We discussed with Daniel Davison from HMI what would be best to implement now and what we could best implement later on, if there is still time left. This way we made extra sure that we were not running out of time. We cut the idea of having a remote on a tablet and decided to run the whole session via the laptop.

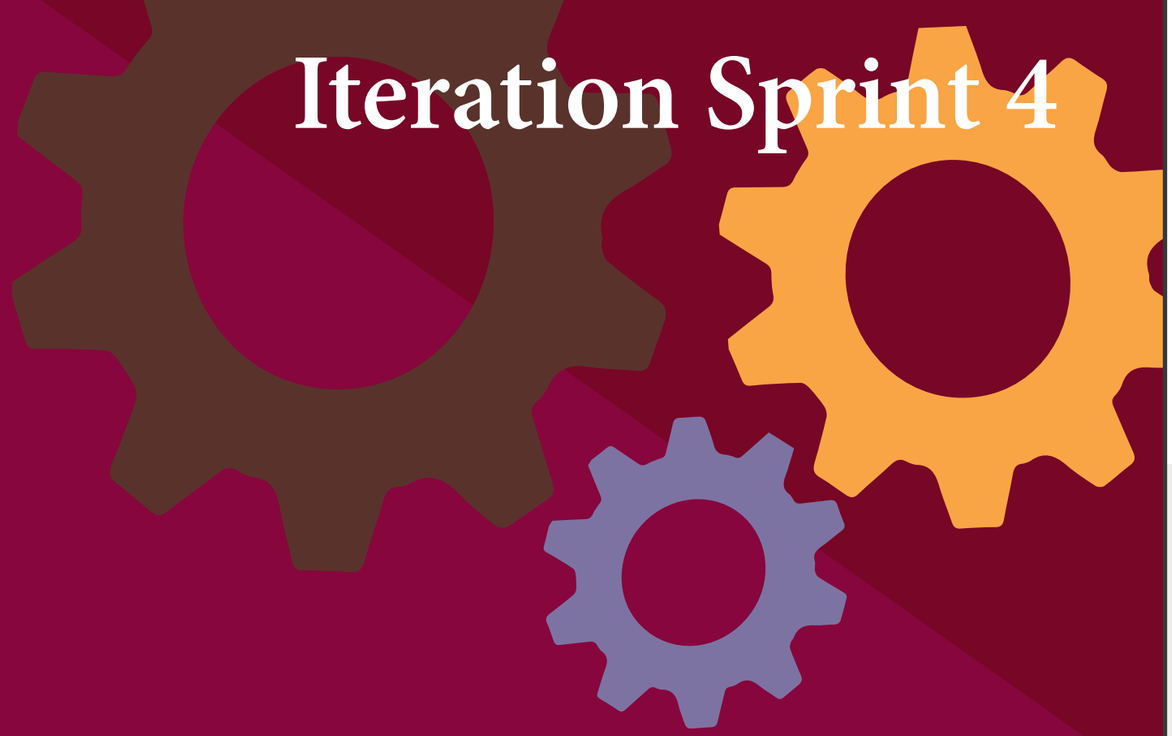
Sprint results

At the end of the third sprint we had a working prototype wherein all of our concepts were applied in a practical way. The robot could be controlled via a Java-based interface and can, as is, be used for implementation evaluation. The reward-system and the game- and storytelling-aspects are implemented and the programs run stable. Also the flipper-structure for the robot’s program was finished so far that we could even make more than just a prototype but realize our whole idea if the time is enough. Our business plan has successfully been made so that we could even sell our idea and services. Also the work on the report was continued and we made third place in the “Dragon’s Den”.

Sprint conclusion and discussion

At the end of the third sprint we discussed our way of working again. This time we concluded that we need to better prepare our presentations if we want to have a more than decent end presentation. As it was already the third sprint we also considered linking our creative work more directly to the report, which we did not always write while we worked. Still, we found our teamwork going very well. As we were sympathetic with each other we decided to stop having too much small talk so that we are not distracted from our goal.

Iteration Sprint 4



Project Management & control

Integration management

As, after finishing the prototype in the third sprint, there was nothing left to do than the final report and the final presentation, integration became easy. We controlled if everything we implemented was in the report and everything that has already been in the report has also been implemented. So to say we did a comparison of the report and the product.

Scope managment

To make sure that the report is neither insufficient nor too big we asked our supervisor for her preferences.

Cost management

No vouchers have been used during the fourth sprint.

Time management

We planned on having the report finished until Tuesday in the second week of the fourth sprint so that we had enough time for spelling and grammar checks, doing the references and making the report nice to read and look at.

Quality management

Every group member did a grammar and spelling check on the final report to ensure correctness of the text. The layout has been created with the group members around so everyone could observe the progress and comment on it. We did a rehearsal for the presentation to see that it is long enough and that it works as we planned.

Project Management & Control

HR management

In the first week of the sprint, one psychologist began controlling the final report paper and searching for parts that were still missing. He then wrote these parts. The industrial designer pre-designed the layout for the final report paper. The other three group members prepared the end presentation, but of course the two people working on the report were involved as well, just not as deeply.

Communication management

Upcoming questions have been answered by our tutors and supervisor via e-mail. The group, again, met every day from 9 to 4 to work together. A to-do-list has been employed on one of the magnetic walls to always have a summary of what still has to be done.

Risk Management

Even though we did our best with time management we figured it would be handy to have some free time in the last week where we could continue working on the report as needed. To avoid any sort of failure during the presentation we rehearsed and then ran the prototype session five times for debugging purposes.

Sprint results

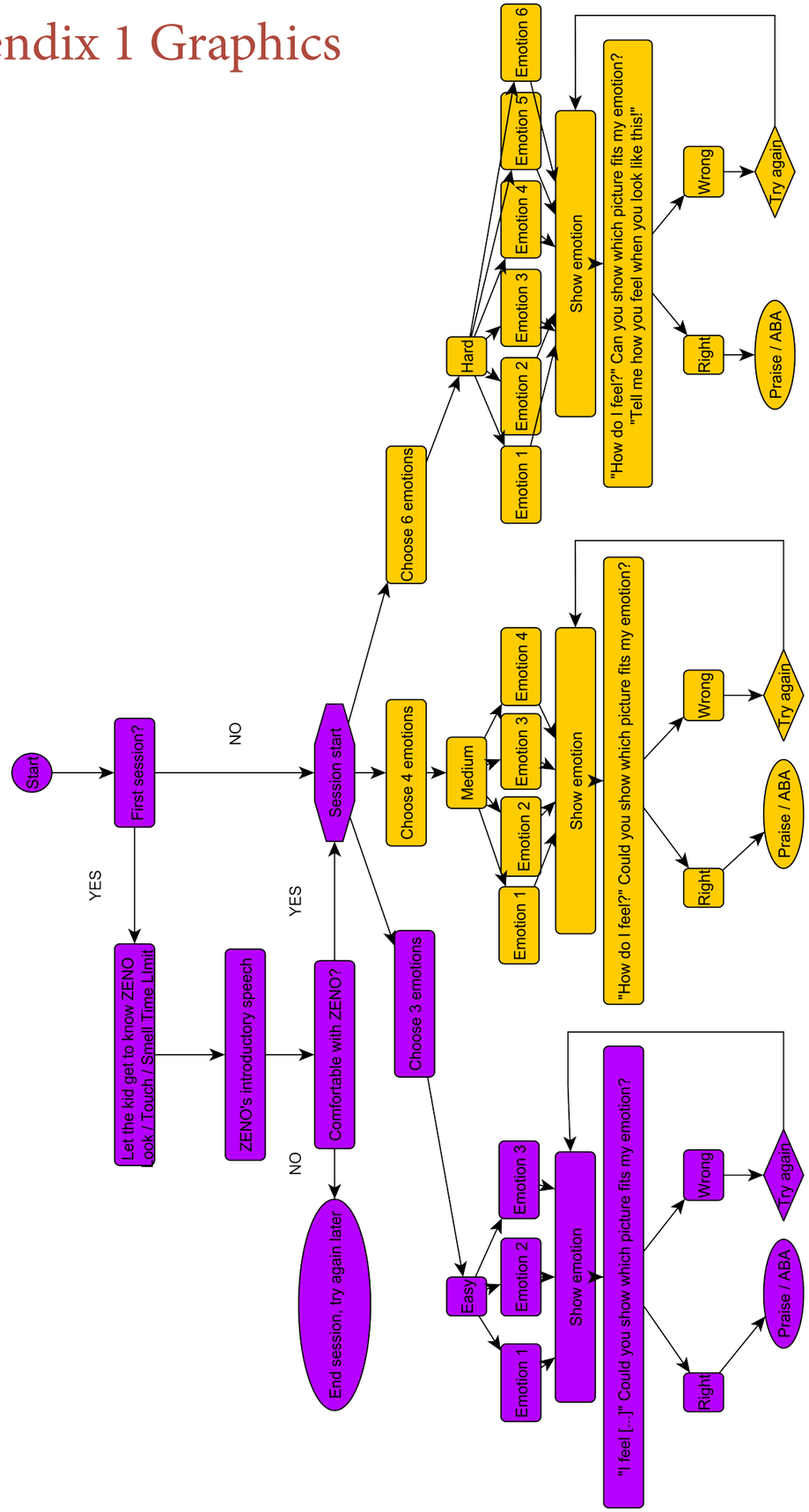
After the fourth sprint we acquired a complete design report with a beautiful layout, improved our prototype by some programming work and held a successful end presentation.

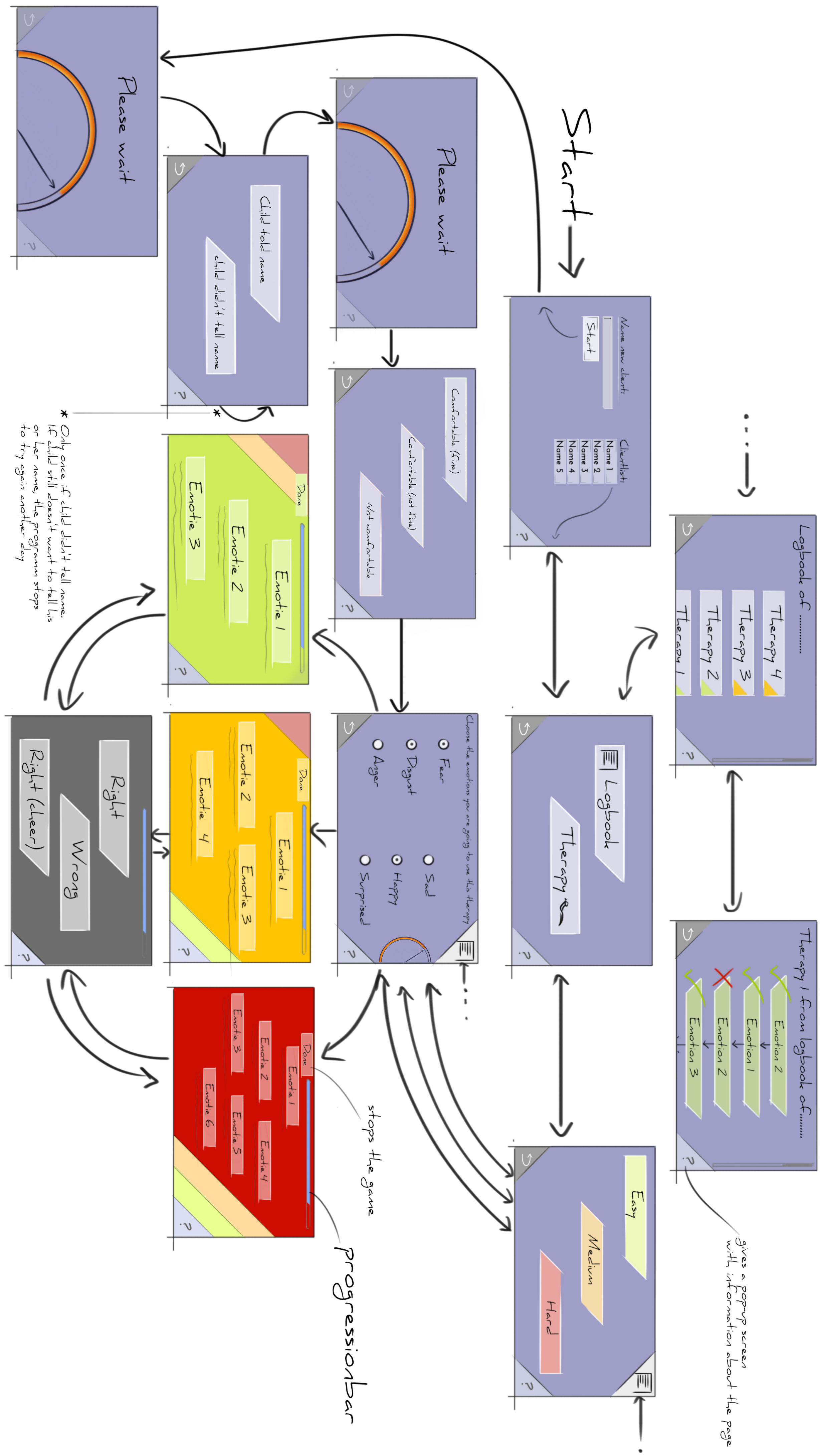
Sprint conclusion and discussion

Participation went really well in this last sprint. We even were able to finish one day early. It was quite astonishing how everyone knew their tasks and what they can offer to the process of writing a report. Through our good communication there were only minor disturbances in the process. For the next report everyone needs to strictly add their references to the EndNote library. This will save a lot of work. Also more time needs to be spared for spelling- and grammar-checks. We underestimated the time this would cost and the length the report would gain.

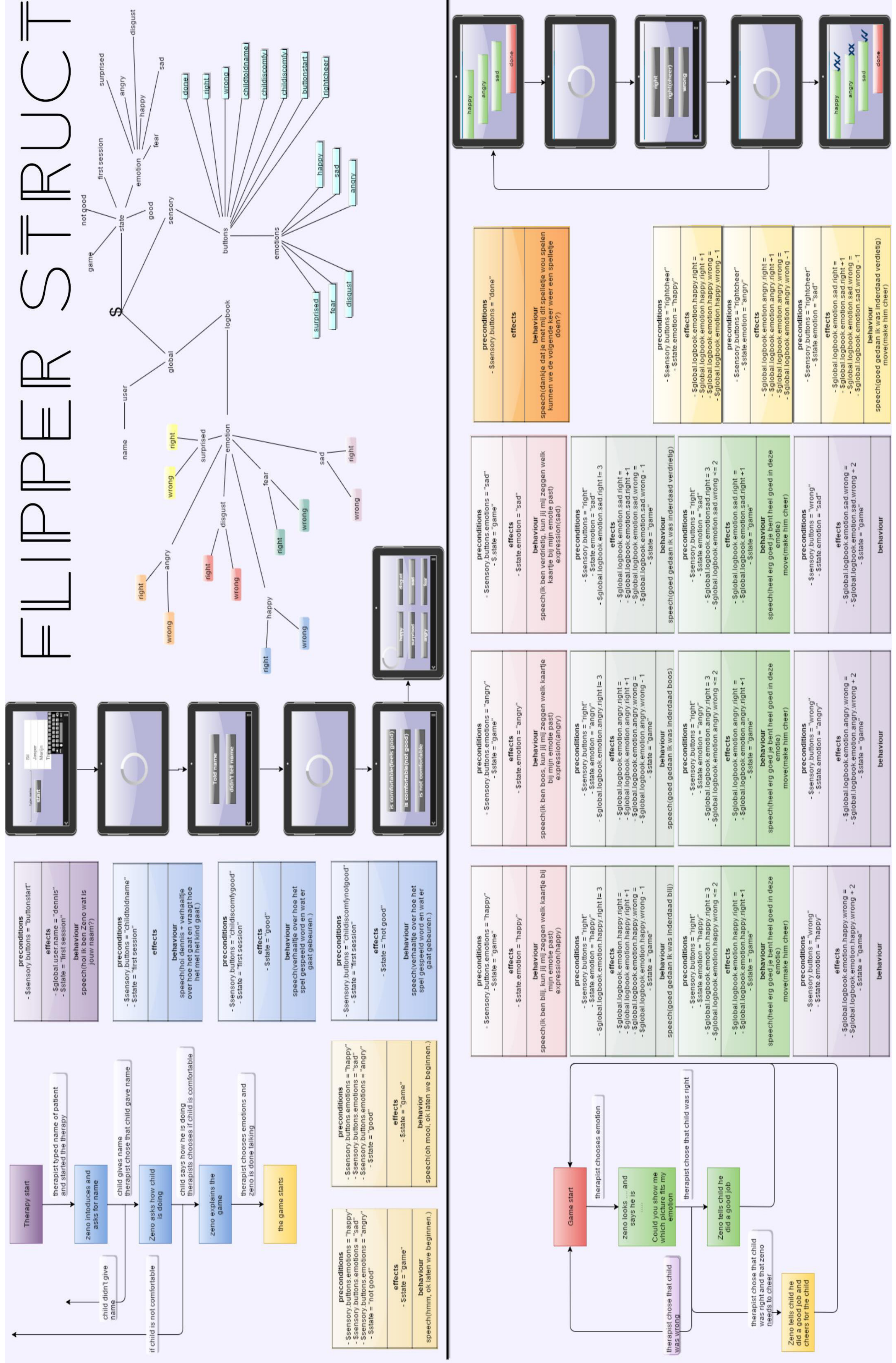
Appendices

Appendix 1 Graphics





FLIPPER STRUCTURE



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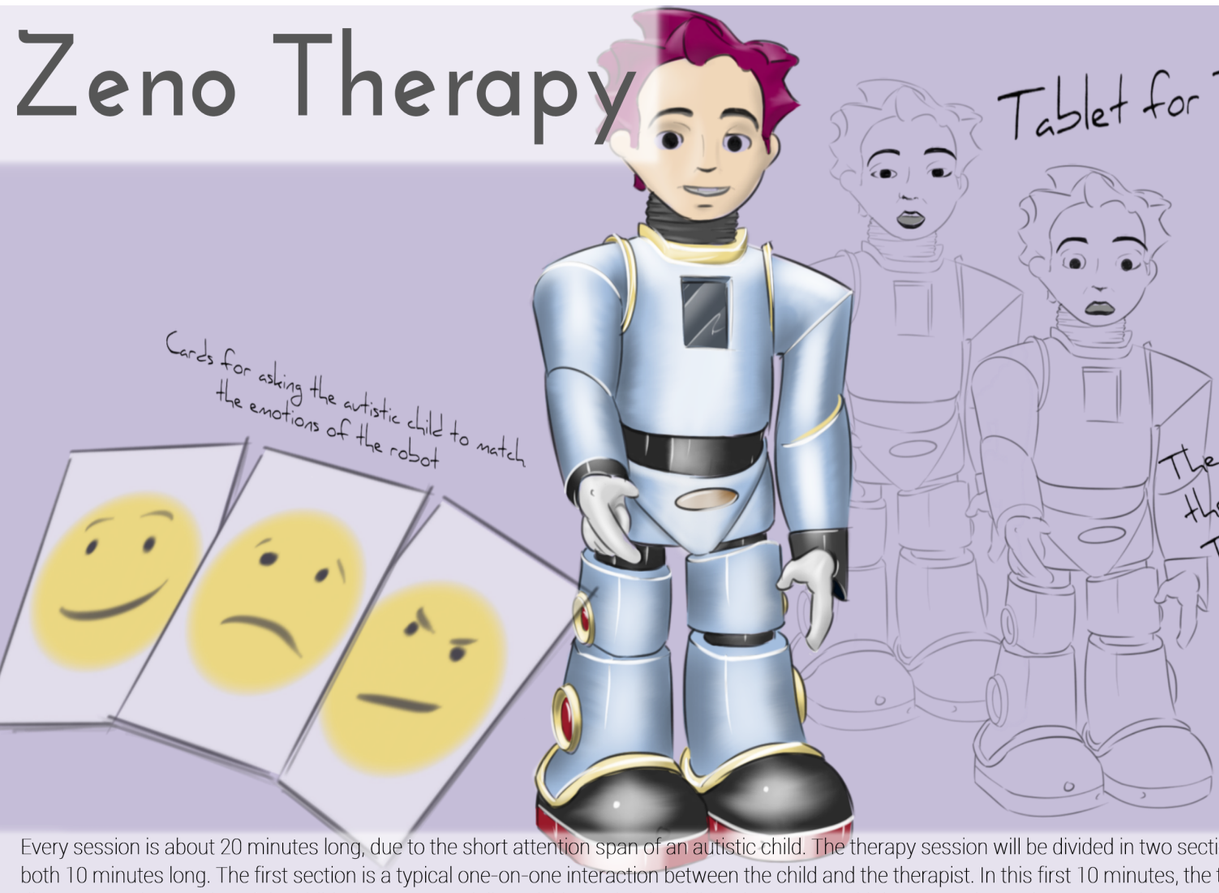
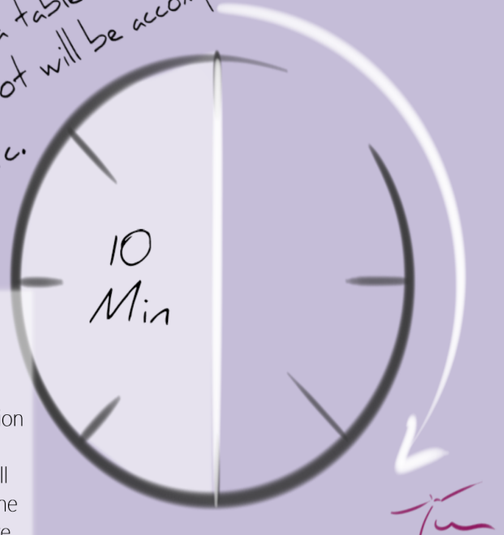
Zeno Therapy



The therapy starts easy with only a few emotions. When the therapy is working more and more emotions will be added. The therapist is able to decide the actions of the robot by using a tablet. Interaction between the autistic child and the robot will be accomplished via participating in a game..... etc.



Every session is about 20 minutes long, due to the short attention span of an autistic child. The therapy session will be divided in two sections, both 10 minutes long. The first section is a typical one-on-one interaction between the child and the therapist. In this first 10 minutes, the therapist discusses various topics of the child's interest, e.g. daily activities, school activities, interaction with known and/or unknown people. In the last 10 minutes, cards with different pictures of emotions (e.g. laughing smiley, crying smiley) on it will be placed between the child and the robot. Then the therapist will choose an emotion with the controller that will be expressed by both Zeno and the therapist. Zeno will ask the child to choose the emotion card that matches Zenos expression. When the child chooses the right card, Zeno will be enthusiastic and says something like: good job! Finally Zeno asks the child what the emotion is called, and if the child can give an example of when the child has the same emotion. This will be done with all the different emotions. It is important that the therapist has the same facial expressions as Zeno at all time. This because of the consistency that if the child switches his gaze from Zeno to the therapist, hell see the same emotions. If a child completes the task with success, the therapist can use more complex emotion card in the next sessions. (First start with very simple doodles →emoticons →real people)

Annex - 1

(P)reflection

Group reflection

At the beginning of this project, no one was familiar with each other or the subject, but from the start the atmosphere between the group members was great. This was beneficial for the progression in this project and the end results. The start of the project has been made by getting familiar to autism and humanoid robots. Next an in depth research has been done to the subject to provide a good base for the concept. In the weeks that followed there has been made a concept, a prototype, a theoretical underpinning, a live demonstration and a report of the project. These deliverables were all made to great satisfaction of the group. The scrum methodology was applied to structure the efforts put in the project and it helped a great deal for keeping an overview of the work done in the process. Each sprint started with planning what was going to be done in the next sprint. Each day started with a daily stand up to discuss the subjects that each group member has to be working on that day and to verify the work that has been done the day before. In each sprint one iteration has been made. At the end of each sprint, the sprint was reflected in terms of the delivered work and the efficiencies of the efforts, also improvements were discussed for the next sprint. This was a good methodology for this project because it infolved a lot of aspects that were hard to manage at the start of the project. To tackle the different aspects of the problem the different back grounds of the team were really helpful. Each of the team members had its own strengths and weaknesses to add to the team and all could learn from each other. Internal difficulties were dealt with by just talking about it, but luckily this was not necessary often. External difficulties and unexpected events were also dealt with efficiently by the team member that was most qualified for the job and therefore problems fatal to the project never occurred. The team was in the beginning of the project hoping on a great product and a working prototype. At the end of the ten weeks this has been accomplished. All were willing to work hard to design a great project. All tasks have been done by the people that were most qualified for the job and when someone was missing skills or knowledge, the other team members were happy to join and solve the problem. For next term more attention has to be put in the documenting and the archiving of the files.

(P)reflection

Individual reflection Alexander Arendt

Name: Alexander Arendt / s1420895
Date: 2-11-2015
Team: 5
Topic: Robot-enhanced therapy for children with autism spectrum disorders

Have your hopes about the process been fulfilled?

Absolutely. I was astounded by, for example, our brainstorming sessions. Normally, if one discusses ideas in a group of five psychologists, at one point in time one is going around in circles. That did not happen with such a diverse group, if we had not set us a limit our brainstorm sessions could have been a day long. I also actually did learn a lot about design processes. A mechanical engineer has very different considerations than a psychologist or an industrial designer. Whilst an industrial designer knows what is beautiful, the mechanical engineer knows if it is realizable and stable and the psychologist knows how people will like the product. It was really nice to experience these processes and how we influenced each other.

How strong did you and your team hold onto these expectations?

Better than I thought we would. Through the scrum-management we always had a very good idea of what was coming next and of how far we were with the whole project. Also, after a talk with our supervisor it was very clear what each discipline had to do in the project and one automatically used the right knowledge from the first two years at the university, even though we first thought we had no idea what to apply of that knowledge. That mostly occurred due to triggering by certain keywords or problem statements one already met in the course of one's study.

What strengths have you brought into the process?

All the strengths I also mentioned in the preflection. Even though it was not possible to use Python for the prototype, my prior knowledge helped me with learning the Java programming language, with which I eventually programmed and designed our user interface for the prototype. I did not use my prior knowledge of Human Factors and Cognitive Engineering as much because I felt that the industrial designer had a pretty good idea of what people like. My prior knowledge of Learning and Instruction helped when I informed the group about methods of therapy for autistic children, as I knew examples for the educational styles used in these therapies that did not have to do with autistic children. Through this prior knowledge, things like operant conditioning and rewarding were already known to me and just had to be applied.

Did the concerns you had become problems?

The concerns did, gladly, not become problems. The syllabus from my first year helped us psychologists with writing the report and everyone else also had a very good idea of what he needed to write. So, even though I was, for some part, nervous about the success of our report, everything went well.

How did you cope with difficulties?

Luckily we did not have too much difficulties. I think that was mostly due to the brilliant scrum-planning done by Jasper. If there were discussions though, it was handy to have some communication skills.

How did you make the process more productive?

I did teach everyone the use of pre-formats and EndNote so that references and layouts were something we did not have to bother with. I also saw that the most important aspects of the current work were always visible in the office and I encouraged the use of the gigantic touchscreens.

Individual reflection Thijs Bemthuis

Name: Thijs Bemthuis
Date: 31-10-2015
Team: 5 Theraxil
Topic: 6: Robot enhanced therapy for children with Autistic Spectrum Disorders

The last two months we have worked on this project and in this time a lot of progression is achieved. At the beginning of this project we handed in a preflection. This reflection I will make in reflect of this preflection and this project.

At the first beginning of this project, no one of our team know each other or was familiar with the subject. But from the first beginning the atmosphere within our group was great, this was very beneficial for the working spirit within our group and the focus on the subject. At the end of this two months we were able to submit a working prototype, with a underpinned therapeutic basic.

The multidisciplinary team was very useful for this project. Our team was a good composition of different student directions. Our project includes different parts, which all need different interest. It included programming, therapeutic research, business ideas and designing abilities. This knowledge was all (partly) available in our team and if this knowledge was not sufficient, the interest was there to increase the knowledge.

I think that everyone in our group has given a sufficient contribution to the project. We subdivided this project into individual assignments and collaborate assignments, which include two or more team members. Therefore everyone could always be busy with this project. I think that my strengths to this process was the experience of working in projects and my industrial engineering and management background. In this project it was very visible that every team member had a different study background.

At the start of this project I had some doubts about the robot and programming part. No one of the team had done anything similar yet. But fortunately, the motivation was there within the group to learn the skills of programming and include this in the final concept. Other difficulties where always discussed within the group and sometimes a team member would know a solution to this or else a voucher where used to fill in this gap of knowledge.

In the last two months a lot of progression is made and I think that we have created a good underpinned prototype. At the end I'm satisfied with this project and I'm glad that I've chosen this minor.

(P)reflection

Individual reflection Merijn Besselink

Name: Merijn Besselink s1363751
Date: 1-11-2015
Team: 5 Theraxil
Topic: Robot enhanced therapy for autism

Overall, I think the minor was a great success. I enjoyed working on an unfamiliar subject with my team-members. In the beginning I was a little bit skeptical with working in a team consisting of students with different backgrounds, but eventually we have even become friends. I have had some difficulties at certain points when I had finished a task, to know exactly what to do next. But because we were very open to each other, things went very well. I did not learn as much as I expected from the other study backgrounds. This was because of the fact that each member got the task to do the parts of the research that fitted with their study backgrounds. For example me and Alexander (both psychology students) did a lot of research on the topics about robotics and autism, while Sil (mechanical engineering student) focused on programming the Zeno robot. Maybe in the second half of the minor I can try to be more engaged in the more technical aspects of the minor. For now the first half of the minor was great and I have had a lot of fun, with either my team mates and with the progress we have made so far. The only thing I have missed was more clarity on some subjects, like with how many people we had to present or what exactly to do for this reflection. Also the prototype week was not really helpful to us, because we rather worked on our own subject than to do something completely different for a whole week. At last I want to say that I am really looking forward for the second half of this minor, and cannot wait to bring the Zeno robot into society.

Individual reflection Sil Spanjer

Name: Sil Spanjer
Date: 01-11-2015
Team: Theraxil
Topic: Robot enhanced therapy for childeren with autism spectrum disorder.

What do you hope will be achieved by the process?

The process of designing and prototyping our project showed me that a lot can be accomplished in ten weeks with a multi disciplinary team. In our team there are a lot of different qualities and skills and also a good motivation to learn qualities that are new to us. It was a project which we started with literally no idea how to tackle and solve the problem, but at the end of ten weeks of research, brainstorming and programming, we ended up with a working prototype that was at least living up to my expectations.

How strong do you think you and your team will hold onto these expectations?

I found out that we were all motivated to make a good project together and we all were willing to share our expertise with the group.

What strengths can you bring to the process?

In this project i was head programming, it was not really a strength that i had on the beginning of the project but i was happy to flex my programming skills a little.

What concerns do you have about your skill base and the skill base of the team?

Concerns about the skill base of the team were absent to me. All five of us had a good base in our field.

What will you do to cope effectively with difficulties?

We coped with internal difficulties just by talking about it, luckily that was not often necessary. For external dificulties we just put our shoulders behind it and dealt with it.

What do you need to know to make the process more productive?

The skrum method was really helpful to get a clear overview of wat was going on in the group.

(P)reflection

Individual reflection Jasper Westenbroek

Name: Jasper Westenbroek
Date: 01-11-2015
Team: Theraxil BV (team 5)
Topic: Robot-enhanced therapy for children with Autistic Spectrum Disorders

What do you hope will be achieved by the process?

In the preflection I said I hoped to achieve a prototype which will be accepted by therapists as an effective product for their therapy. Well we build a prototype which fits the needs of these therapies. However, in order to know if our prototype does what is expected we need to test if its actions really teach the autistic children to recognize emotions.

How strong do you think you and your team will hold onto these expectations?

My team and I worked hard on this project. Our ambitious goals gave fruit into an amazing prototype. But as mentioned before were are far from done. Testing needs to be done and the prototype needs to be broadened. Our prototype resembles the product in a certain moment of its use. In order to test its effect more than only the first session of the therapy is needed. I believe that in the next module the team will do its best to deliver a perfected product.

What strengths can you bring to the process?

With my knowledge as an Industrial Design Engineer I was able to steer my team in one direction. All focused on the same goal we made it possible to achieve our shared vision. In order to make some of my teammates more creative I had to throw in some design techniques. At first coming up with new ideas was hard for them since it was their first time thinking of designing a new product. But after a while they started to get creative and were more involved in brainstorm sessions. Also my broad knowledge in designing made it possible to follow each step of every member. As scrum master I needed to know what everyone was doing at every given moment. I was able to support every member in their assignments and I could be used as backup when needed.

What concerns do you have about your skill base and the skill base of the team?

At first I was very concerned about our programming skills. But we were capable of learning the hard programming language needed for the zeno robot. Since a lot of programming is still needed we could use a programmer in our next module. This would make the process go a lot faster and easier.

What will you do to cope effectively with difficulties?

When someone wasn't able to finish his part in time someone would help him to get the job done. However our plans were ambitious so our planning was tight. But with good teamwork. A good overview, hard work and a flexible planning strategy we made it possible to finish our backlog items every time. There was never a moment of doubt we wouldn't make it in time.

What do you need to know to make the process more productive?

Even if we were missing in depth knowledge about the cognition of autistic children we did a vast amount of research. This was needed to have more insight in the mind of an autistic child. After our research it was a lot easier to come up with solutions since we knew what could work and what not.

Annex - 2

Prototype week

DesignLab

Introduction

The DesignLab is a new ecosystem at the University of Twente, which focusses on creativity and the multi- and cross-disciplinary aspects of the system. In this ecosystem, students, professors and faculties from different fields are involved into projects with companies and governments on the questions and challenges from today's society and the world of tomorrow.

The aim of the DesignLab is to not only research, design and facilitate ground-breaking research of new products and applications, it is also there to lay focus on the training of a new generation of designers who can combine scientific knowledge with creative skills and doing this with an entrepreneurial attitude and the ability to see and integrate the social dimensions of the latest technologies.

Problem analysis

The DesignLab's aim and focus is to increase the creativity and cross-disciplinary aspects of the ecosystem. The Lab offers the facilities for groups and individuals to work on the latest research projects. Another goal of the DesignLab is to bring all kinds of different students and researchers in contact with each other, with the focus on helping each other and the possibilities for the birth of fresh ideas that will change the future.

Currently the main aspect and way to bring each research group in the DesignLab in contact with each other is with standard registration forms. Everyone could fill in a project form which includes the name of the project, the name of the participating disciplines, their goal and further information on the project. The group could also write down if they need help with some kind of the project, other persons could read the project forms and could response on the help request or could stop by the group and ask for more information when interested. The forms are laid on a table or on a board and there is not much motivation from different groups to react on these forms.

The current problem is that there is not much attention for the forms that are filled in. Groups will fill in a form, but afterwards they do not pay any attention at these forms any more. The DesignLab team invented a "Tosti Tuesday" to increase the attention of these forms and increase the interaction between different groups of students. They hoped with this idea the different groups will talk to each other about their projects when there are waiting for their grilled cheese to be ready, and so if they need help they could help or advise each other. This idea of "Tosti Tuesday" did not have the desired effect and it seems that it is more about the grilled cheese than about the projects that are going on.

The observation at the DesignLab is that the groups do not interact a lot with each other and do not put the forms to further use, some of them even did not ask for help on the forms. The reason for this behavior needed to be found out.

On the 5th of October a field survey was hold in the DesignLab and different groups of students were asked if they heard of the forms and why they used or did not use it. In total 71 project forms were filled in, where 41 did not request for help and 30 did. Most of the groups in the DesignLab knew about the forms, but the reasons why they did not use it often differ. The statements depicted in table 3 were found after the field survey in the DesignLab.

Prototype week

DesignLab

Table 3
Reasons for avoiding conversation in the DesignLab

Lack of time (Too busy with their own projects)
Lack of questions (What they want to ask)
Lack of seeing any additional value (Why not just use the internet?)
Lack of time (If they had time, they would help)
Blackboard sometimes is an easier way to discuss with peers

Problem statement and research / design question

The DesignLab team wants to bring different groups of students in contact with each other. Nowadays they use special paper forms for doing this and implemented a "Tosti Tuesday". This did not have the required effect till now and they are looking for changes that can be made to increase the interaction between different students, with the focus on their projects.

Students give different kind of reasons why they do not use the forms as much as the DesignLab expected they would. Most of reasons could be subjected to the reason that students do not see the point and usefulness of the forms and therefore see e.g. the "Tosti Tuesday" only as a free lunch and not as a way to meet other groups.

Therefore the problem is not the forms or the "Tosti Tuesday" idea, but the problem is that students do not see the usefulness of the forms and the connection between different groups. Most of the student groups do not have the idea that they have any questions that other groups could help them with. Therefore students need to become aware of the wisdom of the crowds; that other students could bring up new ideas and therefore could help them with their project. To start this awareness, students need to talk with each other about their projects. After they talked with each other about their projects, discussions could take place and ideas of problems would come at the surface. The current problem is that students are "forced" to have a question in a formal way, but instead of this formal way, students need to bring up questions in an informal way.

Of the above problem analysis and statement the next research question is extracted:
How could it be made possible that different groups of students will talk, discuss and interact with each other about their projects?

The research and the concept that will be done and searched for in this paper will focus on the possibilities to increase the interaction between different groups of students in the DesignLab, with special attention for their projects.

Theoretical underpinnings

The idea of students from different projects and background help each other is based on the principles of the wisdom of the crowds; e.g. the wisdom of many is more than the wisdom of a few. The concept we will generate is based on the information we extracted during the field research in the DesignLab and the Social Cognitive Theory by Bandura (1986). These information are the basis for our further research to a potential solution and will be two of the pillars of the final concept.

The wisdom of the crowd idea will be implemented as the theory behind the idea that different groups need to interact with each other, to get fresh ideas and help each other further with their projects. To initiate this interaction it has been chosen to adapt the environment, in this case the DesignLab at the UT, based on the facilitation-method derived from the Social Cognitive Theory ((Bandura, 1986). This lead to the concept which will be described in the following paragraph.

Impact on society

The definition of the society in this case is the DesignLab society. Within this society, different kinds of students, professors and other experts are working on all kind of different projects. If the integration and communication between the different project groups is increased, the different projects groups will be aware of the subjects and work of all the other projects that are going on in the DesignLab. If the awareness is raised, the help aspect between different groups could be increased. For instance, if you know that a certain group is working on a certain project and you get in touch with someone who is an expert on that topic, you could bring them in contact with each other when requested by the group

he final impact on the DesignLab society is that the quality of the projects could increase, problems could be tackled in a more efficient way and therefore the possibilities of new and fresh ideas for the society of tomorrow could arise.

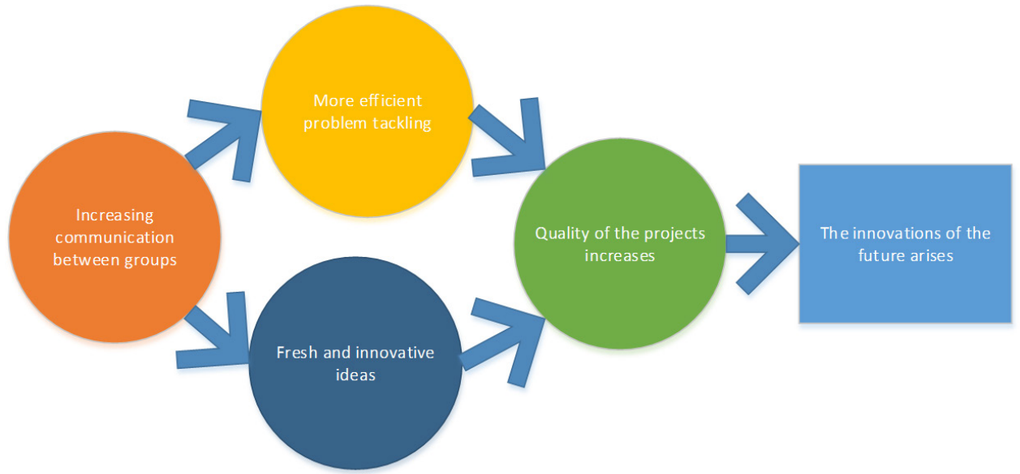


Figure 38 – Imapct on the DesignLab society

Iterations

We began with a brainstorm. We thought about what techniques could be employed to facilitate initiating social interaction about projects. Our first idea was a poster intervention that could motivate people to talk. The idea after that was a simple slideshow of project posters, which, over time, came to be the interactive screen which is our final concept.

Prototype week

DesignLab

Final concept

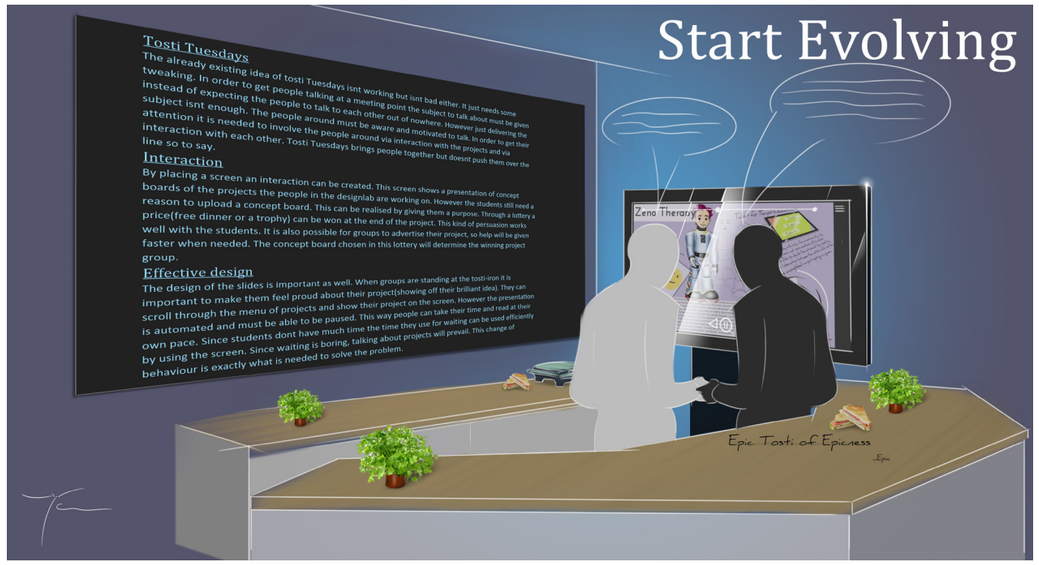


Figure 39 - Concept board DesignLab

Result / concept
Tosti Tuesdays
The already existing idea of "Tosti Tuesdays" is not working but is not entirely bad either. It just needs some tweaking. In order to get people talking at a meeting point the subject to talk about must be given instead of expecting the people to talk to each other out of nowhere. However just delivering the subject is not enough. The people around must be aware and motivated to talk. In order to get their attention it is needed to involve the people around via interaction with the projects and via interaction with each other. "Tosti Tuesdays" brings people together but does not have the desired effect of facilitating social interaction.

Interaction
By placing a screen the social interaction is facilitated. Appendix 1 shows a presentation of concept boards of the projects the people in the DesignLab are working on. However the students still need a reason to upload a concept board. This can be realized by giving them a purpose. Through a lottery a price (free dinner or a trophy) can be won at the end of the project. This kind of persuasion works well with the students of the UT, as people pile up for lotteries and free stuff all the time. That is also part of the Social Cognitive Theory by Bandura (Bandura, 1986, 1989). The method is called vicarious reinforcement. The students see that something good happens or might happen if one sends in a project form and thereby like to do so more likely. It is also possible for groups to advertise their project, so help will be given faster when needed. The concept board chosen in this lottery will determine the winning project group.

Effective design
The design of the slides is important as well. When groups are standing at the toasty-iron it is important to make them feel proud about their project (showing off their brilliant idea). They can scroll through the menu of projects and show their project on the screen. However the presentation is automated and must be able to be paused. This way people can take their time and read at their own pace. Since students do not have much time the time they use for waiting can be used efficiently by using the screen. Since waiting is boring, talking about projects will prevail. This change of behavior is exactly what is needed to solve the problem.

Business plan
The solution for the DesignLab problem has a focus on the benefit it will have for the students and facilities working in the DesignLab. To summarize the benefits of our idea the following plan is written down.

Value proposition
In the current state the communication between groups is very little. A lot of groups do not see the benefits of talking to each other, and the current way of working with the contact forms does not change this behavior. The groups see each other in the Design Lab, but most of the time they do not have a conversation starter to talk about their project. With our concept this will change. By implementing a multifunctional TV screen next to the coffee machine, groups will see all kind of project when they are waiting for their coffee of grilled cheese. When you are interested in a project, you could stop the screen and you could zoom into the project and get more information about it. This is an ideal way to decline the communication barrier between different groups to talk about their project. If you see your own project on the screen, you could stop it and explain it to people who are also waiting for their coffee or grilled cheese.

The current ideas of the DesignLab need to stay, so "Tosti-Tuesday" needs to stay, but our concept will be a replenishment of the ideas that are already implemented. It will increase the communication between the groups with all the possible innovative ideas that could arise.

Customer segments
This concept focuses on the increasing of communication between students who are working on projects. This concept is fitted to be implemented at the DesignLab at the University of Twente. Next to the implementation at the DesignLab, it is also possible to implement this concept at different sections of the University of Twente, where also a project based learning environment is raised. Therefore the customers segment is broader than only the DesignLab, the whole University of Twente is a potential customer.

Key partners
The partners that make this concept a success are the members of the "Dream Team" of the DesignLab. This team have the obligation to refresh the posters on the screen and attend people on the possibility to show some information about their project on the information screen next to the coffee machine. Next to the "Dream Team", the University of Twente is also a partner to implement this concept successfully. The university have to give their approval for this idea and have to invest in the technology.

Prototype week

DesignLab

Key activities

The concept focuses on declining the communication barrier between different students, by offering them a conversation starter when they are waiting for their coffee or grilled cheese. The way of doing it is by showing different kind of posters of project that are going on at the DesignLab and offering more information of this projects for people who are interested.

Key resources

To make this concept a success, the University of Twente has to invest in technology to make the concept possible. Next to the technology, the information about the projects that are going on are important. The “Dream Team” members of the DesignLab have to make sure that enough people are enthusiastic to make a poster for the screen.

Customer relationship

This concepts offers an idea for the University of Twente. After the implementation the relationship will end.

Cost structure

For the implementation of this concept an investment is required by the University of Twente to acquire the technology that are necessary for this concept. This is a one-time investment. Next to the initial investment, this concept will have a variable energy consumption during a month, based on the amount of time the monitor is switched on. This will be the direct costs that are needed to implement this concept.

Next to the direct costs that could be signed to this concept, this concept also requires an indirect costs which the “Dream Team”-members will contribute to. The “Dream Team”-members are necessary to keep the information up to date and motivate students.

Revenue streams

This concept will generate no direct revenue streams. It is a non-profit concept that will increase the communication between students.

HealthCheck

Introduction

The sports center, located at the campus of the University of Twente, has the facilities to perform health checks for employees of the University of Twente. The health check is designed to measure the physical wellbeing of a person. This is achieved by measuring, among other things, blood pressure, cholesterol levels and a condition test. At the moment, the health check is available for University of Twente employees of 50 years and older, for one week a year.

Problem analysis

The sports center wants to extend the number of participants of the health checks. They want to reach that goal by motivating more University of Twente employees to do a health check. They also want to attract external companies for their health check.

There are a couple reasons the sports center does not have a large amount of costumers. These reasons can be found in table 4.

Table 4
Reasons for missing costumers

The health check is only held one week in a year
There is a strict age requirement for participating
The limit of appointments is reached
The website is chaotic
There is no possibility to make an appointment online
The participants are not very well informed

To reach a lot of costumers the sports center also has to add something new to the market.

Problem statement and research / design question

How can the service be improved so that the sports center attracts more costumers for health checks?

Theoretical underpinnings

Making people aware of their own health improves the level of involvement in their own wellbeing. This is greatly beneficial for preventing long term illness. Trying to achieve a low level intake is also beneficial for the amount of participants.

To achieve a change in behavior and make people believe that doing a health check is beneficial for them, the use of the Health Belief Model (Rosenstock, 1966) can be very helpful. According to the Health Belief Model, people will only change their behavior when they realize that their behavior may have serious negative consequences (perceived severity), and that there is a substantial possibility that these consequences may affect them personally (perceived vulnerability). The HBM also assumes that people will be more inclined to change their behavior when they believe that the new behavior will have many benefits and that the barriers to execute the new behavior will be small. So in our example of persuading people to do the health check, we have to make sure that they will understand the positive consequences of doing the health check.

Prototype week

HealthCheck

The major benefit is that health problems, if present, can be detected in an early stage. Therefore medical assistance can prevent further harm. So the perceived severity in this case is that if there is a medical oddity present, the sooner it gets noticed the better the chance for a good recovery. The perceived vulnerability is that if there is a medical problem, it may cause the employee to be unable to maintain his or her work. The barrier can be broken, by letting the employers arrange the schedules for his personnel to do the health check.

Impact on society

The impact on society of the health check problem can be divided in two aspects. The first aspect is that when the sports center reaches more people with health checks, more health problems can be recognized and anticipated on and as consequence the sickness absence cost will decline.

The second aspect is that making the health check available for everybody can change the way everybody manages their own health. When everybody uses the prevention is better than cure strategy the load on the different parts of the health care system will change.

Iterations

Our first idea was a poster intervention. We had in mind to put Uncle Sam on posters around the Kennispark and the campus of the University of Twente with the slogan: "We want YOU to be healthy" in the fashion of the propaganda posters from the USA. This idea evolved into an intervention we put on vehicles that drive around town, but then was scraped of the intervention and the vehicle remained. From that emerged our final concept of a vehicle that can bring the health check to external companies.

Final concept

Figure 40 – Concept board HealthChech

Result / concept

We would like to introduce the HealthCheckBus to make it easier for people to do the Health Check. The HealthCheckBus is a mobile health research center, which will focus on the general aspects of the employees' condition and physical health. These aspects are:

Cholesterol, glucose and blood pressure measurements. By extracting a single blood sample, the cholesterol and glucose levels will be analyzed. While analyzing, the blood pressure will be measured. There will be a professional available to discuss the results and answer questions.

BMI and body fat measurement, to gain a better insight into personal health. A dietician will be available to discuss the results and give advice in response to the BMI & fat percentage measuring.

Stamina check. The endurance and stamina will be measured with the use of a treadmill and a training bike.

There will be a mobile shower available, so everyone can refresh him/herself after the stamina training.

All of this can be done by using a touring car containing all the technologies and space needed for the health check. To gain attention, the appearance of the bus is very important. The exterior of the HealthCheckBus will be covered with advertises about the Health Check. A slogan and/or picture which stresses the benefits of the health check will also be on the bus. The bus has to give the impression that it is modern, clean and beneficial for one's health.

The goal of the HCB, is to reach more employees to do the health check with less effort to take part in it. Because of its mobility it can come to the customer instead of letting the customer come to the health check. Therefore the reach ability will be greatly expanded. With the use of the bus the sports center can also reach companies from outside of the University of Twente.

Prototype week

HealthCheck

Business plan

Value proposition
In order to compete with other health check institutions the sports center uses busses to bring the health check directly to the companies. Right now, no other companies use the services by the University of Twente because the effort is too high for them to be seen as beneficial. By bringing the health check to the companies, the amount of effort decreases and therefore more people will use it. Since other health institutions ask of the companies to come to a designated location the University of Twente will be the first option they will choose. At the same time the bus functions as a billboard thus disseminating the service when going to the companies located at business parks, for example the 'Kennispark' located in Enschede.

Customer segments
Companies in the Netherlands are obligated to persuade employees to do a health check. Since they are the ones who have to do the effort for its employees, they are our customers. The companies are the ones who want to make its employees do the test and with this solution for the sports center they get the perfect opportunity to accomplish that demand.

The University of Twente also is a company which wants his employees to do the health check.

Indirectly the employees are our customers as well. They are the ones that actually experience the given services. They rate the service and through word of mouth other companies will hear the positive effect this project has. This way more companies will want the service.

Key partners
Since the sports center is a part of the university, its key partner is the university

Key activities
The key activities of this business are, for one, providing health checks to companies who offer these to their employees. Secondly, it is aimed on providing these health checks in a modern and mobile fashion. Eventually this should lead to the sports center becoming a top-notch partner for health checks. In more detail, key activities include getting a doctor and a team of nurses to conduct the health check, have someone drive and maintain the bus and have someone build the bus.

A digital possibility to make an appointment needs to be programmed and maintained. Digital and analog means of making an appointment with the bus and its team need to be processed. Communication between the bus, its personal and the schedule needs to be ensured.

Key resources
It is necessary to have enough workforce. Thus, the sports center needs a set team of doctors and nurses for this specific purpose. Also, the bus needs to be build, driven and maintained. Requests for an appointment need to be processed with a cooperation between software and a human. Online appointments can be processed entirely digital, though requests made by phone or letter need to be parsed by a human. For the bus, the apparatuses used for health checks need to be bought and state-of-the-art technology is required to ensure maximum use of the given space in the bus. It is also essential to have someone paint the bus. For that, one needs the paint to make the design real and get a painter and an expert in applying decals to cars.

Customer relationship
The service the sport center will deliver is a complete package of health check and advice with all the facilities needed provided on site. It is a very easy and quick service that is available for companies in a wide area. Interested companies can hire the bus for a predefined time span. The only thing the companies have to provide is a parking place, a connection to the fresh water supply and the electrical grid.

Cost structure
The required investment needed to set up the program is relatively high due to the cost of the purchase and modification of the bus and the cost of the technology needed to perform the health check. The revenue will come from the rent of the bus.

Revenue streams
Revenue will be generated from the rent of the bus. The Revenue will be spent on the maintenance of the bus, the wages of the employees, the debit of the equipment and the bus.

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