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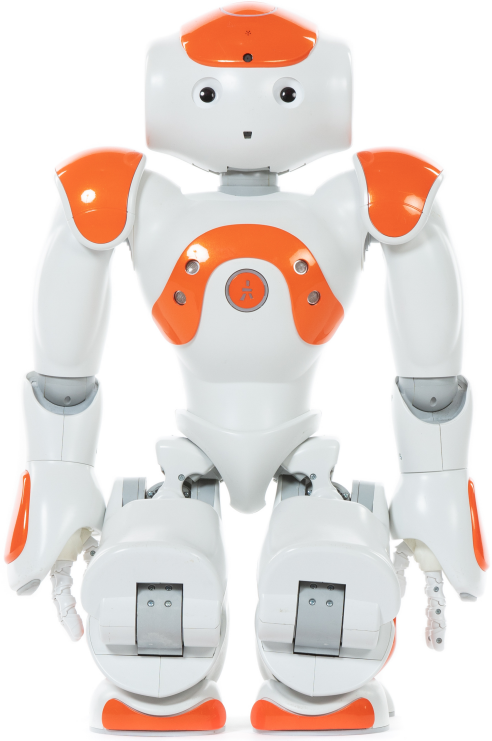

Interaction Design for Autism Spectrum Disorder Therapy

Designing a Robot-Assisted Therapy Session for Preschool Children Diagnosed with Autism Spectrum Disorder

Bachelor's Thesis in Computer Science and Engineering

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Department of Computer Science and Engineering
CHALMERS UNIVERSITY OF TECHNOLOGY
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Abstract

Autism spectrum disorder (ASD) is a diagnosis which is becoming more common among young children and there are several types of therapies available. It has been shown that robots increase children with ASD's willingness to interact, and some researches propose that robots can be used for therapy. This is partly due to robots being easier to understand for a child with ASD, since a robot does not get tired of listening and does not show complicated emotions while still being humanlike. This project aimed to incrementally design the interaction within a therapy session for a child with ASD, making use of a NAO robot, along with an accompanying graphical user interface (GUI). With the help of a medical expert in the area of ASD, the session has been evaluated during three design cycles. The focus of the therapy session has been on making the robot facilitate learning amongst children, in the areas of decision making and recognising feelings in others. A session with six different tasks has been created with an accompanying GUI. The session has been tested and approved by a medical expert in the field of ASD. The medical expert has also given feedback along the way and improvements have been made according to it.

Keywords: Autism spectrum disorder, ASD, Robotics, Interaction Design, Human-computer interaction, Robot-assisted therapy

Sammandrag

Det har blivit allt vanligare att yngre barn diagnostiseras med autismspektrumtillstånd (AST) och idag finns ett flertal olika terapier tillgängliga för att underlätta deras vardag och inlärning. Det har visats att robotar kan öka barnens vilja att interagera och en del forskning föreslår att robotar kan användas som en del av terapin. Robotar är någorlunda människoliknande men kan vara enklare att interagera med för barn med AST, detta eftersom en robot inte tröttnar på att lyssna och inte heller uttrycker komplicerade känslor. Syftet med projektet är att stegvis designa interaktionen i en terapisession för barn med AST, genom att använda en NAO robot, samt utveckla ett tillhörande grafiskt användargränssnitt. Med hjälp av en medicinsk expert inom AST har sessionen utvärderats under tre designcykler. Fokuset för terapisessionen har varit att få roboten att utveckla barnets förmåga att göra val och kunna identifiera andras känslor. En session, som består av sex olika uppgifter, har skapats tillsammans med ett grafiskt användargränssnitt som man kan kontrollera sessionen genom. Sessionen har testats och godkänts av en medicinsk expert inom AST. Den medicinska experten har också gett feedback längs projektets gång och förbättringar har gjorts utifrån förslagen.

Sökord: Autismspektrumtillstånd, AST, Robotik, Interaktionsdesign, Människa-datorinteraktion, Robotassisterad terapi

Acknowledgements

We would like to thank our supervisor Gordana Dodig Crnkovic for giving us helpful and insightful feedback throughout the project. We would like to thank Prof. Eva Billstedt at Gillberg Neuropsychiatry Centre for helping us evaluate the result after each sprint. We would also like to thank Prof. E. Billstedt as well as Anne Lönnermark at The Autism and Asperger Association in Gothenburg, for giving us valuable information about autism spectrum disorder, as well as helping us set a scope for the project. We want to thank Robert Lowe for lending us the battery and charger for the NAO robot and Erik Billing for providing us with insightful information about the robot.

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Glossary

ASD Autism spectrum disorder (ASD) is a developmental disorder that is characterised by a variety of deficits hindering social interactions, development communication and language amongst other things. 1–5, 7–9, 13–15, 20, 21, 26, 27, 29, 32, 35

GUI Graphical user interface (GUI), is an interface that lets the user interact with the computer, often in the form of text, images and buttons. 2, 5, 13, 15, 18–21, 24, 26, 30, 31

NAO NAO is a humanoid, programmable, robot developed by SoftBank Robotics often used in research and education as well as in healthcare centres and various companies. NAO is not an abbreviation; rather, it is simply a name. 1–4, 11, 14–19, 21, 29, 35

Neurotypical Neurotypical is used to describe a person who is perceived as typically developed by the general population. In this report, it refers to a person who has not been diagnosed with ASD. 4, 7, 14, 15

1
Introduction

Robots are becoming increasingly common in everyday life around the world [1]. This pushes the multitude of usage areas in different directions. During the last two decades, a great amount of therapeutic research and experiments have been conducted with robots. One area is between clinicians and preschool-aged children with autism spectrum disorder (ASD) [2].

The subject of child-computer interaction is widely studied, including the field of how technology can be used for to assist children diagnosed with ASD [3]. Multiple projects, both large and small-scale, have been conducted throughout the last two decades. This research has been ranging from simple turn-taking robots, used in e.g. games of tag, to complex anthropomorphic robots capable of detecting emotions and showing empathy [4]. The recently finished European project DREAM [5], conducted studies on a robot named NAO which is used for interaction with children [6].

NAO is only one out of several robots that are used in ASD therapy, and different kinds of robots, as well as different therapy settings, have been examined in multiple projects. In research by C. Huijnen et al., they consulted experts within different areas concerning ASD to establish medical domains and specific categories within the field of ASD therapy and education [4]. One category is the ability of decision making and another is to recognise feelings in others, which is difficult for children with ASD [7]. Recent research in this area has shown great promise [8]. However, other studies have also shown that therapy aiming to improve this area has not yet been done using a NAO robot [4].

1.1 Purpose

The project's primary purpose was to design a robot-assisted therapy session with a NAO to help children with ASD make choices and recognise feelings. By incrementally evaluating the design, the main goal was to end up with a generalised design that could be tested in real-life.

1.2 Problem and Task Description

Designing a robot-assisted therapy session is a task which can be broken down into several objectives. Below is a description of the primary objectives that have been worked towards throughout the project.

Many children with ASD have difficulties concentrating [7]. This poses challenges that have to be met within the session. The session should retain the attention of the child throughout the whole duration. The tasks are required to be playful to keep the child motivated and the duration of the session has to be adapted to the average time of concentration for a child with ASD.

The resulting session needs a high level of certainty that it can be tested on children for it to have a future within the field of robot-assisted therapy. It should hence achieve a deployable state by the end of the project.

With varying technological and therapeutical knowledge of the supervisor, the session and its graphical user interface (GUI) should be easily understood and controlled, for it to be used efficiently by any supervisor.

For the pedagogical purposes of the project, the tasks need to fulfil a certain degree of educative quality. Hence, the tasks should be designed to help the child learn how to recognise feelings and practice the ability of decision making.

For the session to be used in the future, it also requires a degree of trust and demand with the users and their relatives. It is therefore important to get the opinions of those that are close to the targeted children. To procure the necessary information, the project should reach out to people in a close relationship with the children in the target audience.

1.3 Stakeholders

Within the project there exist several stakeholders, below follows a brief introduction to each and how they have affected the project.

Chalmers University of Technology is the university at which the thesis has been conducted. They have also supplied the project with hardware and supervision. The robot was acquired from the Department of Applied Information Technology at Lindholmen together with some necessary additional equipment. They have also contributed with supervision from both the general coordinators as well as a specific supervisor for the project.

During the initial phase of the project, various researchers were contacted. Erik Billing from the team behind the DREAM project helped the project with critical knowledge on how to start implementing the robot and shared some information from his previous experience working with NAO. Prof. E. Billstedt at Gillberg Neuropsychiatry Centre helped the group with a medical view on both the planning and the results throughout the duration of the project. She contributed with critical insights on how the children could react to different parts of the session and was the only way the session could be validated. Additionally, to get started with a basis of information about the disorder, the project consulted the local Autism and Asperger

Association and talked to Anne Lönnermark.

Using a questionnaire, the group was able to get closer to the targeted audience by getting information from their relatives. These answers contributed to a general view on how a session like the one created would be received in practice. This was an important step when making design choices.

Lastly, children relevant to the scope have indirectly, through their relatives and a medical expert, contributed with a large amount of information that has been valuable when designing the session. In particular to the choices that have been made to adapt the session into something that would be found as motivating, interesting and educational. They were also considered in large throughout the ethical analysis and design choices with the robot.

1.4 Restrictions

Children with ASD tend to have a greater developmental impact from therapy in early age [9]; hence, it was decided in consultation with Prof. E. Billstedt that the project would be restricted to the age-span of four to six years. The tasks could then be developed to suit the specific age-span perfectly. The project is also restricted to children that have a language level where at least four to five-word utterances are used. It was also advised, by Prof. E. Billstedt, to not specify a certain variation of ASD as a restriction. Doing that does not seem reasonable, due to the span of the spectrum; rather, any child diagnosed with ASD should be included, as long as they are verbal.

There are multiple reasons for why the final session is not tested on children. For instance, finding children diagnosed with ASD, to perform tests with, and getting their parents approval is too time-consuming. Less than one percent of children in the specified age are diagnosed with ASD, and there are very few preschools in Gothenburg specifically for children with ASD [10]. Another reason is that knowledge about how a child with ASD acts is needed to be able to interpret if the robot-based therapy is working. Since the professional's time, as well as the group's knowledge, is limited, extensive tests with children prove difficult. Additionally, due to the circumstances of COVID-19 epidemic outbreak during the project, evaluation with children was not a possibility.

NAO has a varied set of available languages, including Swedish. However, the standard built-in and only available language, without making additional purchases, is English. Due to this limitation, the language used in this project is English. This is also one of the reasons why no testing with children was done. Finding English speaking children with ASD, in the restricted age group, in Sweden is a task too difficult for the scope of this project.

The final result of the project is a proposal consisting of a set of tasks to be used in a therapy session, which is discussed with a medical expert regarding its potential

as an educational tool for children with ASD. Since the developed session is not able to be tested on children, test cases with a medical expert are needed to verify if it is suitable and does not affect the children in any negative way.

Therapy sessions for children with ASD, where robots are used, can be developed with the focus on several different objectives, such as making contact and imitation. Since the project's time was limited, a restriction of the project's focus area was determined. The given table in *"Mapping Robots to Therapy and Educational Objectives for Children with Autism Spectrum Disorder"*, as seen in Appendix A, provides an overview of ASD's different objectives and domains and how they have been covered by different therapy robots [4]. During the initial research investigations, the table was used as a starting point. Objectives could then be eliminated with different motivations, such as lack of knowledge to complete a reasonable solution or that the objectives had already successfully been implemented on a NAO. The project was finally restricted to the objectives *"Learn to choose and make decisions"* and *Awareness of feelings, wishes, behaviour, thoughts of others*, within the domain areas *"Preschool skills"* and *Social / Interpersonal interactions and relations*.

1.5 Ethical Issues

The focus of the project is children with ASD, hence one primary element was to try to consider all possible ethical issues from the beginning and throughout the project. One of the greatest obstacles and fears during the project was to offend people. Without the possibility to collaborate with both *The Autism and Asperger Association* and the medical expert Prof. E. Billstedt, there would have been difficulties feeling comfortable with the vocabulary of the project, as this was a new area for the group. By talking to two persons in the field, the information felt trustworthy, reliable, gave a great amount of knowledge and foundation to start developing the session. Since the project does not involve user tests with children, there is a small risk that the result is not optimised for them. Even though the medical expert, Prof. E. Billstedt, has great knowledge in the field, she is not able to fully represent the target group. Additionally, design choices may potentially be the result of biases within the group.

1.5.1 Vocabulary

The project's focus on ASD includes a great number of medical terms. The vocabulary of the subject should, therefore, be taken into consideration to prevent provocative dialogue and to avoid offending the participants of the project. To improve the used vocabulary, a great portion of research and reading on the subject was included early on. For instance, using the term 'neurotypical' instead of 'typically developed' does not imply that any development of the brain is typical. The term 'autism' is also avoided entirely, instead 'ASD' is used, since it is the term recommended by the Diagnostic and Statistical Manual of mental disorders [11]. Children who are diagnosed with ASD are never referred to as 'autistic' since their diagnosis should not define them as a person; rather, they are referred to as *having* ASD.

1.5.2 Integrity

It is important to consider protecting the individual's anonymity, confidentiality and integrity. As mentioned in Section 1.4, children are excluded from the test cases, however, the project's main target group is children. It is therefore very important to consider the children's integrity in the design of therapy sessions. All data collected from a questionnaire that was sent out in the project was anonymous, meaning it is not possible to connect the data with the actual person. More detailed answers were therefore expected since the questioned people are aware of the fact that they are anonymous. The interviews held with Anne Lönnermark and Prof. E. Billstedt have been conducted with their integrity in mind, and any conclusions drawn are published with their consent.

1.5.3 Long Term Consequences

As the report *"A Code of Ethics for the Human-Robot Interaction Profession"* mentions, strong bonds between the therapy-robot and child could be developed [12]. This bond could, for example, be so strong that the child would get affected by the separation that the development could go backwards and might even lead to negative results [12].

1.6 Thesis Outline

The report is divided into a total of six chapters. This chapter, *Introduction*, is followed by the second chapter named *Theory*, where the theory is presented about topics such as ASD and ASD therapy. The second chapter also contains guidelines for interaction design and information about the agile workflow and technology that was used in this project.

The process of creating the final result, from planning to implementing, is described in the third chapter, *Method*. The questionnaire is also described as well as how a medical expert continuously helped to improve the session.

The chapter *Result* presents the final session, including both the different tasks and the GUI. The final evaluation from the medical expert is presented as well as the result of the questionnaire.

The fifth chapter, *Discussion*, discusses the different results and how the project might be used in future work. How the virus COVID-19 affected the project is discussed as well as ethical aspects of the project. Lastly, in *Conclusion*, the project is summarised and reflected on.

2
Theory

Technology plays a significant role in today's society and it is used for many different purposes. There are various ways to use technology and it can be modified to fit and be interesting for all types of ages and functionalities.

According to WHO, globally one in 160 children are diagnosed with ASD [13]. Research is conducted around the world on how technology can be used in combination with children with ASD as a therapy to ease their everyday life [4].

A lot of children have a high interest in robots and several studies have shown that robots are especially beneficial when it comes to therapy for children with ASD [14]. For example, a robot never gets tired from repeating a sentence nor shows complex feelings and expressions as a human does, which makes it easier for a child with ASD to understand and communicate with a robot [15]. This chapter provides theory and facts about ASD, therapy methods and the technology used in this project.

2.1 Autism Spectrum Disorder

The definition of ASD is a developmental disorder and it may be noticed in a child as early as during their first three years of life [16]. Although the exact cause of ASD is yet to be found, scientists have limited it down to being caused by abnormal brain development [17]. ASD is characterised by a variety of deficits hindering social interactions, communication and language development amongst other things [7]. It is also important to note that ASD is a whole spectrum, just as the name suggests, which implies that the severity and occurrences of all the limitations vary throughout the spectrum [15].

Children with ASD may, as a result of their different deficits and personalities, can have completely different reactions to equal interventions. The main goal of the therapy programs that exist for children with ASD is to substantially help individuals increase their independence, along with helping them cope in a society that is constructed by and for neurotypical individuals [4]. It has been shown multiple times that early intervention and support for children with ASD have a large impact on the outcome of the therapy [9].

According to the Centers of Disease Control and Prevention (CDC), the prevalence of ASD is currently rising in terms of numbers of diagnosed children [18]. L. Wing

et al. argues that this rise is mainly due to changes in diagnostic criteria and better awareness [19]. Regardless of what the reason for the rise in prevalence is, it results in a need for facilitating therapy and supporting therapists in their work with children with ASD [19].

2.2 Diagnostic and Statistical Manual of Mental Disorders

Diagnostic and Statistical Manual of Mental Disorders (DSM) is one of two handbooks that are used internationally by ASD health care professionals [15], [20]. A list of diagnostic criteria is defined in DSM, which is used by clinicians when diagnosing people with ASD. The criteria are divided into A and B criteria, where all three criteria of A has to be met for the person to receive a diagnosis [20]. The person may have additional variations, which are defined in the B criteria, where at least one criteria have to be met [20].

Since new research is continuously conducted, DSM is regularly revised and new versions are released. DSM-5, which was published in 2013, is the most recent version and is, therefore, the one that is used today [20]. One major change since the previous version is that ASD is defined as a spectrum instead of sub-diagnoses for autism, which it was previously. Autistic Disorder, Asperger Syndrome, as well as some other disorders, are now a part of the same spectrum, instead of being separate diagnoses [20]. The spectrum is divided into three different levels of severity, which define how much support the person needs. The lowest level, ASD Level 1, is defined as requiring support whereas the highest level, ASD Level 3, is defined as requiring very substantial support and ASD Level 2 falls between those two [20].

2.3 ASD Therapy

There are many different types of therapy for people with ASD and there is no "one size fits all" solution that works for everyone. Therapy should, therefore, be tailored to suit every person's individual needs [21]. The spread on the spectrum can vary and some therapies work better for some parts of the spectrum than others. This section describes three types of therapy that are relatively common and reasonable for this project.

2.3.1 Occupational Therapy

Occupational therapy (OT) is used to improve an individual's overall success in all perspectives of life and for the person to become more independent [22]. OT focuses on self-care, learning strategies and play skills [22]. The therapist evaluates the individual's abilities, looks at different aspects of everyday life, and creates goals and strategies for the individual to strive towards [22]. These can be both fine motor skills, like writing and painting, as well as more basic functionality, such as eating

and using the bathroom [22]. OT is usually a session with a length between half an hour to one hour and the number of sessions per week depends on the individual [22].

2.3.2 Applied Behavioural Analysis

Applied Behavioural Analysis (ABA) is a behaviour and communication approach method which is one of the oldest therapy methods for children with ASD, according to the article written by L. J. Rudy [23]. The article mentions how the method is based on a reward and consequences system for specific actions where the idea is to support and encourage desired behaviours and modify undesired behaviours. ABA was first applied in 1987 by a behavioural psychologist, but have since then developed into many forms and replaced the consequences from punishment to withholding the rewards [23]. The article narrates how ABA can be used to educate simple and advanced behaviour such as sharing a toy or sitting still. It is nowadays used to develop all sorts of skills in children with ASD such as the ability to imitate, ability to make choices, and all sorts of learning about everyday and abstract ideas [23].

2.3.3 Robot-Assisted Therapy

Experimentation and research in the area of robot-assisted therapy have shown that the need for flexibility and individual adaptability in the design of the robot is paramount to the future of this field [24]. A. Sandygulova et al. pointed out the importance of making the robot attract a child's attention in order to extract value from the robot's presence in the therapy room [25]. They concluded that having interaction between a child and a robot which is adaptable to suit the preferences of the individual is of utmost importance.

2.4 Interaction Design

During the development of a therapy session, two separate user groups have to be designed towards: the practitioner, and the recipient. The practitioner role will mainly be played by medical experts or teachers in this project, while the recipient will be played by the child with ASD. The recipient will interact with a robot through the practitioner.

Usability in robot-assisted therapy is created through a good interaction design where the users and the primary objective is in focus [26]. The main goal for interaction design is, therefore, to make the users easily achieve the primary objective of the design with minimal effort and maximal engagement, this broad concept includes aspects from effectiveness to constraints [27].

To simplify interaction design Y. S. Teo writes, in the article "*What is Interaction Design?*", about a model called the five dimensions which have been established to facilitate what is included in the broad term [26]. In the article, it is written that the model includes five dimensions which should be taken into consideration while developing a user-friendly design. The first dimension discusses the use of

words [26]. Y. S. Teo writes about how using *words* in an interface can provide the user with the necessary information, however, it is important to not overwhelm the user. The second dimension, *visual representation*, is according to the article a dimension which gives the user knowledge through icons, images and illustration. This facilitates the interface for the user [26]. *Physical objects or space*, as stated in the article, is the third dimension and considers the user's environment while developing the design. Y. S. Teo expresses how the dimension takes into account how an interface should be created depending on, for example, the size of the design and other environmental impacts. The fourth dimension is *time*, which covers all aspects from how much time the user will spend on the design, to if the visuals will change over time [26]. Last but not least, the fifth dimension, *behaviour*, is referred to in the article as to how the design gives feedback to the user depending on their actions [26].

Each dimension has to be taken into consideration to design a good interaction interface and there are hundreds of design options and patterns to choose from [26]. J. Tidwell mentions several ideas in the book *"Designing Interfaces"* which could be combined and recombined in different shapes to create an intuitive and user-friendly interface [27]. J. Tidwell mentions, for example, the importance of a clear entry page, which intends to make it clear and easy for new users to use a page. She also remarks on other aspects, such as safe exploration and how the interface structure can give the user a positive or negative feeling. The interface should, therefore, be well developed with a clear flow which can be achieved with for example the Wizard pattern. By including a theme and base design throughout the interface, called a visual framework, it will be easier for the user to navigate and get acquainted with the interface [27].

In the book *"About Face: The Essentials of Interaction Design"*, Alan Cooper writes about how pliancy could facilitate the interaction between the user and interface [28]. Pliancy is used to let the interface give hints about possible interactions such as dynamic visual hinting. This could, for example, be changing the colour of a button while hovering it or giving a responsive hinting which is that the interface reacts and response when a button is clicked [28]. To make sure an interface is user-friendly it should be tested, optimally on the intended user group. A common test to do is cognitive walk-through where a list of specific tasks should be executed while summarising the encountered problems [29].

2.5 Agile Development Process

An agile workflow delivers value in an iterative process in different project management and software development teams [30]. Agile working highlights the employees' talent by being a flexible workplace and letting them choose what to work on as well as when and where [31]. By being a flexible workplace the goal is to bring out each employee's passion and talent and deliver good results [31]. An agile workflow does not consist of specific meetings and techniques, instead, each team set their own goal and focuses on each employee's increasing improvement and commitment to the short iterative processes [30].

With an agile workflow with iterative cycles, projects are divided into sections usually around two to four weeks [32]. The iterative cycles focus on delivering value and therefore focus on specific missions each cycle [31]. To achieve great value each iteration four aspects are covered, these are planning, execution, review and retrospect [32]. The iteration cycles within this project are called sprints.

2.6 NAO

The session created in this project was implemented in the robot NAO, created by SoftBank, that can be seen in Figure 2.1 [33]. It includes many different features which make the robot unique and used in various areas such as education and health care. With seven sensors, four speakers and microphones, speech recognition and two 2D cameras, NAO can do many things such as locate itself in a room, recognise shapes and interact with humans [34]. SoftBank Robotics has created an open platform for NAO which makes the robot easily programmable with new features. The open platform allows programmers to program in the languages Python, Java or C++ [34].

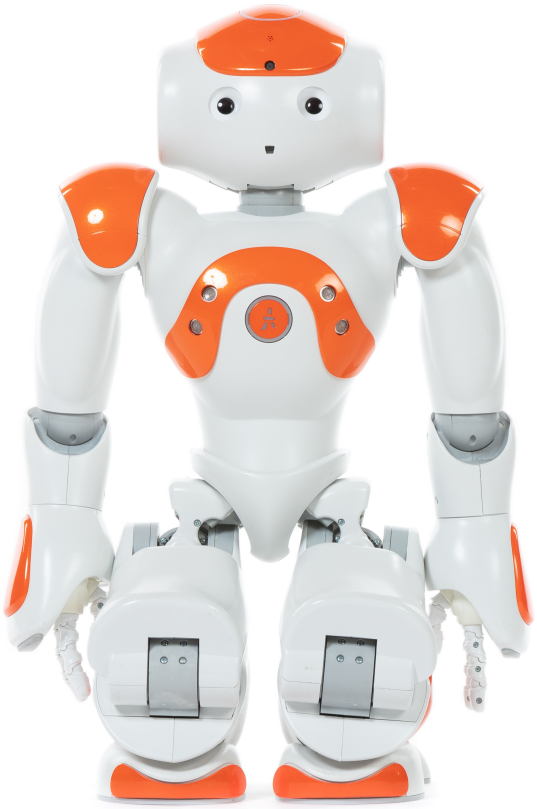

Figure 2.1: The NAO robot used in this project. Photo taken by the group.

2.7 Programming Languages

The programming languages that have been used throughout the project are Python, JavaScript, HTML and CSS. A description of each one is presented below.

The programming language Python is an interpreted high-level language [35]. It includes both functional and object-oriented programming amongst other forms of programming [35]. Due to the substantial amount of documentation and a multitude of features in the python standard library, a person with general programming skills can quickly start to develop applications.

The prototype-based scripting language Javascript is an object-orientated language that is weakly typed [36]. It is most commonly used in web-applications and on web pages. It allows for interactive behaviour on websites and is usually embedded or included within HTML-code [36].

HTML is a markup language for hypertext which together with a couple of other languages populates the majority of the web [37]. HTML allows for some customisation of the design on a web page. To be able to customise to a further extent CSS is used. CSS is a language that is used to state the presentation styling of a web page [38]. It is usually done through a styling template which states how the web page can or should be displayed.

2.8 Software

During the project various software have been used. Two pieces of software that have been vital throughout the entire project are Git and Lucidchart.

Lucidchart is a web page which can be used as a free tool to create visualisations such as diagrams to give a clearer perspective or view [39].

Git is a version handling software that facilitates the development of programming projects [40]. By using Git, multiple users can simultaneously work in the same files. This is usually hosted by a web hotel for source code sharing such as GitLab or GitHub.

3
Method

The project was divided into different phases where the focus was set on different parts of the project during each phase. Before the development of the session could start, relevant information had to be gathered, which was done during the planning stage. After all the necessary information was gathered, it was time for the main phase of the project, where the focus was set on developing the final solution.

This project was performed iteratively, taking inspiration from agile approaches to project management. Using an iterative process proved effective since there was no expectation regarding the correctness of the result during the initial phases of the project, as errors were identified early on and could be corrected during upcoming phases. This was important, especially since the group did not possess any previous knowledge nor experience from working with neither robots nor children with ASD.

3.1 Interaction Design Methods

In every aspect of the project the interaction between the user and the robot or GUI was considered. The choices made with regards to interaction design are presented within each section of the method.

A questionnaire was used as a way of understanding the needs and the attitude of the recipients. How the questionnaire was designed and what impact it had on the choices made, can be found in Sections 3.3 and 4.3.

During the project, a number of interviews were conducted as both usability tests and prototype reviews. This was used as a replacement for testing with children, since that proved to be a task too difficult. The interviews and reviews that were considered from an interaction design perspective are summarised and presented within the section of each respective sprint.

The five dimensions of interaction design were addressed to acquire the result and the final prototype. When designing the GUI, *visual representation* and *time* were the two large factors, meanwhile all of the five dimension where equal factors in the design of the session. In Sections 3.4.1, 3.4.2 and 3.4.3, design choices and how they each contributes to the dimensions are presented. Furthermore, the result of theses choices and the final prototype are presented in Chapter 4

Lastly a reflection of the methods used for interaction design along with future improvements and development is presented in Chapter 5 under Sections 5.2, 5.3, 5.4 and 5.5

3.2 Planning Phase

The first part of the project was the planning phase, where the main focus was to acquire information in the area of ASD and get a wider understanding of the subject. This was done by researching on the internet as well as establishing contact with experts in the area. *The Autism and Asperger Association* in Gothenburg was contacted for an interview, with hopes of getting a better general overview of ASD. A medical expert in the area of education and medical field was also contacted for interviews. The hope for both interviews was that they would contribute to creating a clearer picture of what was needed in therapy for children with ASD, as well as getting more information about the subject.

The contact with *The Autism and Asperger Association* and with a medical expert was also used to ask questions to help define the scope and restrictions for the project. Multiple discussions were held regarding whether children should be included in the user-tests or not. Communication was maintained throughout the project and the contacts were helpful at several stages during the project.

Information about robots and how they can be used in therapy for children with ASD, was also gathered. The group contacted Erik Billing, who worked with the DREAM project, to get further information about robots and their functionality. As the robot NAO was used in the DREAM project, it was decided that the same robot would be used in this. E. Billing has great knowledge about the specific robot used and could hence guide the group in how to best use it. Another major reason for choosing NAO was that it was the easiest for the group to borrow as well as that it includes many features.

3.3 Questionnaire

In order to better understand the attitude towards new technology and especially technology used in education and therapy, a questionnaire was created and shared in relevant communities. To avoid offending the participants, the questionnaire was sent to Anne Lönnermark at *The Autism and Asperger Association* for a review on how the questions had been phrased. The goal was to get as many responses as possible, both from people with a close relationship to children with ASD, as well as from people with a close relationship to neurotypical children. This questionnaire gave an understanding regarding if there is a difference in attitude amongst these two groups of people, specifically regarding their attitude towards technology. It also helped establish an idea of whether the solution developed in this project will be appreciated or not.

The questionnaire was divided into two sections, where the first section was more

general and could be answered by all respondents and the second one was aimed for the respondents that have a close relationship to children with ASD. Questions such as *What is your view on robots used as a tool in ASD therapy?* were not intended to be answered by people who do not have a close relationship to children with ASD and they could, therefore, skip the second part. Answers from people with close relationships to neurotypical children were crucial to get information on how the view on technology differs.

The section with questions regarding ASD also contained questions about therapy. Questions about how therapy works today and how it is perceived helped to get knowledge about the different ways a robot can be used to maximise the benefits of it. Feedback from a professional was taken into account when designing the questionnaire, in order to minimise the risk of offending participants and to make sure that all questions were relevant.

3.4 Sprints

The project was divided into three sprints to incrementally design the therapy session. At the end of each sprint, medical expert Prof. E. Billstedt was sent the current state of the tasks. She also received videos of the tasks implemented on NAO at the end of the second and third sprint. After having reviewed the information that was sent to her, Eva responded with feedback. The session was then adjusted in the following sprint based on the feedback, and the primary goal was to further develop the shortcomings of the previous sprint.

The focus of the first sprint was to use the information gathered during the planning to design a theoretical session. The model created in the first sprint included flowcharts that visualised the session. Implementation was the primary focus of the second sprint and the result of the first sprint was adjusted and implemented in the robot. The third and final sprint's focus was to refine the result from the previous sprints. The most significant change that was made during the third sprint was the development of the GUI, which was transformed into a web application.

3.4.1 First Sprint - Theory

The project's first sprint started by compiling the information gathered from the planning phase. With the data compound and with a great amount of theoretical background, the first draft of the session was created. The resulting session consisted of six tasks as well as a greeting and a goodbye routine. The session was finalised as flowcharts in Lucidchart after it had been discussed and evaluated.

When designing the session multiple choices were made with regards to the interaction between the child and the robot. The greeting routine was created with the intention of welcoming the child to the session to create a friendly environment. Therefore, an interactive part of the child high-fiving the robot was included. Finishing up the session, to leave the child with a good impression, was considered

equally important. Therefore the goodbye routine at the end of the session intended to make the session end in a positive way, rather than just finishing abruptly after completing the final task. Both of these routines are considered vital when addressing the child's behaviour towards NAO and the interaction within the session.

To make each task as educational as possible, responses were created that both were informative and rewarding for the child. Specifically when the child answers a question incorrectly, the robot's response allows the child to have a second try. If a second incorrect answer is given, the correct answer is given to educate the child before moving on to the next step of the session. In line with ABA therapy, a rewarding answer was given by NAO whenever the child answered the question correctly.

The six tasks included in the session were all created with different focus areas in mind. The intention of the first task was to teach the child to make a choice by selecting a coloured ball and placing it where NAO wanted it, as well as distinguishing the colour sought. A similar idea, but different setting, was applied in the second task were the child was intended to match a sound with an animal. The third task designed in the first sprint, intended to teach the child about animals by making the child choose which tail belonged to which animal. By presenting the child with coloured balls and pictures of animals these tasks were made prominently visual. The playfulness of the session was heavily considered when it was designed, hence making the tasks similar to that of other games children play when learning.

The tasks four to six were designed with the intention of teaching the child to recognise feelings in others. In the fourth task, the child is told a story of another child who is in a certain situation. The child is later asked to answer what they think the other child was feeling in the given situation. Task five and six are similar to each other as NAO presents the child with either a description of a feeling or a picture of a child expressing a feeling. The child is then asked to match this feeling to a picture of another child that expresses this mutual feeling. All of these tasks require the child to comprehend and recognise feelings.

With consultation of Prof. E. Billstedt the amount of time the child has to answer each question was selected to be 20 seconds. The motivation for this was to give the child time to think and at the same time not let the waiting time run for too long, since that could make the child lose interest in the session. This was also done with the consideration of the interaction design dimension: time.

The final draft of the session included flowcharts of greeting, goodbye and all six tasks suitable for the project's purpose. The draft, including additional relevant information about the session, was sent to Prof. E. Billstedt. The document is included in Appendix C.

The main focus during the first sprint was to create a draft of the session and in parallel, gather more information. The questionnaire was therefore shared in dif-

ferent social media platforms. The intention was to collect valuable data quickly by receiving as many responses as possible and the questionnaire was therefore shared early on in the project.

3.4.2 Second Sprint - Implementation

After finishing the first sprint there was enough theoretical background to be able to start the second sprint, the implementation. In this sprint, the main focus was on implementing the session on NAO, moreover, changes could be made to the session based on feedback from the previous sprint.

The feedback from Prof. E. Billstedt pinpointed the importance of including unambiguous images as well as the robot having a positive and clear dialogue. The feedback also shed light on how some tasks focused on following instructions, instead of the intended purpose of decision making. Therefore the tasks one through three, from the first sprint, were completely removed and three new tasks were added.

The tasks were placed in a different order in conjunction with the redesign of tasks one through three. This was mainly due to feedback received from Prof. E. Billstedt. The newly created tasks for the second sprint became task one, four and six. Meanwhile the fourth, fifth and sixth tasks of sprint one became the second sprint's tasks three, two and five respectively. This was mainly done to create a better flow for the session if the tasks were to be done in this specific order.

The new tasks, one and four, were remade based on the questionnaire. Even though the questionnaire was not yet closed, the result from the question *"Does the child have any specific interests?"*, was used as a theme in these two tasks to focus on the child's interest. The tasks were designed as decision making tasks with a subjective answer. Making the child choose between something that could not be categorised as correct or incorrect, made the tasks less of an instruction and more of a conscious choice compared to the previous iteration. The sixth task was created to make the child reflect upon their own feelings of the session and then answer with a feeling matching a child on a picture.

Changes to the robot's pronunciation were made in addition to reworking the three tasks, to stay in line with the intended purpose. This was done to get a more phonetically correct pronunciation, for example *cat* was changed to *caat*. Some of the pictures were also replaced based on the feedback, to eliminate the ambiguous pictures to achieve a good interaction between the child and the robot. The changed pictures are documented in Appendix D.

The software was the main focus of the second sprint, hence, a repository on GitHub was created. The implementation on NAO began using the programming language Python. The second sprint intended to make the robot talk and give instructions as well as being able to run a functional click-through session.

During this part of the project, a GUI was created, as seen in Figure 3.1 and 3.2, to facilitate the control of the session for a supervisor that is not familiar with running files in the command window. A simple GUI implementation was therefore created from the python library Tkinter [41]. It was created to help the supervisor navigate through the session. A select few features, e.g. choosing one of the options prompted, made the supervisor able to run the correct routine, based on the child's answers.

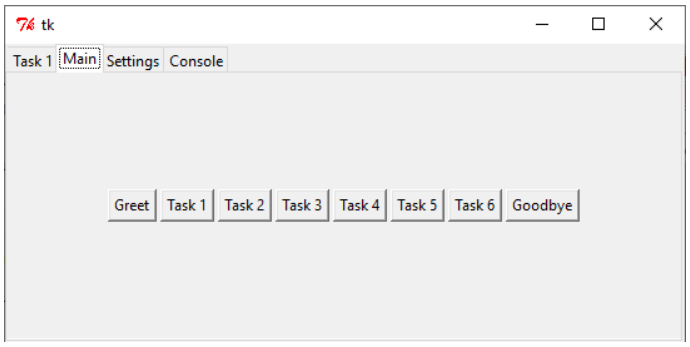

Figure 3.1: The GUI's main window cretaed with Tkinter. Each button opens a task tab in the top bar.

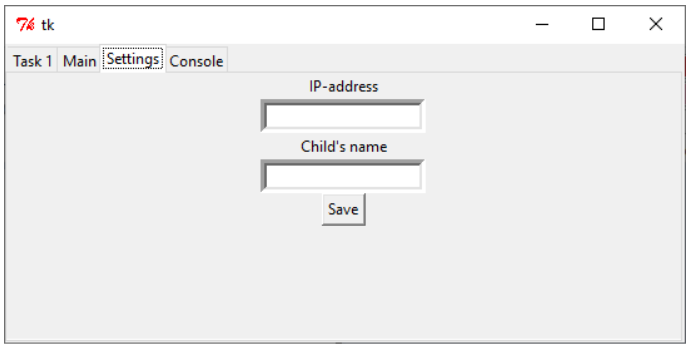

Figure 3.2: The GUI's settings window created using Tkinter. It contains two textbars for settings input.

At the end of this sprint, another user test was done with the medical expert to get a proper examination of the design, this time including NAO. The session with the robot was filmed and sent to the medical expert and the response was used to identify problems or possible improvements for the next sprint. The document sent to Prof. E. Billstedt is included in Appendix D and the movie is included in Appendix E.

3.4.3 Third Sprint - Refining

The third and final sprint focused on the feedback received from the medical expert regarding the second sprint. This feedback included small possible changes to the robot's speech but was overall positive about the result and improvement of the

session. The feedback also pointed out the importance of the third sprint's focus on implementing the robot's movements. During the third sprint, changes to the session was therefore done. Movements such as waving, pointing and giving a high five were implemented and improved for the final result. Minor adjustments were also done to the phrasing and pronunciation of the robot's speech. The finalised design with its changes and choices can be seen in Section 4.

The GUI was remade to make it easier for the supervisor to use it. Due to problems with extending and customising the GUI written in the previous sprint, a decision was made to explore options other than Python's Tkinter [41]. After weighing the pros and cons of a couple of alternatives, the group agreed upon rewriting the GUI as a web application. The primary reason for creating a web application was the endless customisation options that became available thanks to Javascript and CSS, allowing the creation of a more user-friendly and visually pleasing GUI.

The new GUI was created with the help of Pyramid, a Python web framework designed to enable quick creation of stable web applications [42]. Making the web application with Python made it compatible with the robot as the tasks were also written in Python.

The initial design only consisted of two pages, a start page and the main view where the user can start all the tasks. Because the GUI could be difficult to understand, a help page was added so that the user can get more information about the session easily accessible throughout the interface.

Since the goal was to create a more user-friendly interface, the importance of a clear entry page was taken into consideration while developing the start page. The entry page was made clear by only requesting necessary information, such as the child's name and the robot's IP address. This makes it easy for the supervisor to start the session, as well as provides confidence in the navigation. Other changes were also made to the interface to try to achieve good interaction design. Reflections and implementation were therefore made based on the five dimensions, pliancy and including a visual framework. A good interaction design with a flow and familiarity throughout the whole interface was aspired to be achieved through the different design principles and patterns as well as the model used.

At the end of the sprint, the resulting session was once again reviewed by a medical expert in order to acquire a final review of the solution. The session with NAO was filmed, both robot and GUI, and sent to the medical expert together with a similar document as in the first and second sprint. This document is included in Appendix F and the movie is included in Appendix G. A few days later a meeting with the medical expert, with discussions and review of the session and it is GUI, was held.

3.5 Finishing work

Some finishing work was done when all three sprints were completed and the medical expert, Prof. E. Billstedt, had given her feedback. Given this feedback, texts and information within the GUI were changed to achieve a higher level of usability for the supervisors.

The questionnaire was closed during the finishing work and the responses were put together. The responses were sorted according to the child's age as well as if the child has ASD or not. The primary focus laid on the responses where the child's age is between four and six years. The answers to the questions regarding the attitude towards technology used as teaching aids were compared between the two groups: relatives to children with ASD and relatives to children that do not have ASD.

4

Result

This chapter presents the result of the project and the final solution, including the developed session and GUI. The different parts of the result are presented within each section. Later in the chapter, the evaluation by Prof. E. Billstedt is summarised and finally, the answers to the questionnaire are presented.

4.1 Session

The session that was designed throughout the course of the project was finalised as a triadic session with NAO, the child, and a supervisor for the session. It contains a total of eight different parts where six are tasks, to be solved or played through, while the remaining two are there for greeting and saying goodbye to the child. The six tasks are split into two categories: interests and feelings. The interest tasks are mainly created to maintain the child's attention and keep the session fun. The tasks are therefore not ordered, meaning they can be run in any order. The tasks that concern feelings and are more educational are numbered in ascending difficulty meaning they should be run in the order that they are numbered.

The supervisor controls the flow of each different part but allows the interactions to mainly happen between the robot and the child. The session utilises a set of miscellaneous tools, such as toy vehicles, printed pictures and robot movements, to visually aid in the playing and educational tasks.

The session starts with NAO introducing itself and asking for the child's name. The supervisor then starts the first task. This first task is decided by the supervisor who is in full control of the order and selection of tasks. By being able to choose which tasks and the number of tasks that should be run, the supervisor can adapt the session to each child, to suit their needs within the session. A session ends with NAO saying goodbye to the child.

With the information gathered from the initial research and after consulting Prof. E. Billstedt the time of the session was chosen to be approximately eight minutes. She suggested that the average child with ASD is able to concentrate for about ten minutes. Selecting a slightly shorter period time was to maintain the child's attention throughout the whole session and not lose the focus towards the end.

4.1.1 Tasks

The intention of the first task, *1. Interest*, is to increase the child's ability to make a choice. The task also aims to make or keep the session interesting for the child, with a theme based on the child's favourite interest. In this project, the theme was chosen to be vehicles based on answers from the questionnaire. The task includes either toy vehicles or images of vehicles to activate several senses and the child is required to pick their favourite vehicle. The goal of the task is therefore to get the child to choose an answer, which one does not matter.

The second task, *2. Feeling*, instead focuses on trying to increase the child's ability to understand and recognise feelings by following instructions. The child is presented with images portraying different emotions and the task aims to get the child to distinguish a specific feeling. Task three, *3. Feeling*, has the same purpose as task two but requires a deeper understanding of feelings. The child first needs to identify a person's feeling based on a context and then apply it to one of the images in front of the child. The task is therefore quite similar to task two but the task also focuses on teaching the child to distinguish a person's feeling in a specific scenario.

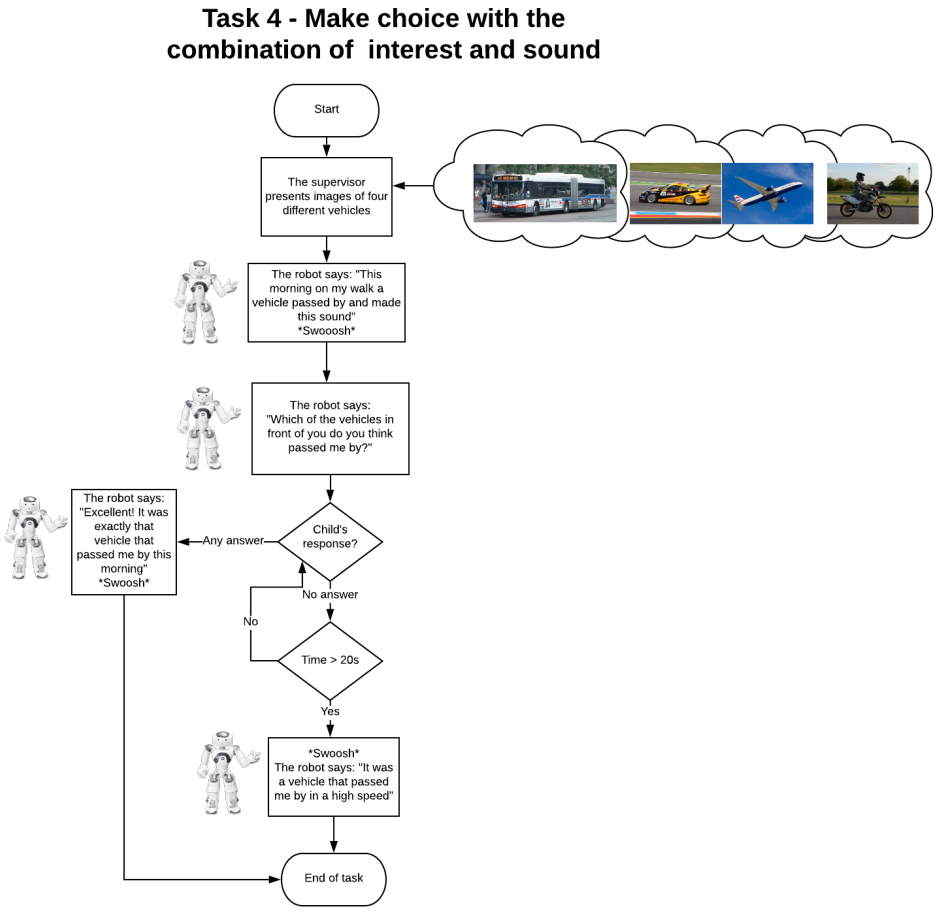

Figure 4.1: Flowchart of task four, *4. Interest*.
NAO robot, from [43] CC-BY. Bus, from [44] CC0. Car, from [45] CC-BY-SA, Airplane, from [46] CC0. Motorcycle, from [47] CC-BY.

Task four, *4. Interest*, aims to increase the child's interest in the session by including an interesting subject, such as vehicles, as well as teach the child to make choices. The task includes the sound of a vehicle to activate several senses and similar to task one all answers are correct, see Figure 4.1 for the flowchart of task 4. The goal of task four is therefore to keep the child's interest and make a choice. Task five, *5. Feeling*, instead focuses on increasing the child's ability to recognise feelings, similar to task two and three. Task five differs from the previous tasks by now trying to learn the child to distinguish a feeling from an image and connect it to one of the other presented images, see Figure 4.2 for the flowchart of task 5.

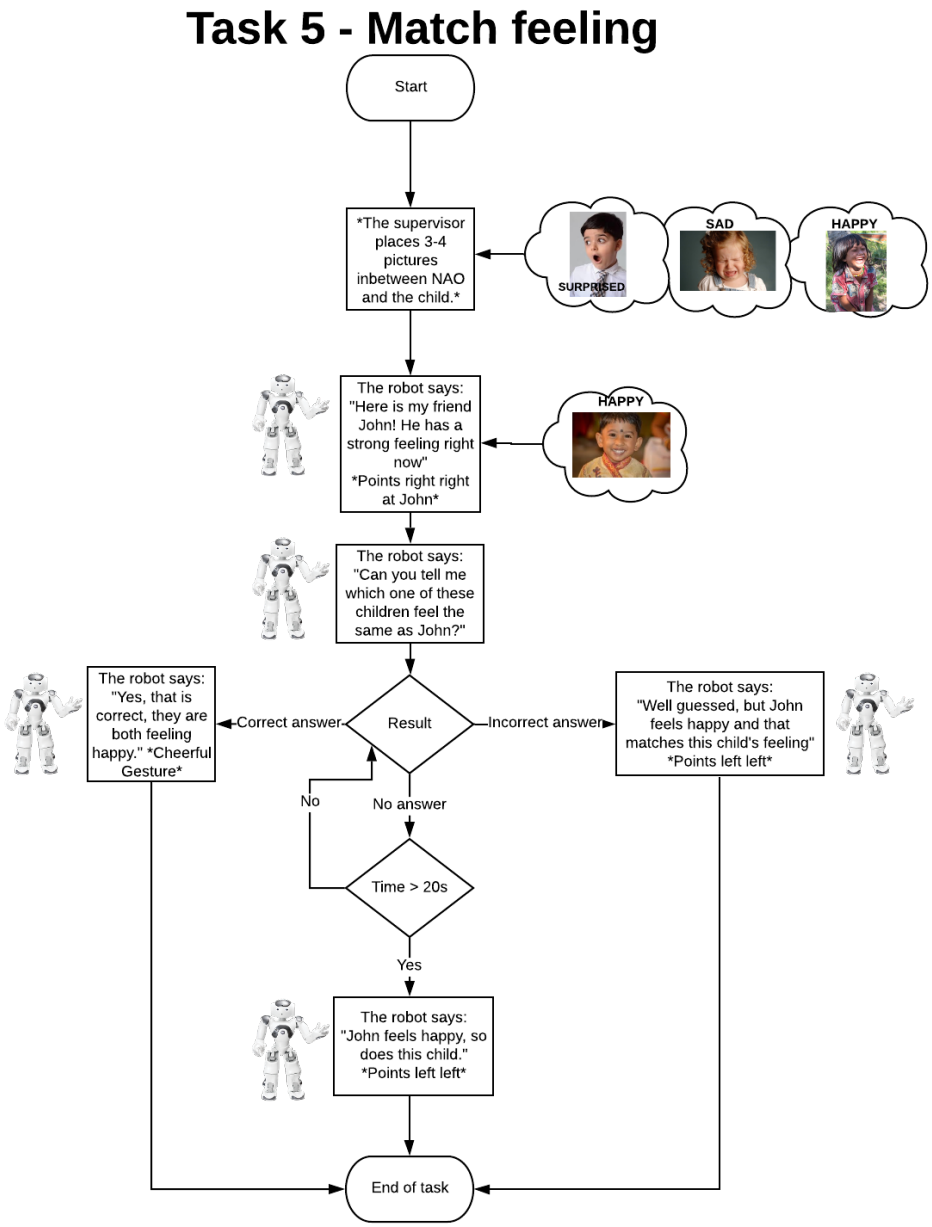

Figure 4.2: Flowchart of *5. Feeling*, task five.
NAO robot, from [43] CC-BY. Surprised child, from [48] CC0. Sad child, from [49] CC-BY. Happy child (top), from [50] CC-BY-SA. Happy child (buttom), from [51] CC0.

Lastly task six, *6. Feeling*, specifically focuses on recognising feelings. The task intends to learn the child to recognise its own feeling as well as distinguish which feeling, of the presented images in front of them, is the closest to its own. The child should therefore during this task be able to differentiate how feelings generally could be expressed as well as distinguish its own current feeling. The flowcharts of all the tasks can be seen in Appendix B.

4.1.2 Graphical User Interface

In this section, the supervisor will be referred to as the main user. To reduce the need for prior technical knowledge, the session is designed in a manner that makes it user-friendly. This was achieved by creating a web application as the interface. By making it as technically non-complicated as possible, the GUI aims to be accessible no matter what the user's technical skills are.

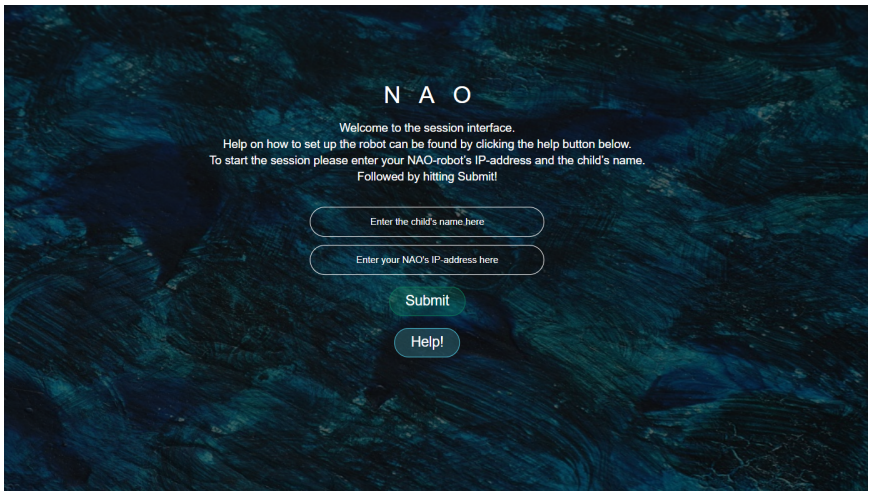

Figure 4.3: First page of GUI. Text-boxes for entering the robot's IP-address and child's name

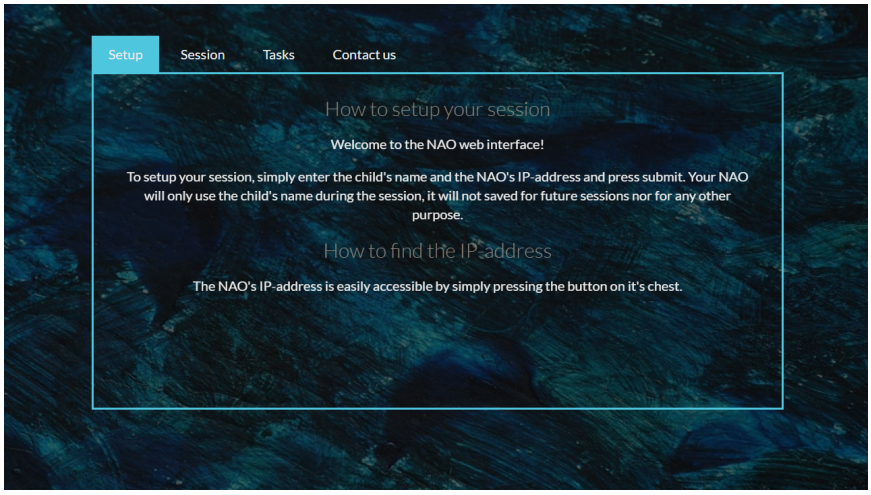

Figure 4.4: Help page that gives information about topics such as the setup, session and tasks

The final iteration of the interface consists of a starting screen where the user is prompted to enter the robot's IP-address and the child's name, as illustrated in Figure 4.3. A help page, where the user can get information on how to run the session, can be seen in Figure 4.4. Lastly, there is also a main page, where all the tasks can be found and started, which is illustrated in Figure 4.5. While progressing through a task the user gets prompted with questions as to what the child has replied to the robot, this can be seen in Figure 4.6. This way the interaction with the interface is kept simple for the supervisor and they can focus more on evaluating the child's interaction with the robot.

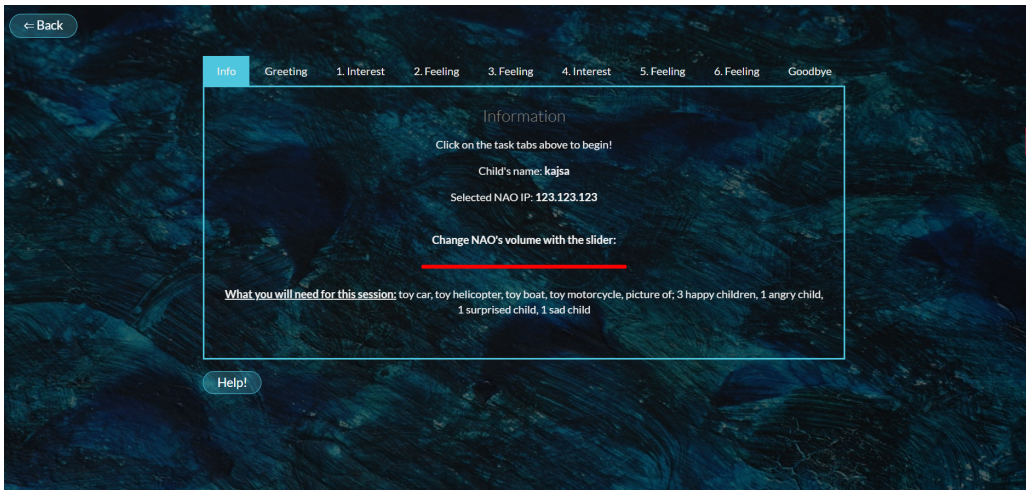

Figure 4.5: Main page that appears when connected to NAO.

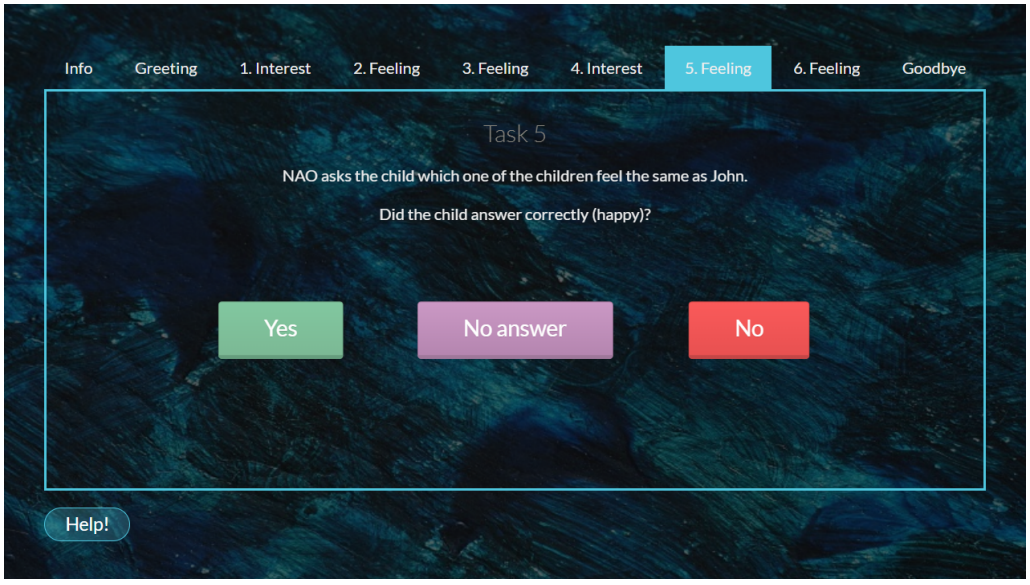

Figure 4.6: Example of a prompted questions in the GUI.

A simple and intuitive application was a core design parameter when building the interface, hence facilitating the usage for any supervisor both technically and non-technically skilled.

4.2 Evaluation by the Medical Expert

When the resulting session and the accompanying GUI was finished, it was evaluated together with Prof. E. Billstedt in an online meeting. Her overall impression of the session was positive. She felt that the GUI at some places lacked information that would be beneficial for the supervisor. Information on how to prepare for the session as well as informative instructions along the way would be helpful. When asked about the tasks' features: movement, speech and visual aids, she replied that although it is hard to know what the reaction of each child is going to be, her overall expression was that the features were sufficient and balanced. She expressed that she thought every task would suit every individual differently and hence thought that the mix of different tasks was a strength within the session. She pointed out that even though testing the session on children is outside the scope of the project, it would be the next step towards future development.

There were some features that she would like to add to the session and the GUI, for example the possibility of storing previous session data on the child was one of her suggestions. She believed this change would help the supervisor trace the child's progress in between sessions. It also allows the supervisor to structure sessions with several children. She also suggested that extra information about the tasks would be presented earlier in the GUI for the supervisor to better prepare. Lastly, she would have wanted some more information as to how much the supervisor should participate in the session.

4.3 Questionnaire

A total of 67 people responded in the questionnaire, but unfortunately most of the responses were given by people in close relationship to children over the age of ten. 16 responses concerned children in the age between four and six, which is the restricted age group for this project. Out of these 16 responses, seven were concerning children who have been diagnosed with ASD and nine concerned children who have not been diagnosed. Worth mentioning is that children who are currently being evaluated for ASD are classified as not diagnosed with ASD.

Some of the questions aimed to be answered by both people in close relationship with children diagnosed with ASD and children who have not been diagnosed with ASD are listed in Table 4.1 along with the average and median result of the answers. The optional values of answers ranged from one to five for all questions, with five being a positive attitude towards technology used and one being a negative. The last question, *How long can the child focus on a specific task?*, however, has a different structure. The options for that question was divided into intervals, ranging from "less than five minutes", to "more than one hour".

	Child diagnosed with ASD		Child not diagnosed with ASD	
Question	**Average**	**Median**	**Average**	**Median**
What is the child's attitude toward technology?	5	5	4,22	4
What is your attitude toward technology?	4,57	5	3,88	4
What is your attitude toward technology used as an aid in preschool/school?	4,57	5	3,55	4
How long can the child focus on a specific task?	-	5-10 min	-	15-30 min

Table 4.1: Result of some of the questions from the questionnaire. The first three questions are answered with values ranging from one to five, negative to positive. The last question differs with answers within intervals; maximum of five minutes, five to ten minutes, ten to fifteen minutes, fifteen to thirty minutes, thirty minutes to one hour and more than one hour.

From the table, it is clear that children in the age of four to six years old are very interested in technology. Children with ASD seem to be especially interested as both the average and median for the question *What is the child's attitude towards technology?* were five, meaning that all people answering chose a five out of five. From the table, it is also possible to see that the attitude toward technology, as well as technology used as an aid in preschool or school, were given a higher number by people in close relationship to children diagnosed with ASD, than not diagnosed.

Another question that was asked to both groups was if the child has any specific interests. The people responding to the question had to answer using their own words, meaning that the answers received varied greatly, as no predefined options were given. Three different types of interests were, however, mentioned more than once. One of these interests was vehicles, or a specific type of vehicle, which was mentioned two times each for the two groups. The other two interests were music, which was mentioned three times by people in close relationship to children with ASD, and superheroes, which was mentioned two times by the group concerning children who have not been diagnosed with ASD.

More specific questions regarding ASD and ASD therapy were asked in the second part of the questionnaire, which only was intended for the people in close relationship to children diagnosed with ASD. Two questions, *Have you heard of robot-assisted therapy for children with ASD?* and *Do you believe that robot-assisted therapy could be beneficial for children with ASD?*, were asked regarding robot-assisted therapy. Only 29% said that they had heard of robot-assisted therapy before, but everyone who answered the question believed that it would either beneficial to some degree or very beneficial.

5
Discussion

This chapter provides a discussion regarding the final results, methodologies used, and reflections from the group concerning what worked and what could have been done differently. The result from the questionnaire is discussed as well as potential future work. How the virus COVID-19 affected the project and changed the way the group worked is also discussed.

5.1 Session

Even though the final result of the session was expected, there are different parts that can be improved and added to generate an even better session. For example, everything that NAO says and does, such as movements and speech, are predetermined. Even though NAO can answer differently depending on the child's response, NAO can not answer something else than what is programmed. The focus during this project has been to increase interaction skills for children with ASD using NAO's movements and speech, as previously mentioned. However, adding other features to the session could further improve the interaction.

The NAO robot has built-in functionality, for example, it is able to tell if the child is looking at a specific spot. This functionality is not used in the session created in this project, however, that would definitely make the session more autonomous and self-assisted. Another built-in functionality is that NAO is able to grip objects. This would mean that if a specific task requires items, such as toy vehicles or pictures, NAO would be able to place these in front of the child, instead of the supervisor. Both of these two examples would improve the session in terms of making it more autonomous and easy-going and it would additionally result in less involvement in the session for the supervisor.

Another aspect to be taken into consideration, regarding the session, is the fact that some tasks of the final session have not been evaluated to the same extent as others. Since the process of reaching the final session was agile, some of the tasks were deleted and updated after the evaluations with Prof. E. Billstedt. Even though minor changes were done to improve the tasks for the last and final sprint, it would have been beneficial to have more evaluations and discussion of the tasks with Prof. E. Billstedt for further improvements.

A specific piece of feedback received from Prof. E. Billstedt was that she would

have wanted information before the session starts such as how involved the supervisor should be, or how autonomous the robot is. This aspect has not been in focus during the project since the thought was to have the full focus on the robot. The possibility to take advantage of the supervisor to be more involved in the session could be a possible upgrade in creating a more interactive session. To develop a session where the robot and supervisor complement each other could create a better atmosphere and overall impression. Therefore taking time to reflect on how the supervisor could be involved and what that could bring could be great in future work.

5.2 Graphical User Interface

The entire GUI was created during the last sprint, which resulted in little time to expand upon and improve, based on feedback. One proposed extension from Prof. E. Billstedt was to add some sort of journal system for keeping track of how well the session went for different children. This would be particularly useful for practitioners who work with multiple children.

Since the GUI is crucial in order to enable the session to be executed in the way it is designed, maybe more time should have been spent on developing it. Also, to optimally execute the proposed session with a child, the user has to be able to quickly react to the child's behaviour, which the GUI should support, or a lot of value could be lost from the developed session.

Ease of use was one of the primary focuses during the development of the GUI. The final version of the GUI has, according to the feedback that was received, achieved that. Unfortunately, none of that feedback came from people who would be the users of a solution like the one produced. This adds a lot of uncertainty about if the GUI is fulfilling its purpose or if major changes are needed. If more time was to be spent on the GUI and if the world was not in the middle of a global pandemic, a user test would be a good way to proceed.

One of the most internally discussed questions where whether to cater the GUI to advanced users or not. The current version of the GUI has a lot of helpful information and is almost fail-safe with buttons locked out when they are likely not supposed to be used. Hopefully, this will not annoy advanced users who regularly use the GUI. A possible improvement discussed was to have too beginner-friendly features enabled by default but also include settings to change the GUI into an advanced mode. Changing into the advanced mode would give the user complete control of the session.

5.3 Evaluation by the Medical Expert

Without collaboration with Prof. E. Billstedt, the project would have had difficulties moving forward due to the limited amount of knowledge. With the help of

her opinions and knowledge, great feedback and valuable information were given after each evaluation. For instance, after the first evaluation, a great amount of feedback was received based on the fact that half of the tasks did not focus on teaching the child decision making, rather; focusing on the child following instructions. Somehow the project had skewed towards focusing on a subject that was not included in the purpose or scope and got noticed in an early stage of the development due to the iterative review sessions. Without the outside perspective and collaboration with Prof. E. Billstedt, this could have been an aspect that would never have been noticed. The session would then have been developed with a focus outside the project's purpose and scope which would affect the result.

With newly acquired knowledge of the subject, sentences were attempted to be made clear and unambiguous. Still, some notes on how to improve the robot's speech were received from each evaluation. The robot's speech was therefore updated and adapted to fit the language level of children within the project's restrictions. This would have been difficult without the collaboration with Prof. E. Billstedt and her large amount of knowledge and experience in the matter.

The decision to set the duration of the session to eight minutes would have been difficult to decide in the early phase of the project without Prof. E. Billstedt. By being able to discuss the gathered information on the subject with an educated person in the field, it was easier to come to a well-founded decision. When the questionnaire later had been answered and evaluated the result of five to ten minutes showed that the decision made, to limit the session to approximately eight minutes, was a suitable restriction.

5.4 Testing

It is important to state that the resulting session has not been tested on the target audience and hence there might be aspects of the design that have not yet been handled. Although, by using the reviews from Prof. E. Billstedt with regards to the session, it can be argued that the project has arrived at a state which seems hopeful for commencing tests with children.

Additional improvements could have been done by evaluating with preschool teachers to validate that both the session and the GUI were accessible enough. Even though the GUI was tested by Prof. E. Billstedt and the project's supervisor, it could have been beneficial to get further perspective from people who are not as familiar with this technology as the members of the project group, since biases always exist when prior knowledge is present. Unfortunately, this became increasingly difficult due to the COVID-19 epidemic outbreak. Meeting in person was unrealistic and organising a meeting with preschool teachers in tools such as Zoom would not give a fair portrayal of both the session and the GUI.

5.5 Questionnaire

The number of answers received in the questionnaire was higher than initially anticipated, but unfortunately, the response rate was not as high in the age group four to six years. The questionnaire was posted in a Facebook group for people with ASD or relationship to people with ASD and most of the answers received from the people in close relationship to children with ASD were probably received from people in that group. More answers from that target group would have been beneficial, but due to the fact that a very small part of the population are diagnosed with ASD, it made it difficult to find people with a close relationship to children with ASD in that age.

The questionnaire was answered anonymously, meaning that no personal data, such as name, phone number, or email address was collected. This was important as the people who answered had to be able to feel secure in answering personal questions about children that they have a close relationship with. The result from the questionnaire has been presented as a summary of the answers in Table 4.1, to avoid specific answers to be shown.

The result from the questionnaire showed that the most common interest for children in the restricted age group is vehicles. Vehicles is also the interest that was chosen as the focus of two of the tasks in the session. The intention of these two tasks is to keep the session fun and interesting for the child so that the child does not lose their focus. Even though vehicles was the most common interest, it was not stated as an interest for all children. This proves the need for having several different tasks with different interests so that the child's interest can be matched.

Everyone that answered the questionnaire said that they believe that a robot could be helpful in ASD therapy. It is important that the developed session can be seen as helpful and meaningful. If the people in a close relationship with the children had not seen the therapy as positive, they would probably not have wanted the child to use it.

Conclusions could not be drawn from the answers to the other questions, as no trend could be found in the results. The results from these questions have therefore been excluded, as presenting individual answers has been avoided.

5.6 Future Work

The purpose of this project has been fulfilled and the result is a functional general session that can be tested as a method of therapy for children with ASD. However, the focus on this project has been to create a session that is usable and it has been restricted to exclude children. Therefore, the next step in the session's development would be to do user tests on children with ASD, to see if it can be used as a therapy and see if it can improve their skills in making decisions and recognise feelings.

There are parts that can be improved, for example, the specific interest chosen as an example in the session is *vehicles* and it was chosen because of the results from the questionnaire. However, it would have been beneficial to have many different alternatives of interests to choose from. Other interests mentioned in the questionnaire were, for example, music and superheroes. That would have made the session even more customisable for each child and would hopefully result in a greater interest in completing the session.

As previously mentioned, Prof. E. Billstedt discussed the possible demand and benefits of being able to save data from the different sessions. This is an important feature to implement, due to the advantages of being able to summarise the progress of each child, as well as to detect if e.g. one specific task is particularly difficult for some children. If this feature would be added there are several aspects that need to be taken into consideration and especially the ethical issues. Saving data about a child is something that should only be performed with the consent of the child's guardian before the session. Even though the feature could possibly counteract the involvement of some percipient, it would probably be worth it due to the improvement benefits that could be made from the gathered data.

5.7 COVID-19

Due to the COVID-19 epidemic outbreak, the project was affected, both regarding internal communication as well as the implementation of the project. The group meetings from week 13 to 23 were held online. By having the meetings online, through digital platforms, the communication got restricted. Through digital platforms, it is easy to talk over each other as well as not fully take part in conversations due to difficulties to know how and when to enter a conversation without talking over somebody. Besides the obstacles of having digital meetings, the group adapted to the situation well and tried to, as good as possible, have interactive meetings.

Retrospectively being able to meet the medical expert would have been more rewarding due to the restrictions of creating good communication digitally. The feedback from the second sprint was much more restricted compared to if we would have had the opportunity to meet in person. By meeting and showing the robot and session together, an improved communication could have been held, as well as receiving answers to questions that appear along the way. By preparing for a digital meeting with several questions the meeting with the medical expert gave a lot of feedback. The gathered feedback was useful and both the group's and the medical expert's questions were answered. However, if it had been possible to meet in person, it would have been more beneficial as communication is simply easier. By having a non-virtual meeting, gesticulation could have helped the communication. At the same time, the medical expert could have seen and touched the robot as well as tried different outcomes of the tasks. Nevertheless, due to the circumstances, the gathered feedback and collaboration went well and was informative and educative.

6
Conclusion

The project's primary purpose was to design a robot-assisted therapy session with a NAO to facilitate a certain set of skills in children with ASD. T he result of this project is a high-fidelity prototype of a finished session, which can be run by a supervisor through a web application that controls the NAO. This session could, in theory, be performed with a child, which is suggested as the next logical step in the session's development by the consulting medical expert Prof. E. Billstedt. Hence, it is hard to say whether the session facilitates any skills of the child, or not.

Secondarily, the questionnaire that was distributed to people with a close relation to children, with or without ASD, led to some interesting insights about robot-assisted therapy in practice. Conclusions were drawn from the result such as people with a close relation to children having a much more positive attitude towards using technology as an aid in school, as well as supporting the idea of robot-assisted ASD therapy. Hence, there is a desire of participating in this type of therapy, and if the session created in this project were to be developed further on, it certainly would be able to satisfy that demand.

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A

Mapping of ASD Domains

Summary table of the different robots covering different ASD domains and objectives.

Table 2 Overview of ASD domains and objectives (results from focus groups) with mapping of robots from literature

Domain	Objectives	ICF-CY code	Nao	Robota	Probo	KEEPON	Cat Robot	Isobot	Tito	GIPY-1	HOAP-3	KASPAR	Robot arm	PLeo	Ifbot	Labo-1
Communication	Orientation to listen	d115													●	
	Making contact	d3				●						●				
	Learn a new form of communication	d3														
	Understand intention of gesture	d3150														
	Understand intention of image / symbol	d3151 d3152														
	Understand intention of word	d310														
	Use gesture	d315														
	Use nonverbal abilities	d335													●	
	Talk – use verbal abilities	d330												●	●	
Social / Interpersonal interactions and relations	Imitation	d130	●	●				●			●		●			
	Attention	b140	●									●				
	Appropriately cope with own anger / sadness /…	d7202														
	Awareness of feelings, wishes, behaviour, thoughts of others	d7104			●		●									
	Appropriately react to behaviour of others	d7				●						●				
	Social routines (greet, say goodbye, introduce)	d72			●											
	Turn taking (behaviour)	d720		●								●				●
	Respect / value others (or things)	d71														
	Appropriate behaviour w.r.t. physical proximity / contact or personal space	d7										●				
	Collaboration / joint attention	b1403	●						●							
	Ask for help	d132														
	Conflict management	d175														
Self-care, independent living	Potty training	d53														
	Eating, drinking	d550 d560														
	(un)Dressing	d540														
	Self-care, personal hygiene	d5														
	Domestic skills	d6														
	Mobility	d4														
	Hobbies, leisure time	d920														
Play	Imitation	d130		●					●							●
	Develop interest in play	d8808														
	Development own play	d880				●				●						
	Parallel play (next to each other, same material)	d8802			●					●						
	Playing together – collaborative play	d8803	●									●				
	Variation in play (expand play)	d8808														
	Negotiate about rules	d8808														

Figure A.1

Table 2 continued

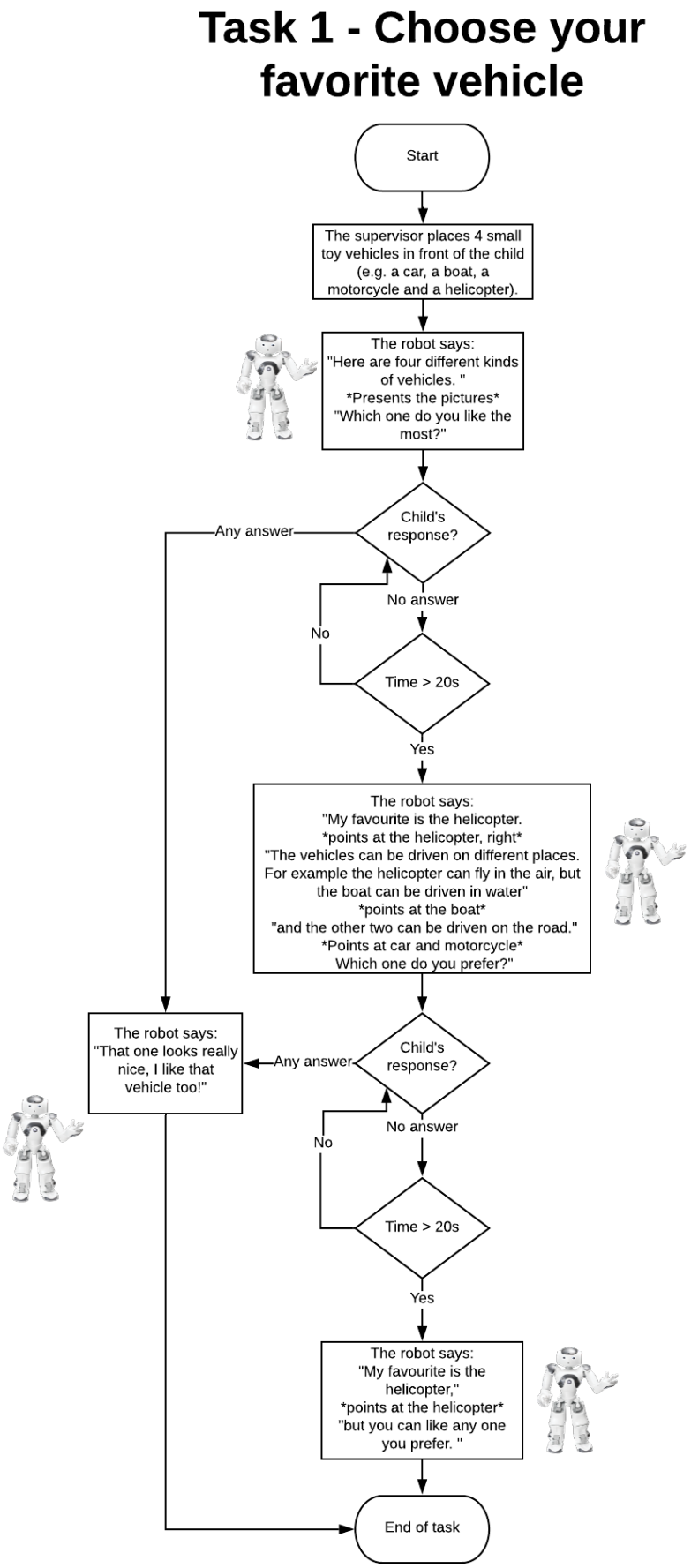
Domain	Objectives	ICF-CY code	Nao	Robota	Probo	KEEPON	Cat Robot	Isobot	Tito	GIPY-1	HOAP-3	KASPAR	Robot arm	PLeo	Ifbot	Labo-1
Emotional wellbeing	Recognise and regulate own emotions	b1520														
	Self-image, ASD awareness, who am I?	b1800										✓				
	Resilience (detect and guard limits, defend oneself)	b1268														
	Confidence, self esteem	b1266														
	Rest, relaxation	b152														
	Having fun, experiencing pleasure	d920														
	Safety	b152														
	Making thoughts positive	b1251														
Sensory experiences and coping	Adequate processing sensory triggers, regulate, stimulate	b156										✓				
	Understand what body is "saying" (pee, hunger, noises)	b2										✓				
	Change stereotype behaviour	b1250														
	Prevent panic reactions	b1521														
	Be able to postpone urge / want	b1304										✓				
Motor experiences and skills	Balance and equilibrium	b235														
	Body awareness	b260														
	Grove and fine motor skills	b7														
	Movement	d4														
	Coordination	b7		✓												
	Strengthening of muscles	b7306														
Preschool skills	Work posture (sit still, no wobbling)	d815														
	Train or practice skills	d155														
	Be able to start/stop independently	d210														
	Work on his/her own, task approach	d2102														
	Cope with schedule/programme	d198														
	Pose a question / ask for help	d815	✓													
	Distinguish main from minor issues	d198														
	Follow up instructions	d3102														
	Execute task (simple / complex task)	d2														
	Didactic subjects (e.g. maths, reading)	d820														
	Spatial concepts	b114														
	Learn to wait	d815														
	Perseverance	b1254														
	Learn to choose, make decisions	d177														
Functioning in daily reality	Cope with unexpected situations or changes	d2304														
	Flexibility, switch smoothly, less rigid	b1643				✓										
	Problem solving skills	d175														
	Taking initiative	d179									✓	✓				
	Transfer of skills / knowledge	d179														
	Open mind to tasting / eating food	b126														

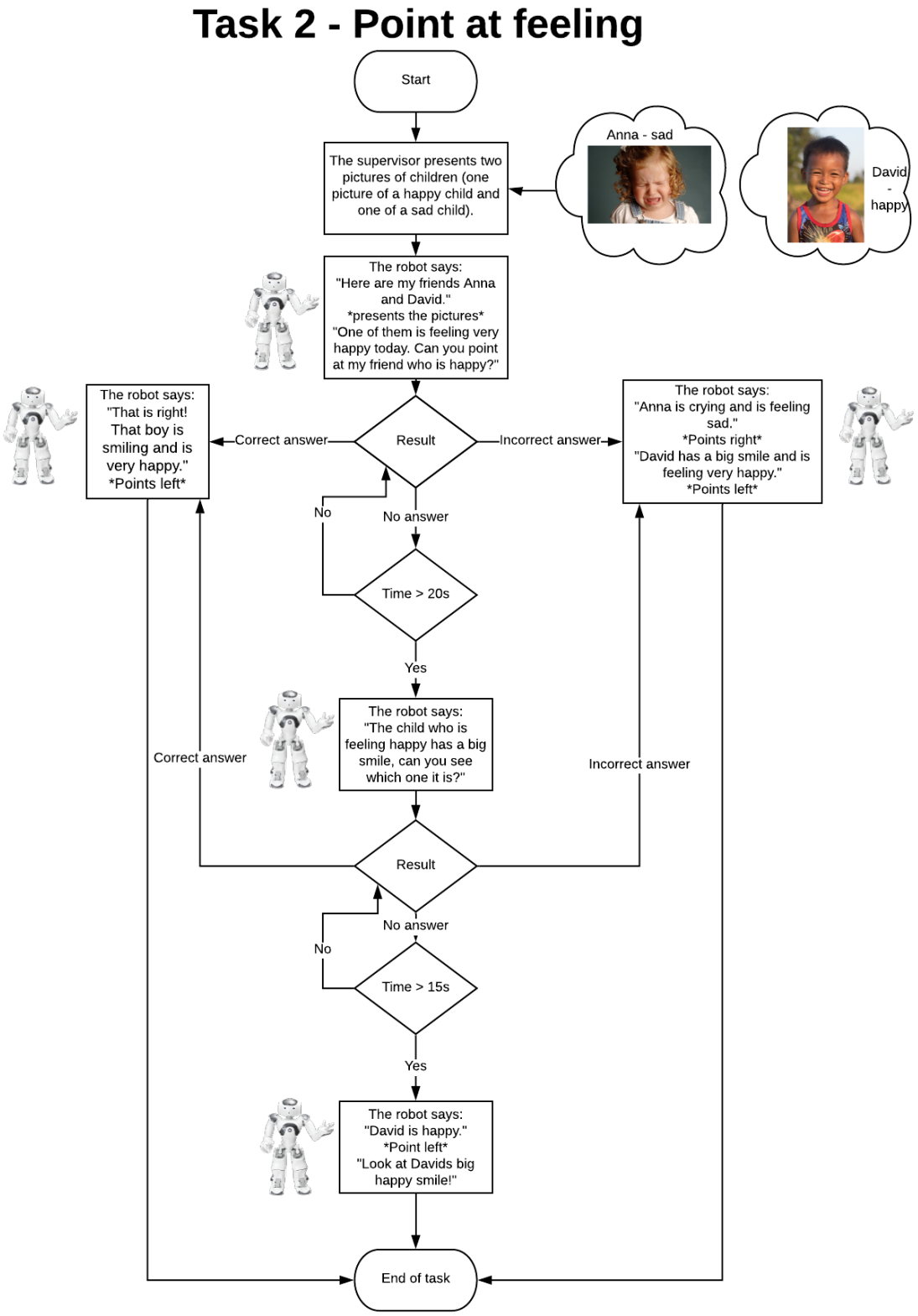
Figure A.2

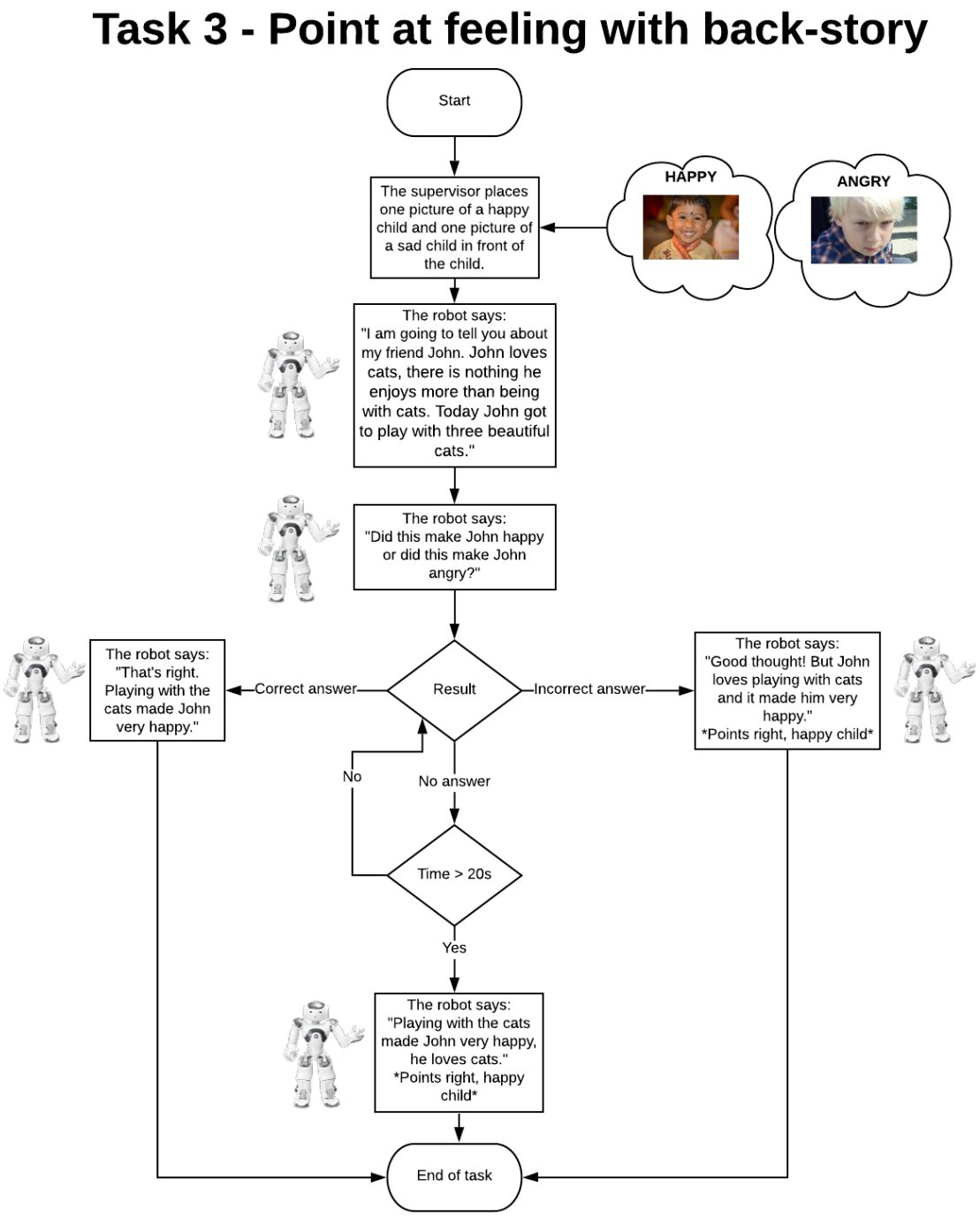
B

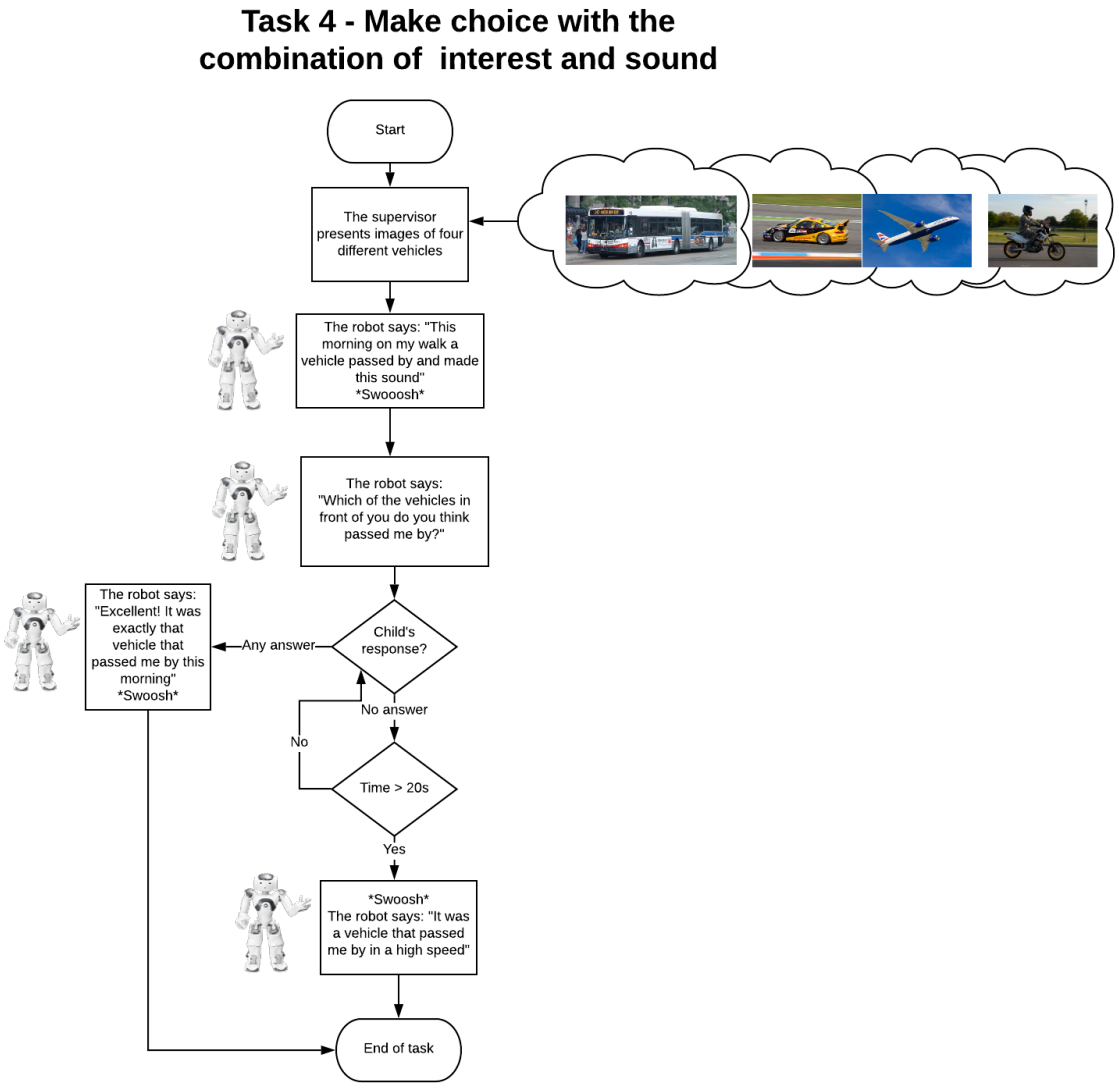
Flowcharts for the six created tasks

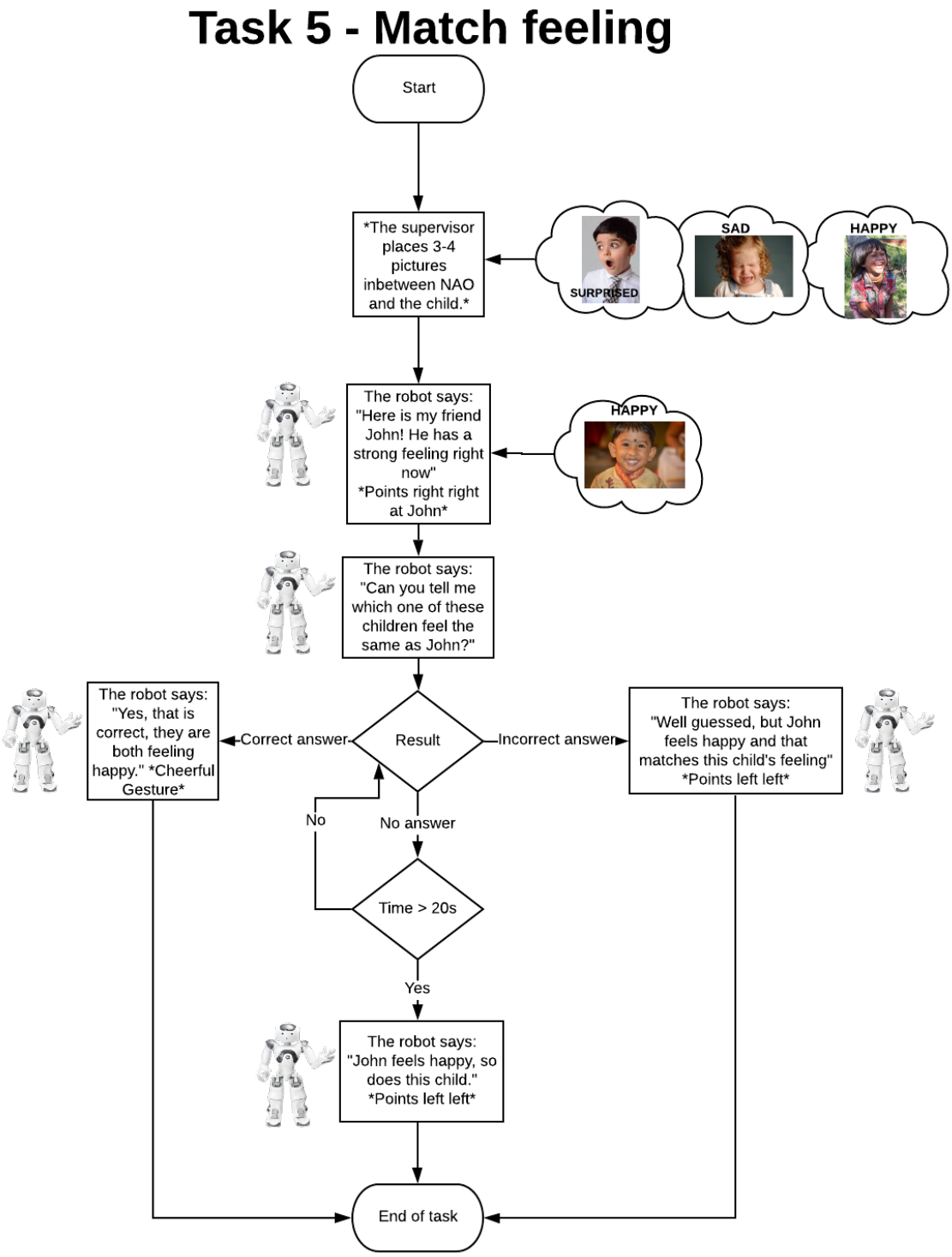
The developed sessions six tasks illustrated as flowcharts.

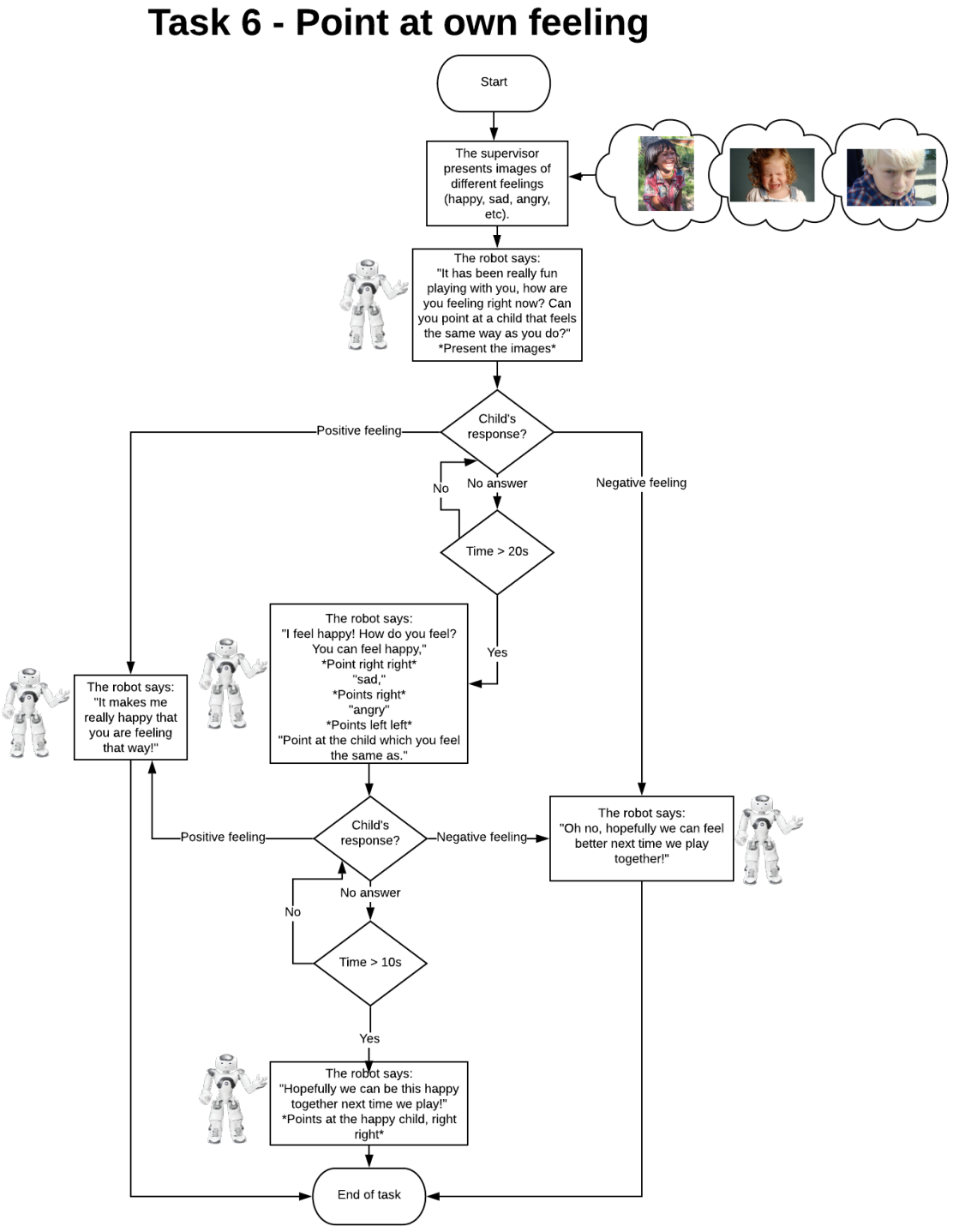

Task 1 - Choose your favorite vehicle
Start
The supervisor places 4 small toy vehicles in front of the child (e.g. a car, a boat, a motorcycle and a helicopter).
The robot says: "Here are four different kinds of vehicles. " *Presents the pictures* "Which one do you like the most?"
Child's response?
Any answer
No answer
No
Time > 20s
Yes
The robot says: "My favourite is the helicopter. *points at the helicopter, right* "The vehicles can be driven on different places. For example the helicopter can fly in the air, but the boat can be driven in water" *points at the boat* "and the other two can be driven on the road." *Points at car and motorcycle* Which one do you prefer?"
The robot says: "That one looks really nice, I like that vehicle too!"
Child's response?
Any answer
No answer
No
Time > 20s
Yes
The robot says: "My favourite is the helicopter," *points at the helicopter* "but you can like any one you prefer. "
End of task


Task 2 - Point at feeling
Start
The supervisor presents two pictures of children (one picture of a happy child and one of a sad child).
Anna - sad
David - happy
The robot says: "Here are my friends Anna and David." *presents the pictures* "One of them is feeling very happy today. Can you point at my friend who is happy?"
Result
Correct answer
Incorrect answer
No answer
No
Time > 20s
Yes
The robot says: "That is right! That boy is smiling and is very happy." *Points left*
The robot says: "Anna is crying and is feeling sad." *Points right* "David has a big smile and is feeling very happy." *Points left*
The robot says: "The child who is feeling happy has a big smile, can you see which one it is?"
Correct answer
Incorrect answer
Result
No answer
No
Time > 15s
Yes
The robot says: "David is happy." *Point left* "Look at Davids big happy smile!"
End of task


Task 3 - Point at feeling with back-story
Start
The supervisor places one picture of a happy child and one picture of a sad child in front of the child.
HAPPY
ANGRY
The robot says: "I am going to tell you about my friend John. John loves cats, there is nothing he enjoys more than being with cats. Today John got to play with three beautiful cats."
The robot says: "Did this make John happy or did this make John angry?"
Result
Correct answer
Incorrect answer
The robot says: "That's right. Playing with the cats made John very happy."
The robot says: "Good thought! But John loves playing with cats and it made him very happy." *Points right, happy child*
No
No answer
Time > 20s
Yes
The robot says: "Playing with the cats made John very happy, he loves cats." *Points right, happy child*
End of task


Task 4 - Make choice with the combination of interest and sound
Start
The supervisor presents images of four different vehicles
The robot says: "This morning on my walk a vehicle passed by and made this sound" *Swooosh*
The robot says: "Which of the vehicles in front of you do you think passed me by?"
Child's response?
Any answer
The robot says: "Excellent! It was exactly that vehicle that passed me by this morning" *Swoosh*
No answer
No
Time > 20s
Yes
Swoosh The robot says: "It was a vehicle that passed me by in a high speed"
End of task


Task 5 - Match feeling
Start
The supervisor places 3-4 pictures inbetween NAO and the child.
SURPRISED
SAD
HAPPY
The robot says: "Here is my friend John! He has a strong feeling right now" *Points right right at John*
HAPPY
The robot says: "Can you tell me which one of these children feel the same as John?"
Result
Correct answer
The robot says: "Yes, that is correct, they are both feeling happy." *Cheerful Gesture*
Incorrect answer
The robot says: "Well guessed, but John feels happy and that matches this child's feeling" *Points left left*
No answer
No
Time > 20s
Yes
The robot says: "John feels happy, so does this child." *Points left left*
End of task


Task 6 - Point at own feeling
Start
The supervisor presents images of different feelings (happy, sad, angry, etc).
The robot says: "It has been really fun playing with you, how are you feeling right now? Can you point at a child that feels the same way as you do?" *Present the images*
Child's response?
Positive feeling
Negative feeling
No answer
No
Time > 20s
Yes
The robot says: "I feel happy! How do you feel? You can feel happy," *Point right right* "sad," *Points right* "angry" *Points left left* "Point at the child which you feel the same as."
The robot says: "It makes me really happy that you are feeling that way!"
Child's response?
Positive feeling
Negative feeling
The robot says: "Oh no, hopefully we can feel better next time we play together!"
No answer
No
Time > 10s
Yes
The robot says: "Hopefully we can be this happy together next time we play!" *Points at the happy child, right right*
End of task

C

Documentation Sprint 1

Interaction Design for Autism Therapy with Robots for Preschool Children

Sprint 1: Process described with flow charts

Filip Andreasson, Pontus Backman, Kajsa Bjäräng,
Viktoria Enderstein, Simon Rogmalm Hornestedt, Ellen Widerstrand

Introduction

Robots are becoming increasingly common in everyday life around the world. One area where robots are used is between clinicians and preschool aged children with autism spectrum disorder(ASD). Research regarding interactive robots have been conducted in multiple projects and experiments around the world throughout the last two decades. One example of a project where this type of research has been conducted is DREAM [1]. The robots range from simple turn-taking robots used in games of tag to complex anthropomorphic robots capable of detecting emotions and showing empathy [2].

Sandygulova et al.[3] pointed out the importance of making the robot attract a child's attention in order to extract value from the robot's presence in the therapy room. Arriving at the conclusion that having an interaction between a child and a robot that is adaptable to suit the preferences of the individual is of utmost importance.

Hence, this project will focus on constructing and developing a session between a child and a NAO-robot. It will be restricted to children in the age between four to six years with ASD, who has the ability to form complete sentences. The focus will be to improve the child's ability to make decisions and distinguish emotions. The project will be divided into three sprints where the first sprint will give an example of the developed session visualised with flowcharts and additional text describing each part of the session. This document provides the draft from the first sprint and is presented below.

Purpose

The project aims to incrementally design the interaction within a therapy session for a child with ASD making use of a NAO-robot. The ability to make choices and recognising feelings in others is difficult for children with ASD. Hence the focus of the therapy session will be on making the robot facilitate learning in these areas with a set of different games or questions. By iterating over the design, the main goal is to end up with at least an embryo of a generalised design that could be tested in a real setting.

Scenario

The session is planned to take place in a room with a child, the robot and a therapist or other medical expert. The room should include two chairs and a table. Additionally to this, some of the tasks include other objects that has to be prepared before the session starts. A summary of everything needed for the session can be seen in figure 1. The therapist will be equipped with these necessary props before the session. The child will be sitting in front of the robot, which is placed on the table in a reachable distance and with the therapist sitting beside the child.

Props
Bowl
Three green balls
Three blue balls
Picture of cat
Picture of pig
Picture of pigtail
Three pictures of happy children
Picture of a sad child
Picture of a surprised child

Figure 1: Table of props needed for the session

Figure description

The flowcharts are all designed with the shapes in figure 2.

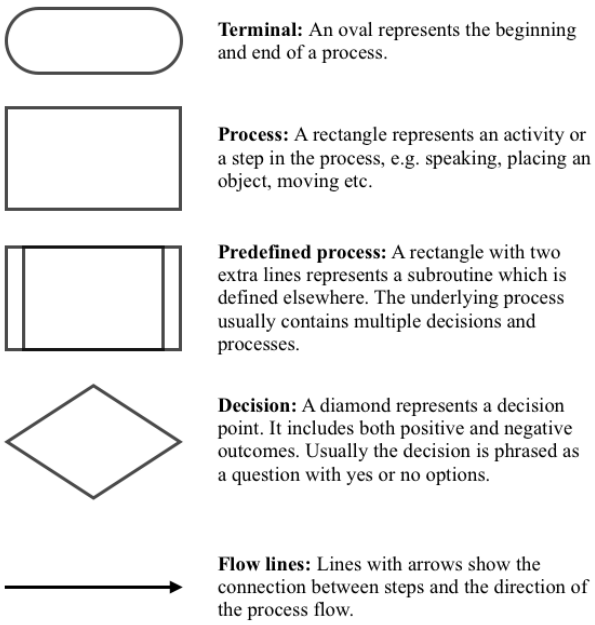


Figure 2: Description of the flowchart shapes

Thoughts regarding the tasks

- How many "fun" tasks should be used?
  - The main purpose is to increase the child's ability to recognise feelings and several tasks regarding feelings have therefore been added. How often should a more fun task be done (a task not involving recognising feelings)?

Overview

Figure 3 describes the flow of the full session. Following the flow chart we can see that the session starts with a greeting and introduction. Moving into a looping state where a number of tasks are to be completed. A check is made after each task to see if the child is still interested in the robot and the session. At any time during the session, the flow can be stopped by the child, signalling that he/she does not want to continue. The robot will eventually end the session in a social manner if the 8 minutes of the session has expired. Each and every sub-process of the session is described in the following sections.

The time of the session has been chosen with regards to previous research [3] where the group mean is 11 minutes. To avoid that the child starts losing interest by the end of the session we have made the choice of limiting our session to eight minutes.

The six tasks that are currently designed are split into two different categories: feelings (Task 4,5 and 6) and playful (Task 1, 2 and 3). All the tasks are made in an educational manner and can be picked in any combination or sequence to suit the child's individual preferences. Tasks within the category feelings have been created to, in different ways, teach the child to recognise, match or pair feelings. The primary focus of the playful tasks are to maintain an interest in the sessions, while still keeping the educational moment of having to choose the correct answer.

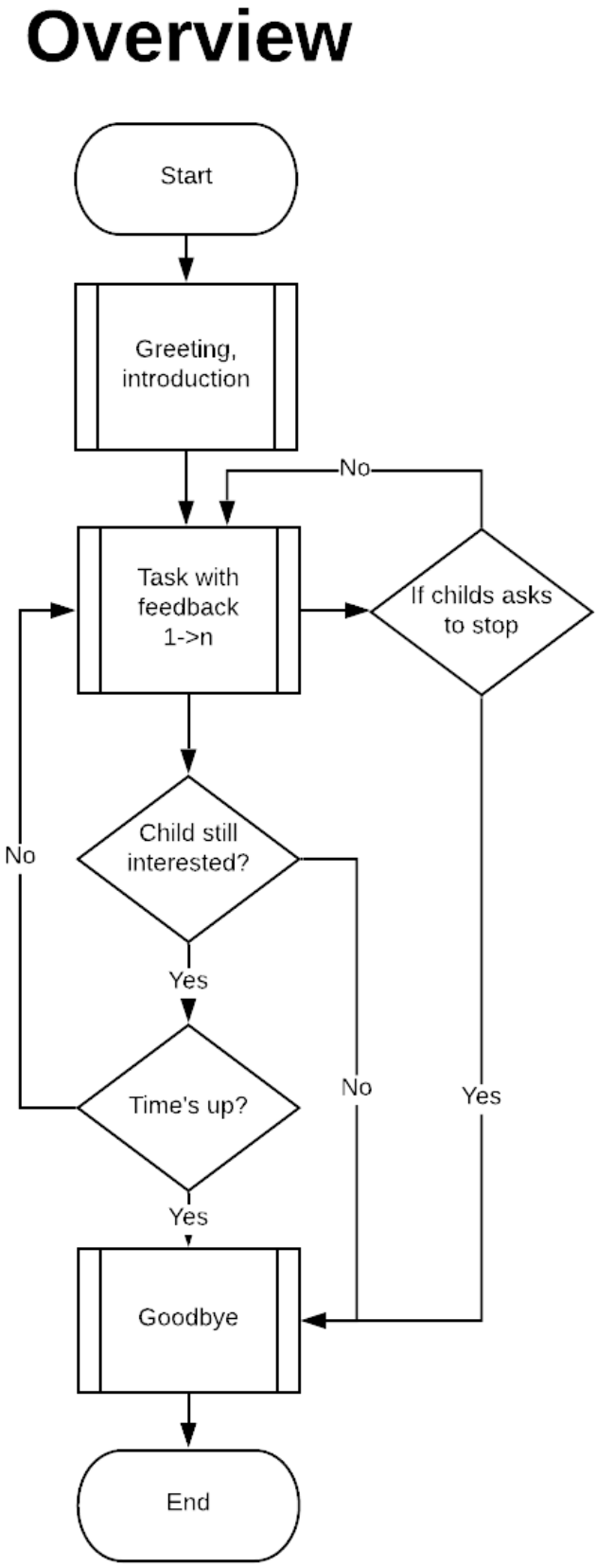


Figure 3: Overview flowchart

Greeting

Intention

The intention is to welcome the child to the session and inform him/her on what is going to happen and approximately how long.

Description of the sub-routine

The robot greets the child and introduces itself. It also interact with the child and asks for his/her name. If the child doesn't respond with a name within 10 seconds the robot continues with the introduction of the session. The robot tries to be positive and encouraging and attempts to give a high five before starting with the tasks.

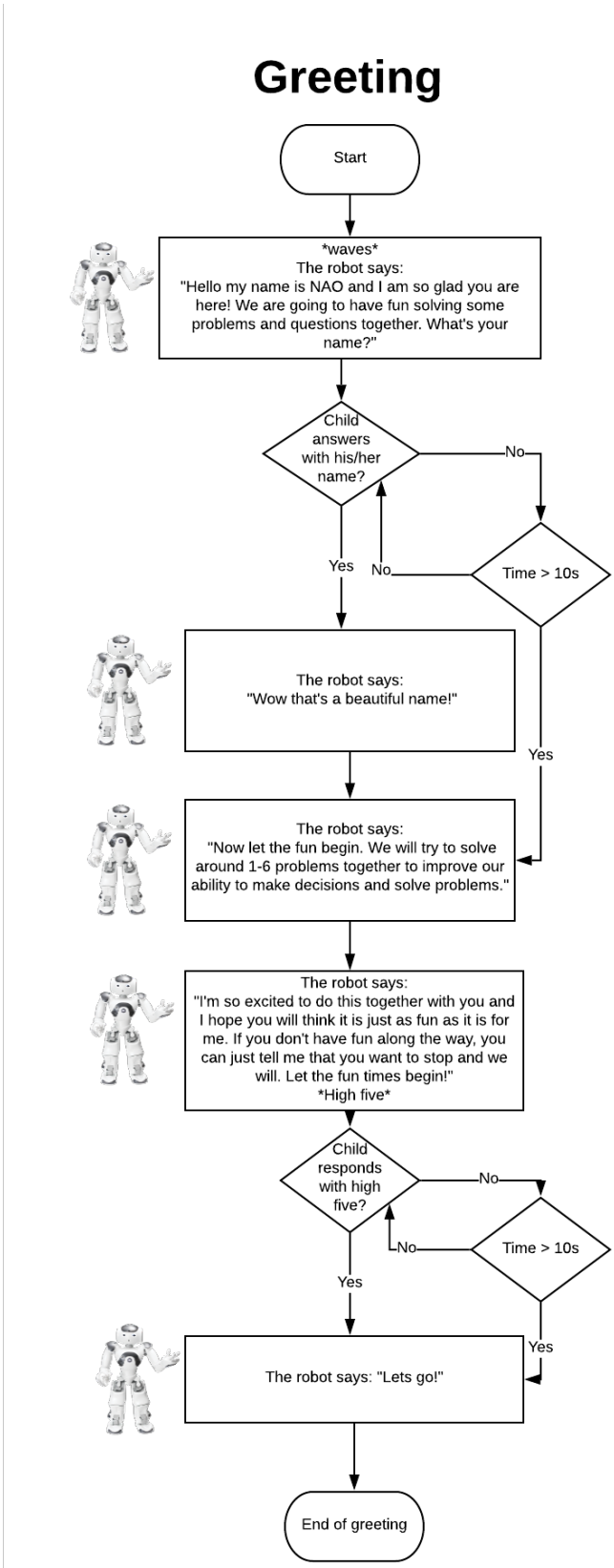


Figure 4: Greeting flowchart. NAO robot, from [4] CC-BY

Task 1

Intention of the task

For the child to succeed in this task they have to be able to differ between two colours and then make a conscious choice to place the correctly coloured balls in a bowl. Therefore the task should improve the child's ability to make choices and identify colours.

Description of the task

The robot starts this task by expressing its love for the colour green and green balls. Three green balls, three blue balls, and a bowl will then be placed in front of the child. The robot will then tell the child that it needs help with collecting all the green balls and that they should be placed in the bowl.

Child's response

After the robot is done explaining the task, 20 seconds are given to complete the task. If the child successfully places all green balls in the bowl before this time has passed, the robot will give positive feedback and the task will then end. If an incorrect answer or 20 seconds passes, the robot will help the child by placing one green ball in the bowl and then ask the child to place the other two green balls in the bowl. If the child now solves the task, positive feedback will be given before the task ends. Another incorrect answer or if 20 seconds passes again will generate additional feedback from the robot before the task ends.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct, incorrect or if the child did not answer.

Thoughts regarding the task

- Regarding the time limit for defining the answer as no answer:
  - Is 20 seconds a good time interval? Is it enough time for letting the child think?
  - This question regards all tasks. The same time interval has been used for all tasks.

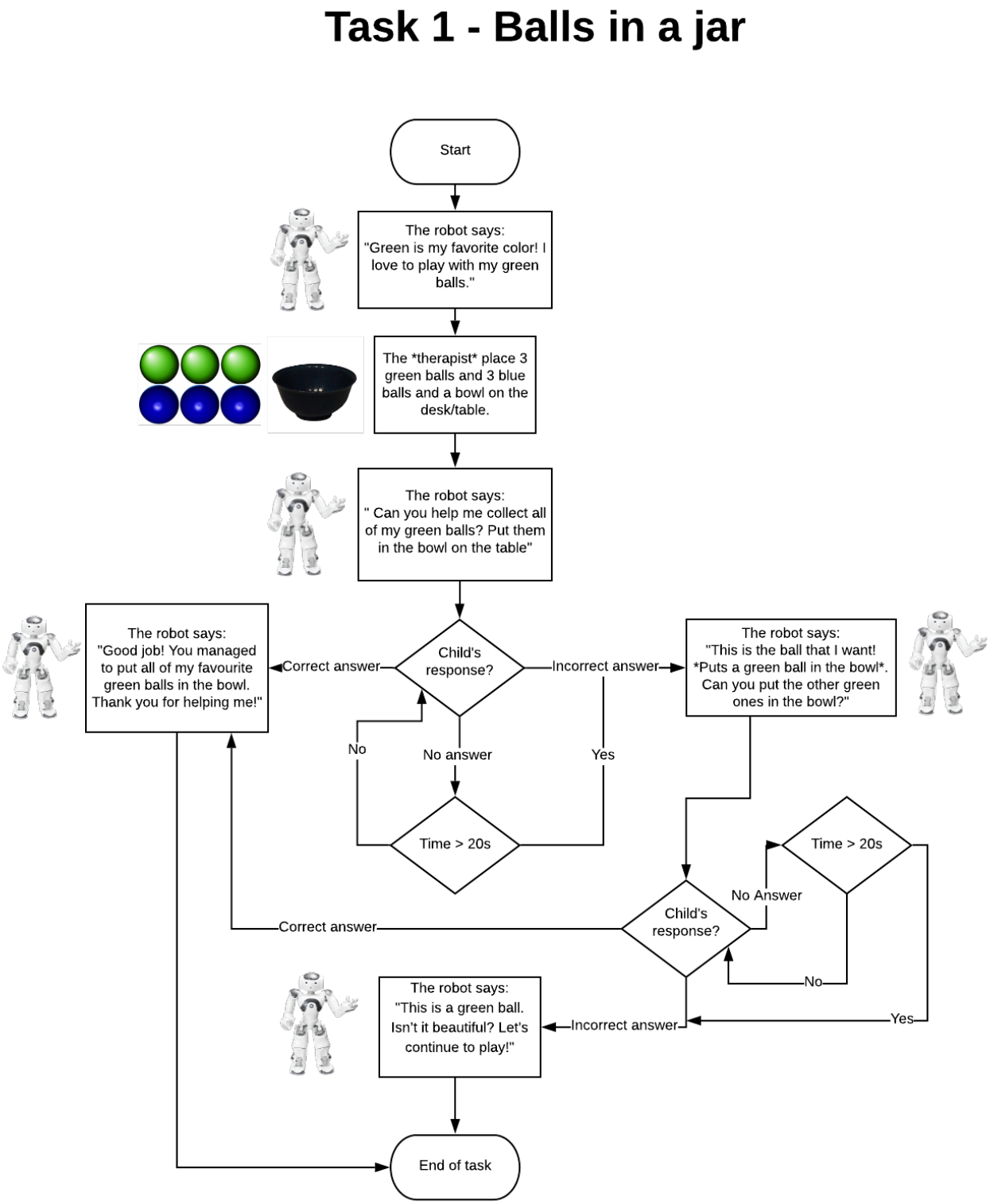


Figure 5: Task 1 flowchart. NAO robot, from [4] CC-BY. Blue balls, from [5] CC-0. Green balls, from [6] CC0. Bowl, from [7] CC-BY-SA.

Task 2

Intention of the task

The intention of task two is for the child to increase their skill in matching sound and animal with correct responding picture. The child has to identify what animal the robot is talking about and recognise the sound of the animal in question to be able to match it with the correct animal-pictures out of different ones in front of the child. The goal of this task is to increase the child's ability to learn to choose and match an animal's sound with the correct animal and identify it from the context of the story.

Description of the task

The task starts by the robot telling a story about the robots dog and playing the sound of a dog. The therapist places pictures of two different animals in front of the child. The task continues with the robot asking the child to point at the dog.

Child's response

If the child point towards the right animal the robot will give a correct answer. If the child child gives an incorrect answer, the robot will tell the child what animal he/she pointed towards and tell the child what answer is correct without point out that the child answered incorrectly. If the child doesn't respond within 20 seconds, the robot will tell the child which one is correct.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct, incorrect or if the child did not answer.

Thoughts regarding the task

- Regarding how to ask the child which animal it is:
  - Should the robot both say the animal's name (dog) and make a sound? Is it to hard if we only make the sound?
  - Is it better to first only name the animal and then play the sound if the child answers incorrectly/does not answer?
- Repeat the question with different animals?
  - If the child seems to enjoy the task, is it possible to repeat the question several times (with different animals)?
  - If it is repeated, should the task be repeated immediately or after a few other tasks?

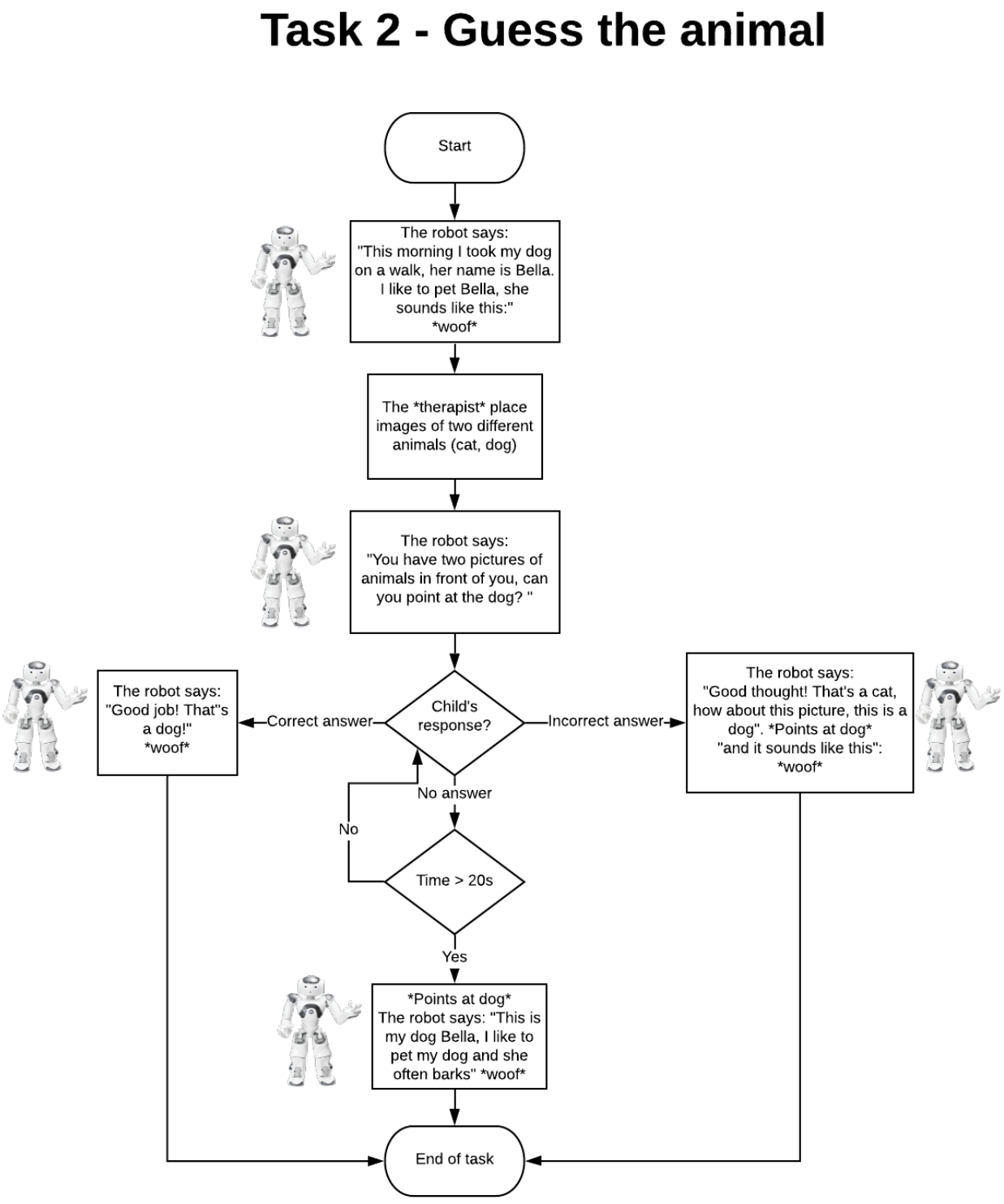


Figure 6: Task 2 flowchart. NAO robot, from [4] CC-BY

Task 3

Intention of the task

This task is supposed to teach the child about animals while also improving their ability to make choices.

Description of the task

Two images, one with a cat and one with a pig, will be placed in front of the child. The child will also be given one image with a pig tail. After the child has received the tail picture, the robot will ask the child if it can match the tail with the correct animal picture.

Child's response

After the robot is done explaining the task, 20 seconds are given to complete the task. If the child successfully matches the tail with the animal picture before this time has passed, the robot will give positive feedback and the task will then end. If an incorrect answer or 20 seconds passes, the robot will help the child by explaining that the tail looks the same as the pig's tail, pointing at the pig, and making pig sounds. If the child now solves the task, positive feedback will be given before the task ends. Another incorrect answer or if 10 seconds passes will generate additional feedback explaining that the tail should be matched with the pig picture, the task then ends.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct, incorrect or if the child did not answer.

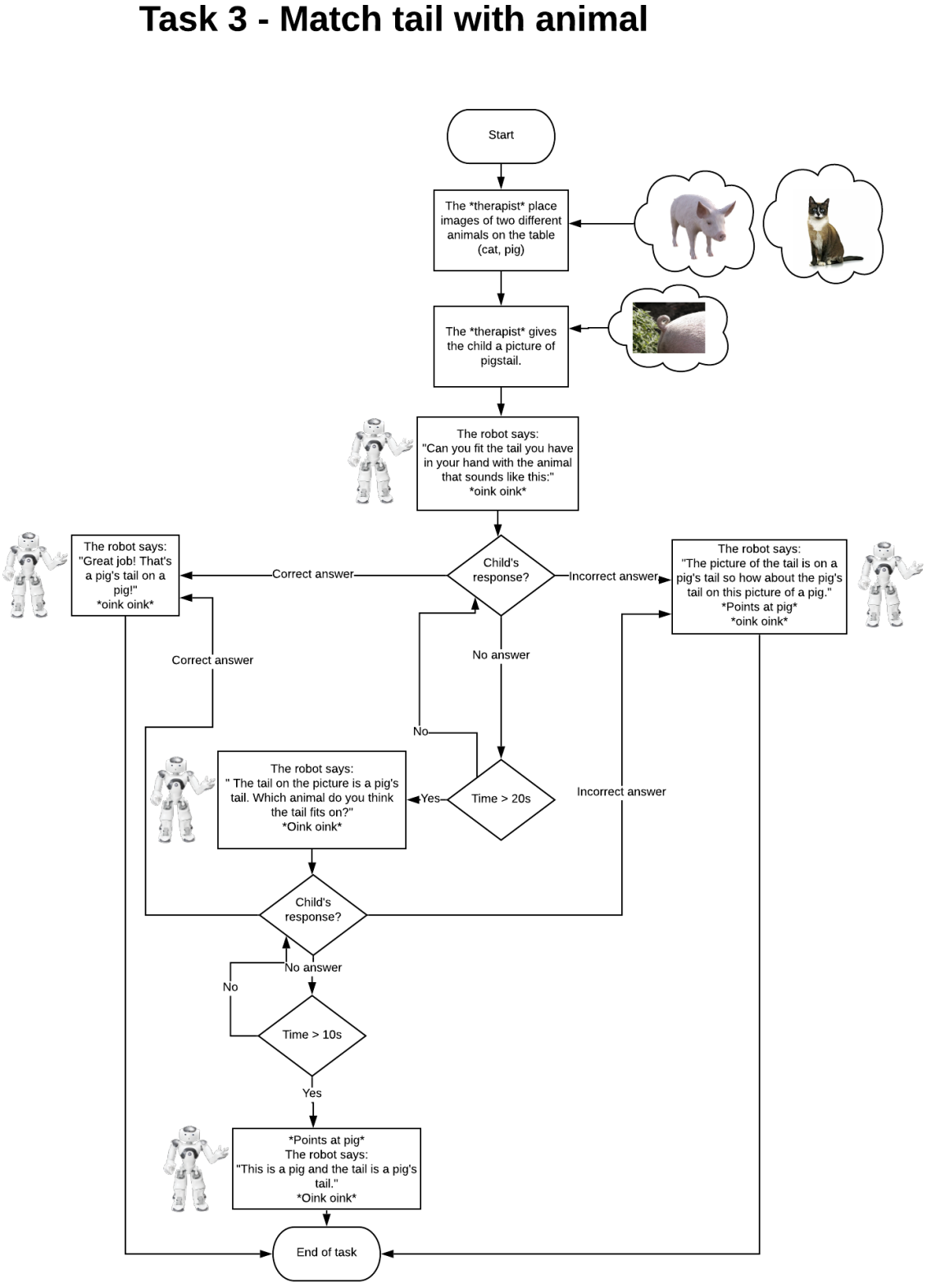


Figure 7: Task 3 flowchart. NAO robot, from [4] CC-BY. Pig, from [8] CC0. Cat, from [9] CC-BY. Pigtail, from [10] CC0

Task 4

Intention of the task

The intention of task four is to increase the child's ability to recognise feelings. The child first has to identify what feeling the girl in the story, told by the robot, is feeling and recognise that feeling through pictures. The goal is to deeper distinguish a feeling a person can feel in a specific scenario.

Description of the task

The child is first told a story, about a girl in a specific scenario, by the robot. The therapist then places two pictures of two children portraying the feelings happy and sad. The robot asks the child "Did this make the Lisa happy *points at the happy child* or did this make Lisa sad? *points at the sad child*"

Child's response

The child answers correctly to the question if he/she points at the picture portraying the happy child or by words explaining that picture/child. If the child points at the picture portraying the sad child that is seen as an incorrect answer. If the child does not answer the question at all within 20 seconds (neither by pointing at nor describing any picture/child), it is defined as no answer.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct,incorrect or if the child did not answer. The child is told that cats make Lisa happy since she loves cat which clarifies the answer.

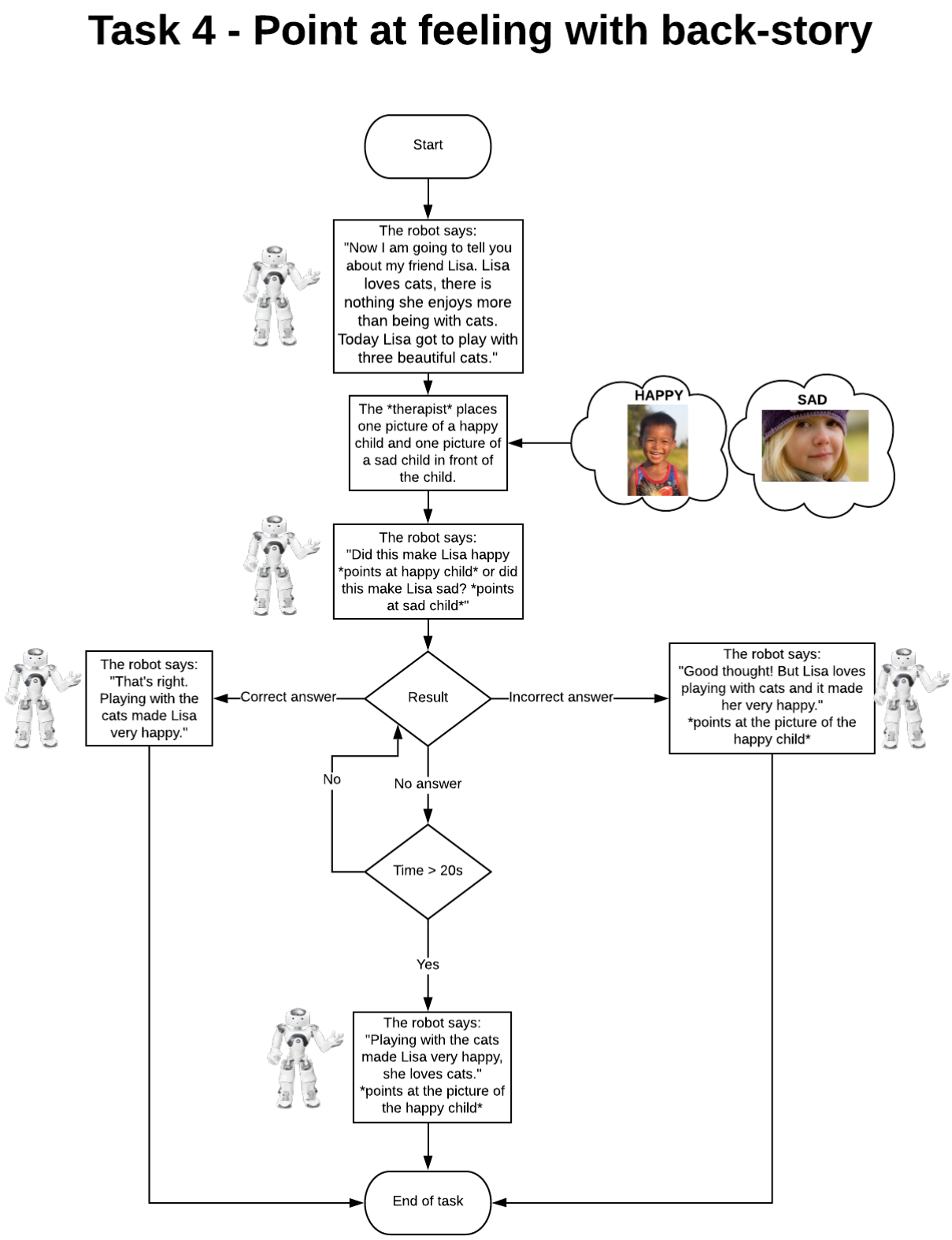


Figure 8: Task 4 flowchart. NAO robot, from [4] CC-BY. Happy child, from [11] CC-BY-SA. Sad child, from [12] CC0.

Task 5

Intention of the task

The intention of task five is for the child to increase his/her ability to understand and recognize feelings. This task is very similar to task four, the difference is that this task gives the child two alternatives of choices and he/she has to decide which one is matching with the robot's description of the feeling. This will increase their ability to multiple choice questions.

Description of the task

The child is first faced with two images of children who is expressing the feelings happy and sad. The robot tells a story about his two friends Anna and David and asks the child to point at his happy friend.

Child's response

The child answers correctly to the question if he/she points at the picture portraying the happy child or by words explaining that picture/child. If the child points at or describes the other picture, that is seen as an incorrect answer. If the child does not answer the question at all within 20 seconds (neither by pointing at nor describing any picture/child), it is defined as no answer and the robot then gives a new clue. If the child doesn't answer the question within 15 seconds (neither by pointing at nor describing any picture/child) it is defined as no answer.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct, incorrect or if the child did not answer. With no answer the child will get a clue and get the possibility to answer the question again. The robot explains how you can see that David is feeling happy.

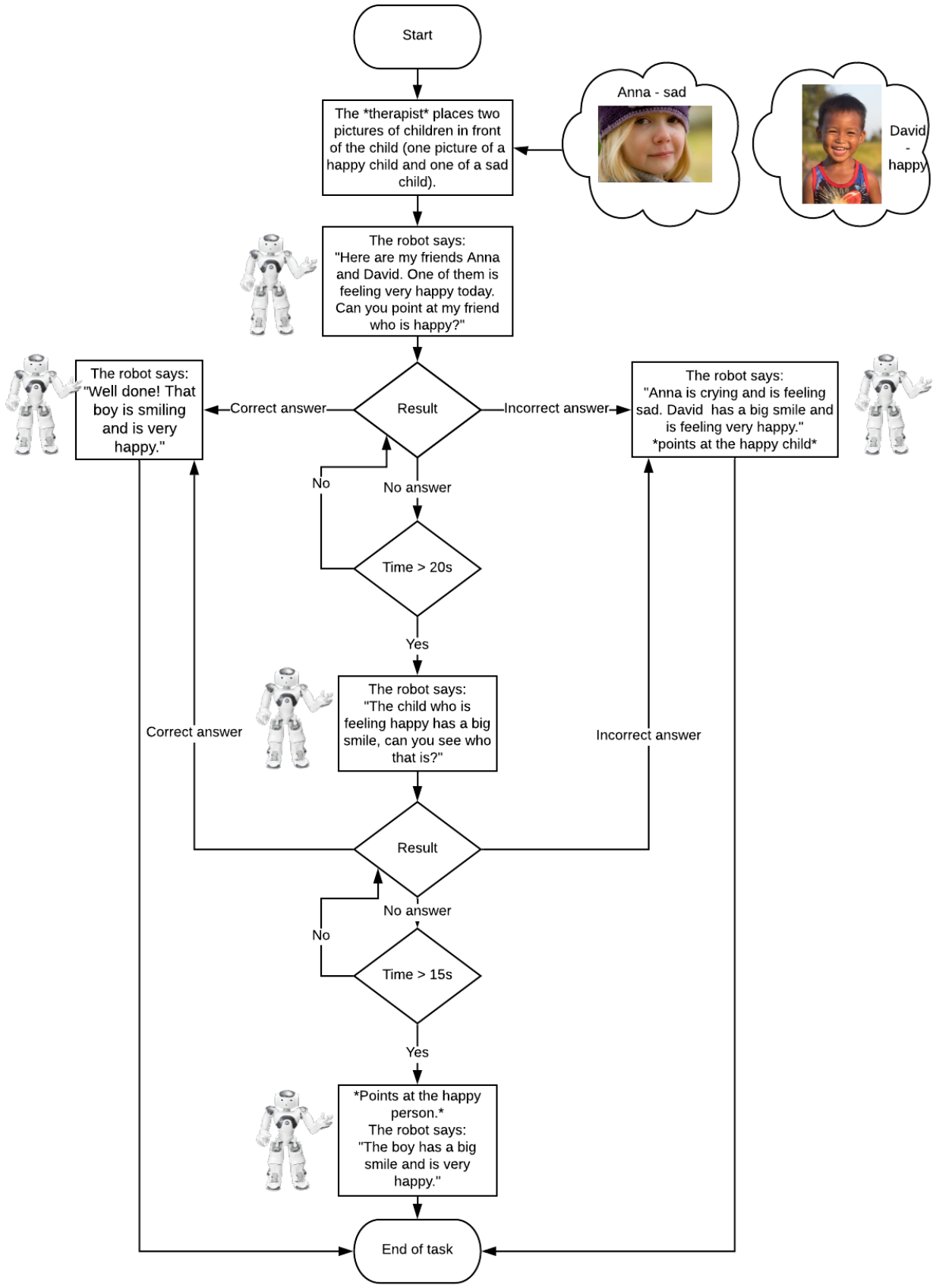


Figure 9: Task 5 flowchart. NAO robot, from [4] CC-BY. Sad child Anna, from [12] CC-0. Happy child David, from [11] CC-BY-SA

Task 6

Intention of the task

The intention for the sixth task is to increase the child's ability to recognise feelings. The child first has to identify what feeling a child is expressing and then decide which other child is expressing that same feeling. The goal is to deeper the understanding of how a feeling can be expressed in different ways.

Description of the task

The child is first faced with an image of a child who is expressing a feeling (happy). The child is told by the robot what the picture portrays but is not told what feeling the child in the picture is expressing. The therapist then places approximately three pictures of other children in front of the child. The robot asks the child "Can you tell me which one of these children feel the same way as John?".

Child's response

The child answers correctly to the question if he/she points at the picture portraying the other happy child or by words explaining that picture/child. If the child points at or describes another picture, that is seen as an incorrect answer. If the child does not answer the question at all within 20 seconds (neither by pointing at nor describing any picture/child), it is defined as no answer.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct, incorrect or if the child did not answer. The child is told what feeling the first child is expressing as well as which other child child is expressing the same feeling.

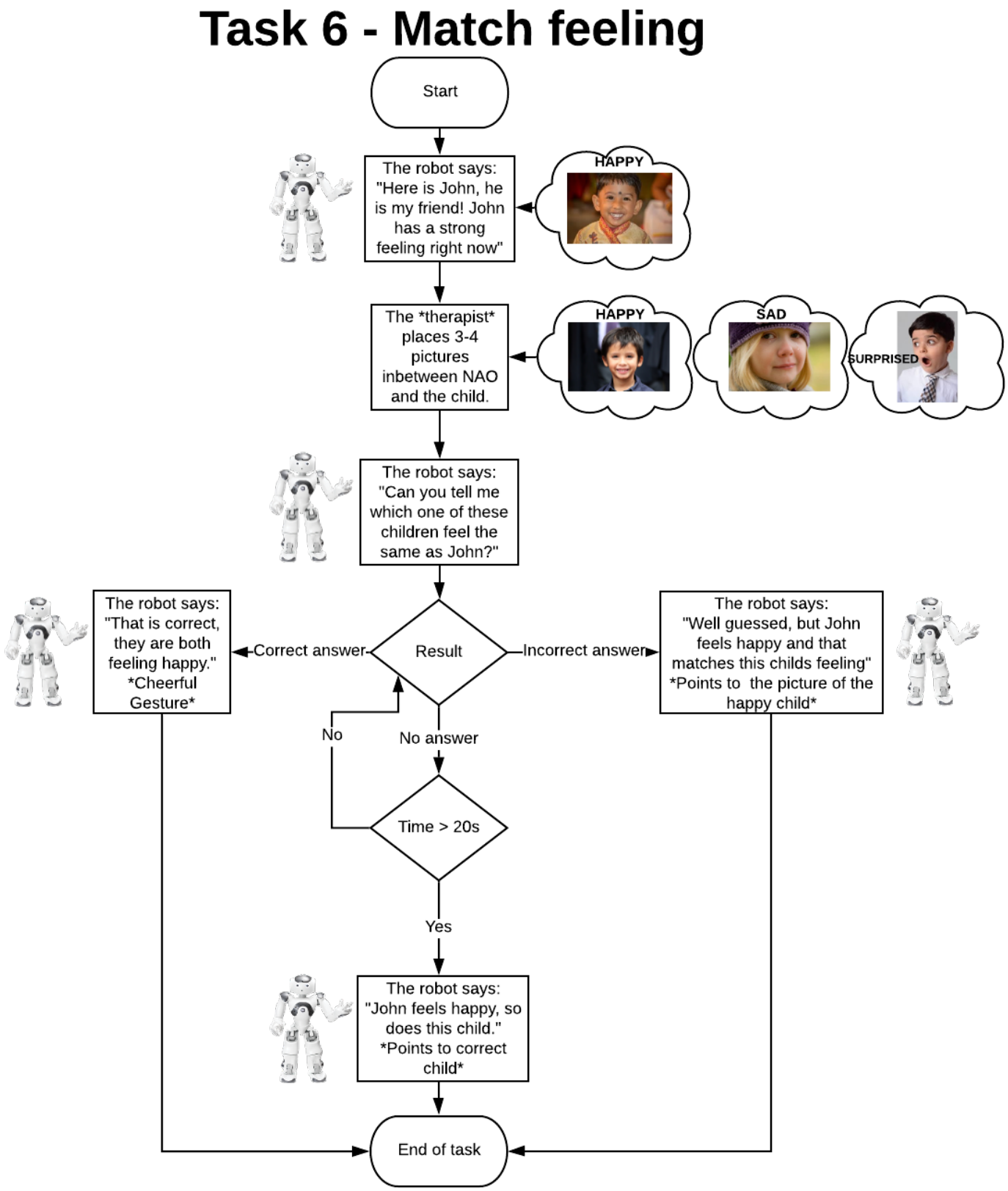


Figure 10: Task 6 flowchart. NAO robot, from [4] CC-BY. Happy child (top), from [13] CC0. Happy child (buttom), from [14] CC0. Sad child, from [12] CC0. Surprised child, from [15] CC0

Goodbye

Intention

The intention for the sub-routine *Goodbye* is to make it clear for the child that the session is over and tell him/her that he/she did a great job.

Description of the sub-routine

The sub-routine only consists of one part, where the robot tells the child that he/she did a good job. The name of the child is included, to make the child feel special. The phrase "Hope I'll see you soon again" is included to inform the child that it is possible to work with the robot again.

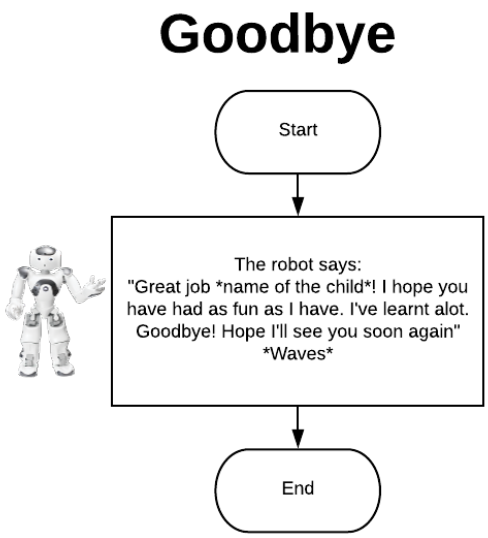


Figure 11: Goodbye flowchart NAO robot, from [4] CC-BY

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[13] Sk Akher, "Smiling Child" 2018. [Electronic image]. Available: https://www.pexels.com/sv-se/foto/1703420/, Accessed on Mar 03 2020.

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D

Documentation Sprint 2

Interaction Design for Autism Therapy with Robots for Preschool Children

Sprint 2: Updated tasks and implementation

Filip Andreasson, Pontus Backman, Kajsa Bjäräng,
Viktoria Enderstein, Simon Rogmalm Hornestedt, Ellen Widerstrand

Introduction

Robots are becoming increasingly common in everyday life around the world. One area where robots are used is between clinicians and preschool aged children with autism spectrum disorder(ASD). Research regarding interactive robots have been conducted in multiple projects and experiments around the world throughout the last two decades. One example of a project where this type of research has been conducted is DREAM [1]. The robots range from simple turn-taking robots used in games of tag to complex anthropomorphic robots capable of detecting emotions and showing empathy [2].

Sandygulova et al.[3] pointed out the importance of making the robot attract a child's attention in order to extract value from the robot's presence in the therapy room. Arriving at the conclusion that having an interaction between a child and a robot that is adaptable to suit the preferences of the individual is of utmost importance.

Hence, this project will focus on constructing and developing a session between a child and a NAO-robot. It will be restricted to children between four and six years old with ASD, who has a language level where at least 4-5 words utterances are used. The focus will be to improve the child's ability to make decisions and distinguish emotions. The project will be divided into three sprints where the first sprint will give an example of the developed session visualised with flowcharts and additional text describing each part of the session. This document provides the draft from the second sprint and is presented below.

Purpose

The project aims to incrementally design the interaction within a therapy session for a child with ASD making use of a NAO-robot. The ability to make choices and recognising feelings in others is difficult for children with ASD. Hence the focus of the session will be on making the robot facilitate learning in these areas with a set of different games or questions. By iterating over the design, the main goal is to end up with at least an embryo of a generalised design that could be tested in a real setting.

Scenario

The session is planned to take place in a room with a child, the robot and a supervisor such as a teacher, parent or medical expert. The room should include two chairs and a table. Additionally to this, some of the tasks include other objects that has to be prepared before the session starts. A summary of everything needed for the session can be seen in figure 1. The supervisor will be equipped with these necessary props before the session. The child will be sitting in front of the robot, which is placed on the table in a reachable distance and with the supervisor sitting beside the child.

Props
Toy bus
Toy car
Toy airplane
Toy motorcycle
Pictures of specific interest such as vehicles e.g. a bus, car, airplane, motorcycle
Three pictures of happy children
Picture of a sad child
Picture of a surprised child
Picture of a angry child

Figure 1: Table of props needed for the session

To personalise the session for each individual child, two of the tasks have been changed to integrate the child's interests. In this session, *vehicles* are the chosen "interest" and can be changed to any other interest. *Vehicles* holds for an example of the personalisation in this project and should be seen as a view of the bigger picture.

Figure description

The flowcharts are all designed with the shapes in figure 2.

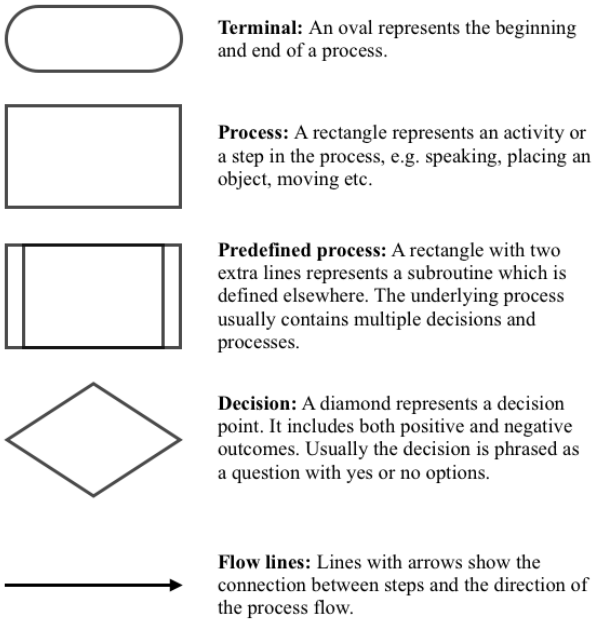

Figure 2: Description of the flowchart shapes

Thoughts regarding the tasks

- How many "fun" tasks should be used?
  - One of the main purposes is to increase the child's ability to recognise feelings and several tasks regarding feelings have therefore been added. How often should a more fun task be done (a task not involving recognising feelings)?

Changes made from sprint 1

The previous restriction of the child's utterance was "who has the ability to form complete sentences". After the feedback, that restriction was changed to "has a language level where at least 4-5 words utterances are used" since the session does not require the child to speak full sentences. It is only required that the child can point at or describe an answer and if they want to stop the session, that can be accomplished with at least 4-5 words utterances.

Task 1, 2 and 3 has been remade or modified based on the feedback from the previous sprint. The focus of task 1 and 3 was to understand instructions and not making a choice, which was the initial intention. Task 1, 2 and 3 were then completely remade based on the feedback and the focus of the three new tasks are on making decisions and the topic of some of them are specific interest the

child has. The order of the tasks have also been changed based on the feedback and evaluation to get a great mix of "funny" and "educational" tasks.

The list of props has been updated since a few of the tasks has been deleted or updated. For example, the balls and jar have been substituted with 4 different vehicles. Additionally to this, two of the tasks has been personalised, as mentioned above, and the text describing this has been added/modified.

Overview

Figure 3 describes the flow of the full session. Following the flow chart we can see that the session starts with a greeting and introduction. Moving into a looping state where a number of tasks are to be completed. A check is made after each task to see if the child is still interested in the robot and the session. At any time during the session, the flow can be stopped by the child, signalling that he/she does not want to continue. The robot will eventually end the session in a social manner if the 8 minutes of the session has expired. Each and every sub-process of the session is described in the following sections.

The time of the session has been chosen with regards to previous research [3] where the group mean is 11 minutes. To avoid that the child starts losing interest by the end of the session we have made the choice of limiting our session to eight minutes.

The six tasks that are currently designed are split into two different categories: feelings (Task 2,3, 5 and 6) and questions oriented in the child's specific interest area with a focus on learn to choose (Task 1 and 4). All the tasks are made in an educational manner and can be picked in any combination or sequence to suit the child's individual preferences but a specific order has been discussed and chosen. Tasks within the category feelings have been created to, in different ways, teach the child to recognise, match or pair feelings. The primary focus of the playful tasks are to maintain an interest in the sessions, while still keeping the educational moment of having to choose the correct answer.

In this sprint the robot's movement haven't been in focus since it took longer time to get the robot to work than expected. In the next sprint, more focus will be in creating a more interactive session by adding more arm movements for the robot.

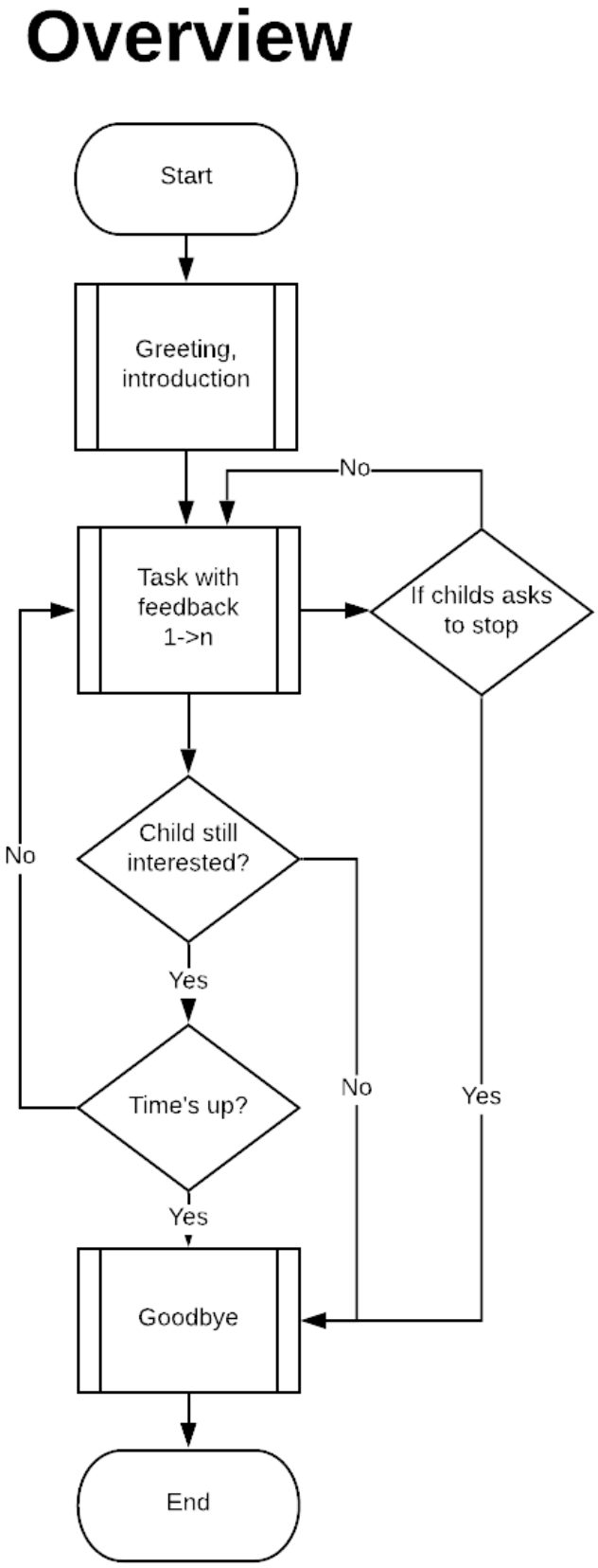

Figure 3: Overview flowchart

Greeting

Intention

The intention is to welcome the child to the session and inform him/her on what is going to happen and approximately how long.

Description of the sub-routine

The robot greets the child and introduces itself. It also interact with the child and asks for his/her name. If the child doesn't respond with a name within 10 seconds the robot continues with the introduction of the session. The robot tries to be positive and encouraging and attempts to give a high five before starting with the tasks.

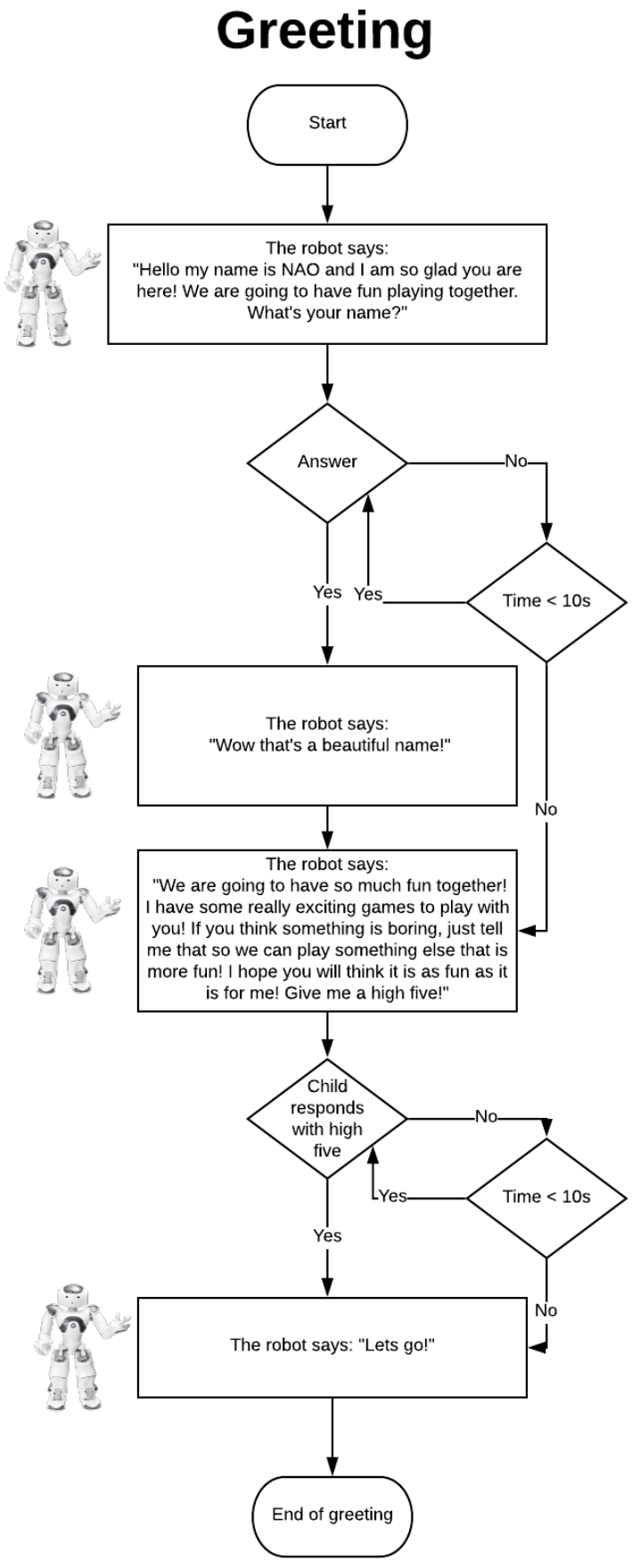

Figure 4: Greeting flowchart. NAO robot, from [4] CC-BY

Task 1

Intention of the task

The intention for the first task is to increase the child's ability to make choices. This task is also aimed at keeping the session interesting for the child's, as the topic of it is supposed to be one of the child's interests (e.g. vehicles). It is important that all answers are correct. The goal is to get the child to chose one answer, which one does not matter.

Description of the task

The supervisor starts by placing four toy vehicles in front of the child. The toys can be replaced by images of vehicles if no toys are available, but to include more senses it is preferred to have toys, as the child can touch them (in the video images is instead shown.

The robot informs the child that four different kinds of vehicles have been placed in front of the child and asks which one he/she likes the most.

Child's response

No matter which vehicle the child chooses, it is defined as a correct answer. The child can either say the name of the vehicle or point at it/pick it up.

If the child does not answer within 20 seconds, the question will be repeated and the child is given an extra 20 seconds to answer. If the child gives any answer within that time period, it is seen as a correct answer. If the child does not answer within those 20 seconds, it is seen as no answer.

Feedback

The robot will give cheering feedback for both types of answers. It is important to keep the child's interest and not point out that he/she did something wrong. If the child does not give an answer, the robot will say its favourite vehicle.

Changes made from sprint 1

This task is a completely new task and replaces the previous task "Balls in a jar". The focus of the previous task, "Balls in a jar", was mainly to increase the child's ability to follow instructions. The new task will focus on the ability to make choices instead, as it is the purpose of the project. The restriction that the child needs to be able to recognise colours and identify the colour names has also been removed as a result of removing the task "Balls in a jar".

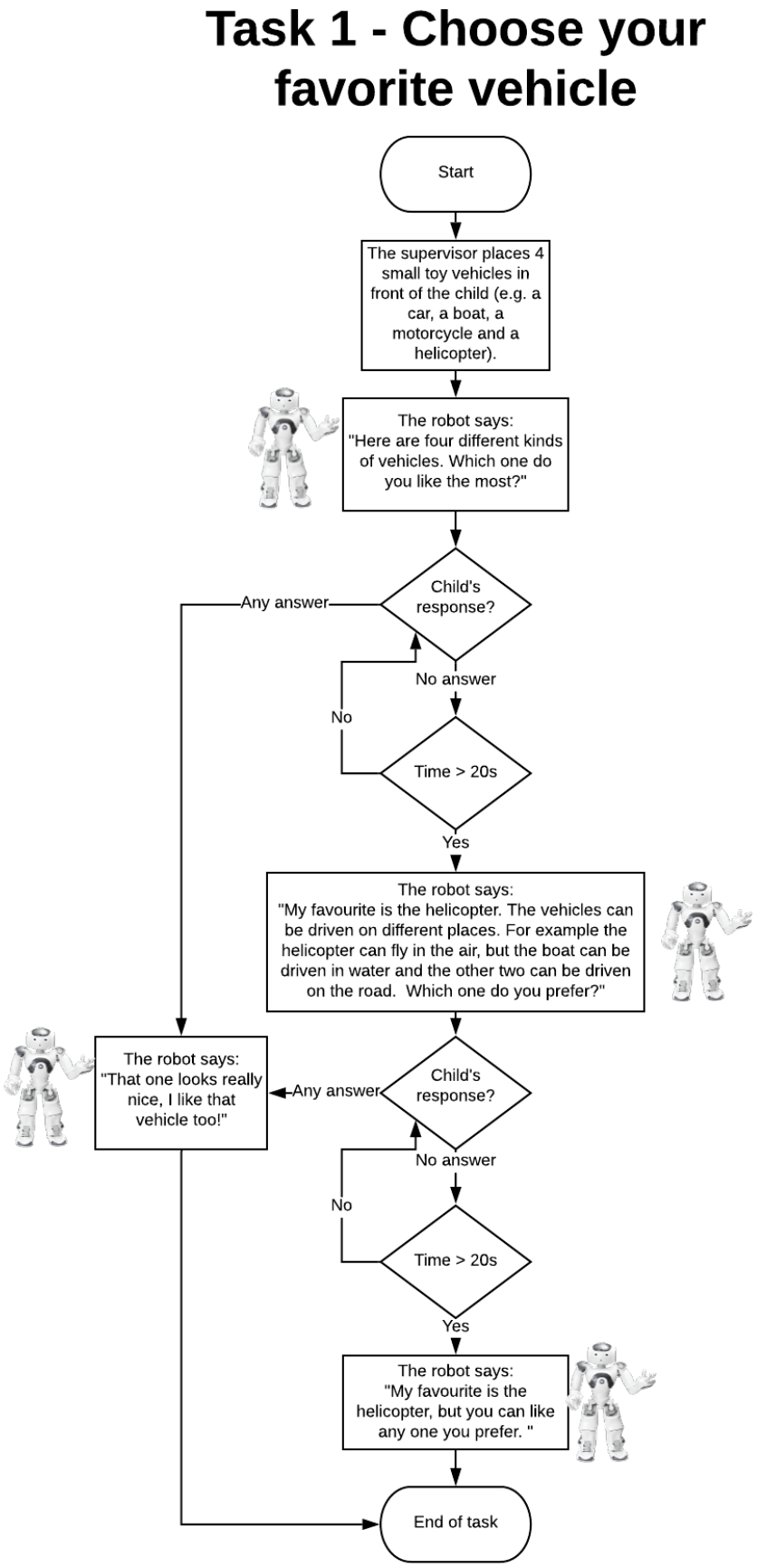

Figure 5: Task 1 flowchart. NAO robot, from [4] CC-BY

Task 2

Intention of the task

The intention of task two is for the child to increase his/her ability to understand and recognise feelings by following instructions. This task is very similar to task three, the difference is that this task gives the child two alternatives of choices and he/she has to decide which one is matching with the robot's description of the feeling. This will increase their ability to multiple choice questions.

Description of the task

The child is first faced with two images of children who is expressing the feelings happy and sad. The robot ask which of the children on the picture is David who is happy.

Child's response

The child answers correctly to the question if he/she points at the picture portraying the happy child or by words explaining that picture/child. If the child points at or describes the other picture, that is seen as an incorrect answer. If the child does not answer the question at all within 20 seconds (neither by pointing at nor describing any picture/child), it is defined as no answer and the robot then gives a new clue. If the child doesn't answer the question within 15 seconds (neither by pointing at nor describing any picture/child) it is defined as no answer.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct, incorrect or if the child did not answer. With no answer the child will get a clue and get the possibility to answer the question again. The robot explains how you can see that David is feeling happy.

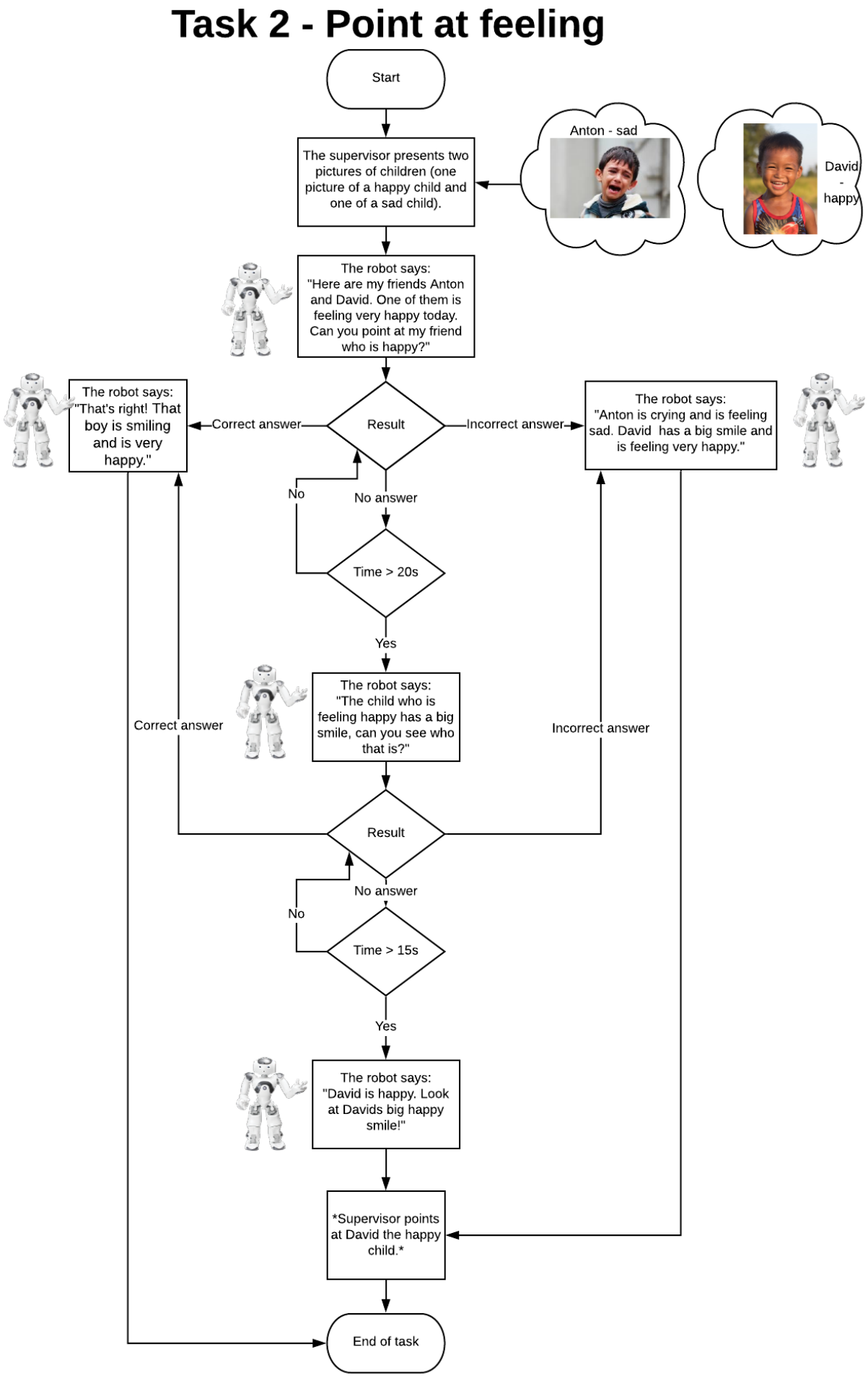

Figure 6: Task 2 flowchart. NAO robot, from [4] CC-BY. Sad child Anton, from [5] CC0. Happy child David, from [6] CC-BY-SA.

Task 3

Intention of the task

The intention of task three is to increase the child's ability to recognise feelings. The child first has to identify what feeling the boy in the story, told by the robot, is feeling and recognise that feeling through pictures. The goal is to deeper distinguish a feeling that a person can feel in a specific scenario.

Description of the task

The child is first told a story, about a girl in a specific scenario, by the robot. The supervisor then places two pictures of two children portraying the feelings happy and sad. The robot asks the child "Did this make John happy or sad?".

Child's response

The child answers correctly to the question if he/she points at the picture portraying the happy child or by words explaining that picture/child. If the child points at the picture portraying the sad child that is seen as an incorrect answer. If the child does not answer the question at all within 20 seconds (neither by pointing at nor describing any picture/child), it is defined as no answer.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it is correct, incorrect or if the child do not answer. The child is told that cats make John happy since he loves cat which clarifies the answer.

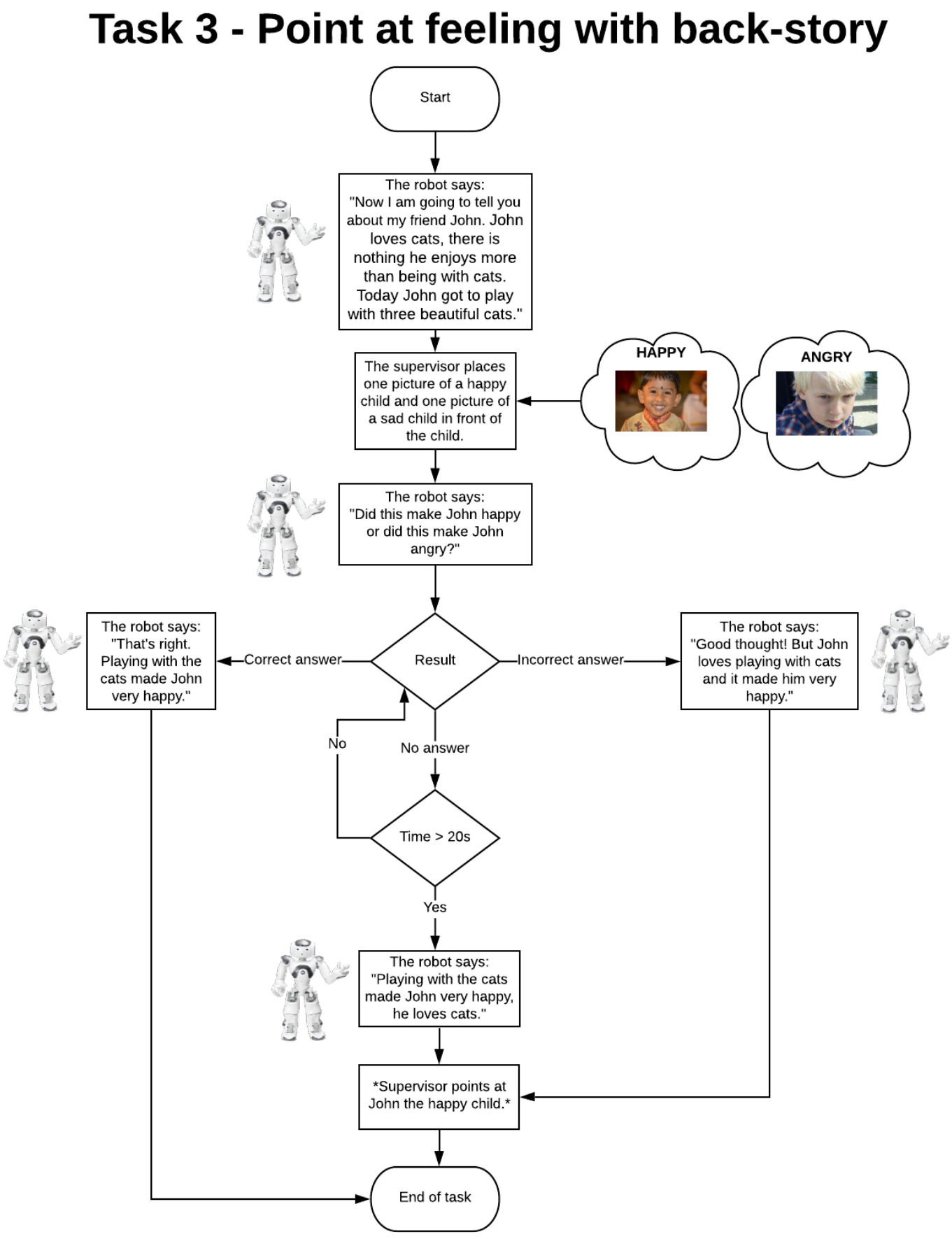

Figure 7: Task 3 flowchart. NAO robot, from [4] CC-BY. Happy child, from [7] CC0. Angry child, from [8] CC-BY.

Task 4

Intention of the task

The intention of task four is to increase the child's ability to make a choice as well as try to make it interesting since it focus on the child's interest. The child has to make a choice of what vehicle could make the sound the robot plays up. The choice to include sound is to activate several senses.

Description of the task

The supervisor places four pictures of different vehicles on the table. The robot tells the child about a scenario and play up a sound of a vehicle. The robot then asks the child which vehicle she/he thinks passed by.

Child's response

Any answer in this task is correct. If the child answers within 20 seconds the response from the robot is happy and encouraging. If the child doesn't answer within 20 seconds the robot says:"Which of the vehicles in front of you do you think passed me by?" and plays the sound again.

Feedback

The child will receive encouraging answer on any response. If the child doesn't answer after 20 seconds the robot asks again and after that the child has 10 seconds to answer the question before the robot will continue with the next task.

Changes from sprint 1

This task is a remake from the previous sprint's task 2. Previously the task focused on that the child should understand which animal the robot referred to. The task is remade to focus on an interesting subject, in this case an example of vehicles, where no specific answer is correct. This is to focus on the purpose of learning the child to make choices.

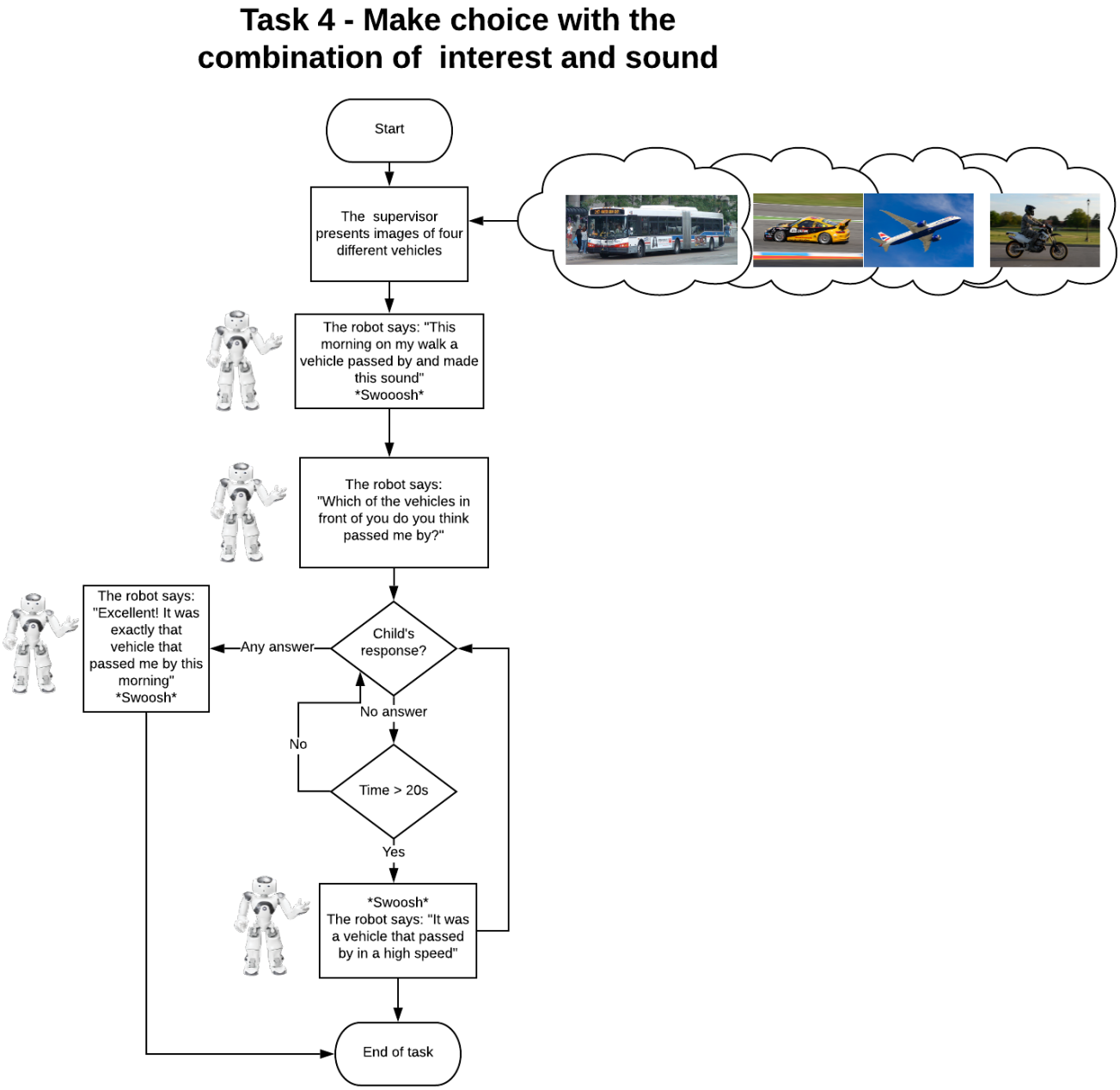

Figure 8: Task 4 flowchart. NAO robot, from [4] CC-BY. Bus, from [9] CC0. Car, from [10] CC-BY-SA, Airplane, from [11] CC0. Motorcycle, from [12] CC-BY.

Task 5

Intention of the task

The intention for the fifth task is to increase the child's ability to recognise feelings. The child first has to identify what feeling a child is expressing and then decide which other child is expressing that same feeling. The goal is to deeper the understanding of how a feeling can be expressed in different ways.

Description of the task

The child is first faced with an image of a child who is expressing a feeling (happy). The child is told by the robot what the picture portrays but is not told what feeling the child in the picture is expressing. The supervisor then places approximately three pictures of other children in front of the child. The robot asks the child "Can you tell me which one of these children feel the same way as John?".

Child's response

The child answers correctly to the question if he/she points at the picture portraying the other happy child or by words explaining that picture/child. If the child points at or describes another picture, that is seen as an incorrect answer. If the child does not answer the question at all within 20 seconds (neither by pointing at nor describing any picture/child), it is defined as no answer.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct, incorrect or if the child did not answer. The child is told what feeling the first child is expressing as well as which other child child is expressing the same feeling.

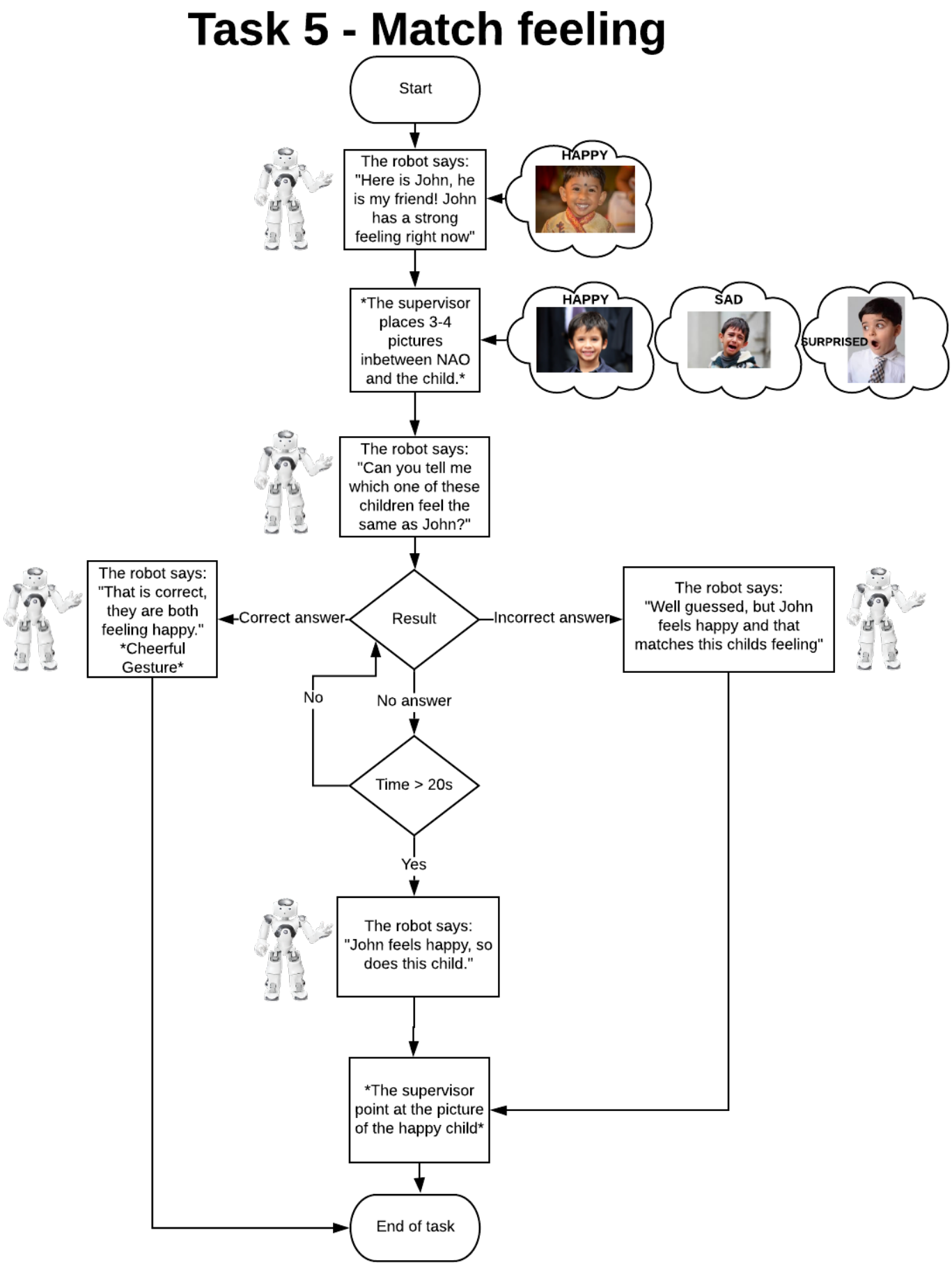

Figure 9: Task 5 flowchart. NAO robot, from [4] CC-BY. Happy child (top), from [7] CC0. Happy child (buttom), from [13] CC0. Surprised child, from [14] CC0.

Task 6

Intention of the task

The intention for the sixth task is to increase the child's ability to both make choices as well as recognising feelings. First of all the child needs to recognise it's own feeling during the session, and then choose the corresponding picture of a child that matches that feeling. This helps the child recognise how other children are feeling by referring to their own feelings.

Description of the task

The child is presented with images of other children who express different feelings. The child is told that he/she/they should point at the child who feels just like he/she/they does. The number of feelings presented is up to the supervisor, since the number of choices could be harder on the child.

Child's response

The child could make three different responses. Either the child points at a positive feeling (happy, laughing, content), a negative feeling (crying, angry, sad) or the child doesn't provide any answer at all. If the child does the latter, the robot will encourage the child by providing clues such as describing all the feelings that are presented.

Feedback

Pointing at a positive feeling will make the robot react happily. Pointing at a negative feeling makes the robot sad, yet hopeful for a happier response next time. Not pointing at anything at all makes the robot point at a happy child and says that the next time they play this game they hopefully feel that happy.

Changes from sprint 1

This task is a completely new task, which replaces the task "Match tail with animal" (task 3) from the previous sprint.

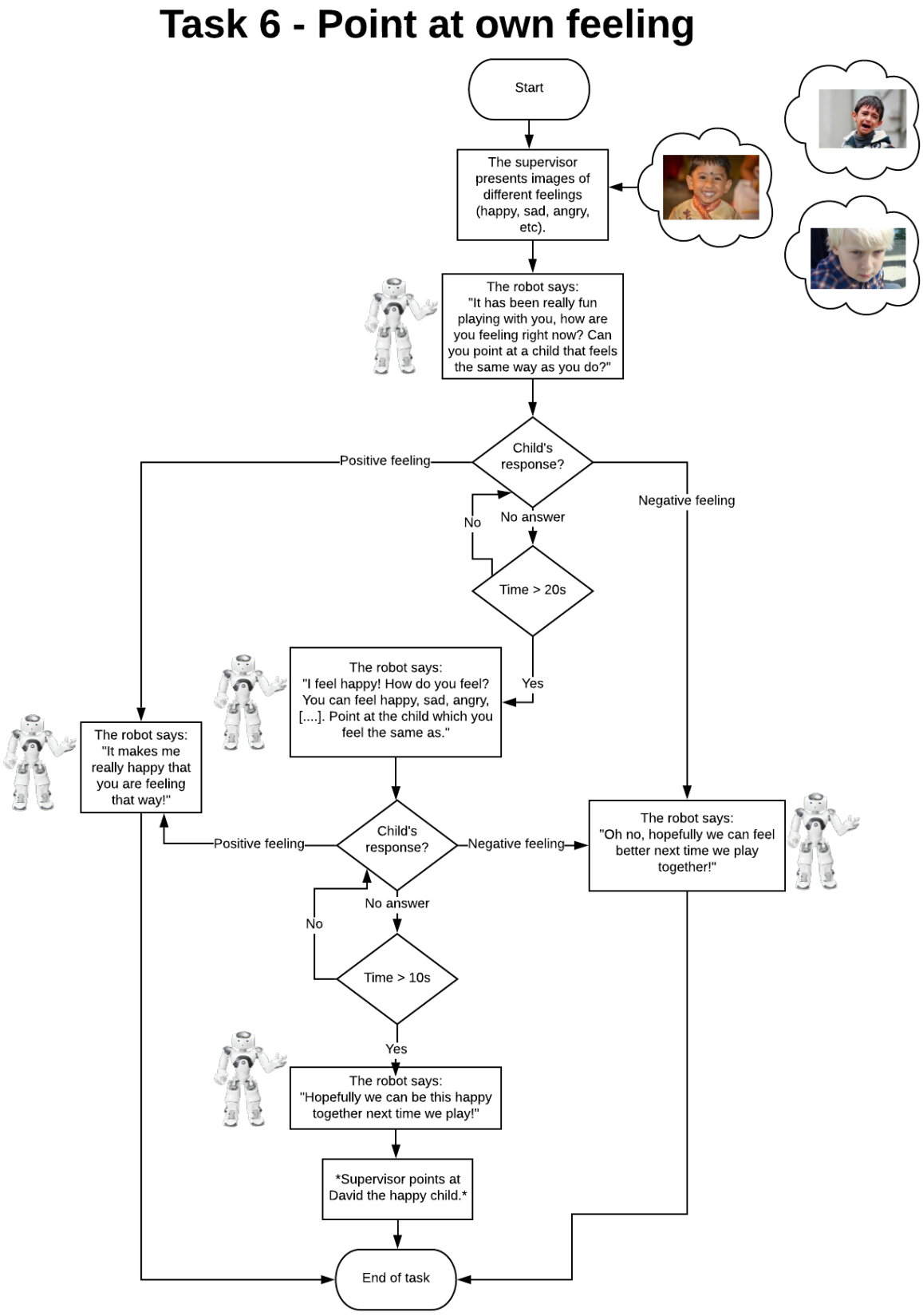

Figure 10: Task 6 flowchart. NAO robot, from [4] CC-BY. Sad child, from [5] CC0. Happy child, from [7] CC0. Angry child, from [8] CC-BY.

Goodbye

Intention

The intention for the sub-routine *Goodbye* is to make it clear for the child that the session is over and tell him/her that he/she did a great job.

Description of the sub-routine

The sub-routine only consists of one part, where the robot tells the child that he/she did a good job. The name of the child is included, to make the child feel special. The phrase "Hope I'll see you soon again" is included to inform the child that it is possible to work with the robot again.

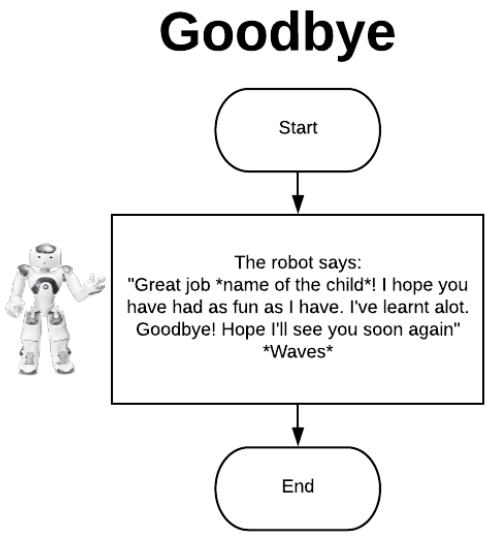

Figure 11: Goodbye flowchart. Nao robot, from [4] CC-BY

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E

Movie Sprint 2

The movie "*Session with NAO: Sprint 2*", created during the second sprint, shows the first implementation of the session. The movie includes the robot, showing its movements and speech, and it can be viewed on the following link:

`https://www.youtube.com/watch?v=LcA8F4qSZyc&t=5s`

F

Documentation Sprint 3

Interaction Design for Autism Therapy with Robots for Preschool Children

Sprint 3: Updated tasks and implementation

Filip Andreasson, Pontus Backman, Kajsa Bjäräng,
Viktoria Enderstein, Simon Rogmalm Hornestedt, Ellen Widerstrand

Introduction

Robots are becoming increasingly common in everyday life around the world. One area where robots are used is between clinicians and preschool-aged children with autism spectrum disorder(ASD). Research regarding interactive robots have been conducted in multiple projects and experiments around the world throughout the last two decades [1]. One example of a project where this type of research has been conducted is DREAM [2]. The robots range from simple turn-taking robots used in games of tag to complex anthropomorphic robots capable of detecting emotions and showing empathy [3].

Sandygulova et al.[4] pointed out the importance of making the robot attract a child's attention in order to extract value from the robot's presence in the therapy room, arriving at the conclusion that having an interaction between a child and a robot that is adaptable to suit the preferences of the individual is of utmost importance.

Hence, this project will focus on constructing and developing a session between a child and a NAO-robot. It will be restricted to children between four and six years old with ASD, who have a language level where at least 4-5 words utterances are used. The focus will be to improve the child's ability to make decisions and distinguish emotions. The project is divided into three sprints where the first sprint gives an example of the developed session visualised with flowcharts and additional text describing each part of the session. This document provides the draft from the third sprint and is presented below.

Purpose

The project aims to incrementally design the interaction within a therapy session for a child with ASD making use of a NAO-robot. The ability to make choices and recognising feelings in others is difficult for children with ASD. Hence the focus of the session will be on making the robot facilitate learning in these areas with a set of different games or questions. By iterating over the design, the main goal is to end up with at least an embryo of a generalised design that could be tested in a real setting.

Scenario

The session is planned to take place in a room with a child, the robot and a supervisor such as a teacher, parent or medical expert. The room should include two chairs and a table. Additionally to this, some of the tasks include other objects that have to be prepared before the session starts. A summary of everything needed for the session can be seen in figure 1. The supervisor will be equipped with these necessary props before the session. The session will be governed by the supervisor and an application controlling the robot. The child will be sitting in front of the robot, which is placed on the table in a reachable distance and with the supervisor sitting beside the child.

To personalise the session for each individual child, two of the tasks have been changed to integrate the child's interests. In this session, *vehicles* are the chosen "interest" and can be changed to any other interest. *Vehicles* stands as an example of the personalisation in this project and should be seen as a view of the bigger picture.

Props
A tablet/computer for accessing the application
Toy bus (a picture works good if it's difficult to include a toy)
Toy car (a picture works good if it's difficult to include a toy)
Toy airplane (a picture works good if it's difficult to include a toy)
Toy motorcycle (a picture works good if it's difficult to include a toy)
Pictures of specific interest such as vehicles e.g. a bus, car, airplane, motorcycle
Three pictures of happy children
Picture of a sad child
Picture of a surprised child
Picture of a angry child

Figure 1: Table of props needed for the session

Figure description

The flowcharts are all designed with the shapes in figure 2.

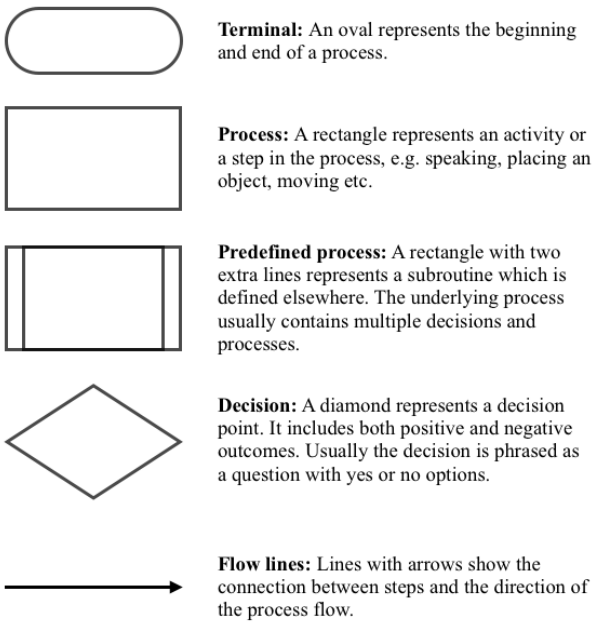

Figure 2: Description of the flowchart shapes

Thoughts regarding the tasks

- How many "fun" tasks should be used?
  - One of the main purposes is to increase the child's ability to recognise feelings and several tasks regarding feelings have therefore been added. How often should a more fun task be done (a task not involving recognising feelings)?

Changes made from sprint 2

The changes made from the previous sprint has focused on making the robot more interactive. The robot now points at the related pictures and makes additional movements and sound. Some of the sentences have also changed to achieve the best possible pronunciation by the robot.

The graphical user interface (GUI) which is used to control the session has been upgraded to be more user friendly. The GUI is supposed to be used by the supervisor of the session. Therefore the GUI should achieve as good a session as possible.

Overview

Figure 3 describes the flow of the full session. Following the flow chart we can see that the session starts with a greeting and introduction. Moving into a looping state where a number of tasks are to be completed. A check is made after each task to see if the child is still interested in the robot and the session. At any time during the session, the flow can be stopped by the child, signalling that he/she does not want to continue. The robot will eventually end the session in a social manner if the 8 minutes of the session has expired. Each and every sub-process of the session is described in the following sections.

The time of the session has been chosen with regards to previous research [4] where the group mean is 11 minutes. To avoid that the child starts losing interest by the end of the session we have made the choice of limiting our session to eight minutes.

The six tasks that are currently designed are split into two different categories: feelings (Task 2,3, 5 and 6) and questions oriented in the child's specific interest area with a focus on learning to choose (Task 1 and 4). All the tasks are made in an educational manner and can be picked in any combination or sequence to suit the child's individual preferences but a specific order has been discussed and chosen. Tasks within the category feelings have been created to, in different ways, teach the child to recognise, match or pair feelings. The primary focus of the playful tasks are to maintain a child's interest in the sessions, while still keeping the educational moment of having to choose the correct answer.

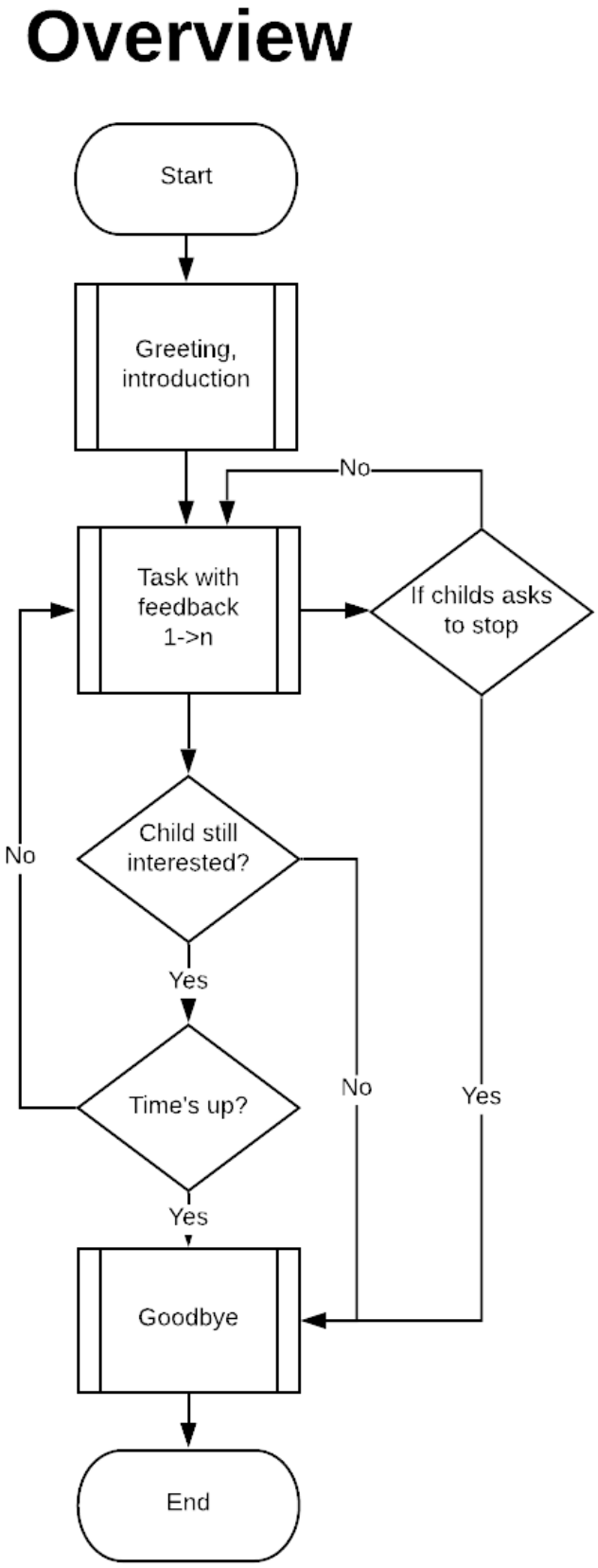

Figure 3: Overview flowchart

Application

The intention of the application is to make it easy for the supervisor to govern the session. Throughout the session the application helps the supervisor by making it possible to choose which task to make, if the child answers as well as if she/he answers correctly. The supervisor could also from the application control when to end the session depending on the time as well as the child's interest.

The application is developed to be as user friendly as possible with a help-button easily accessible throughout the application. The application also includes short descriptions of each task to make it easier for the supervisor.

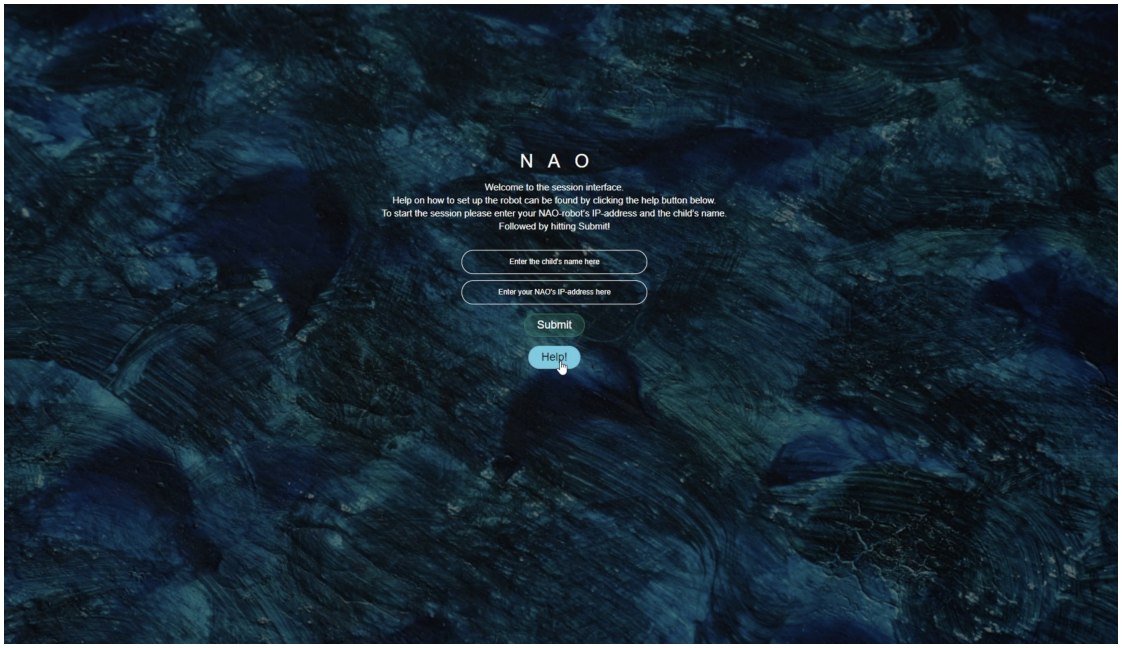

Figure 4: The applications start page with focus on task 1

Greeting

Intention

The intention is to welcome the child to the session and inform him/her about what is going to happen and approximately how long.

Description of the sub-routine

The robot greets the child and introduces itself. It also interacts with the child and asks for his/her name. If the child doesn't respond with a name within 10 seconds the robot continues with the introduction of the session. The robot tries to be positive and encouraging and attempts to give a high five before starting with the tasks.

Changes from sprint 2

The sentence "just tell me then we can play something else that is more fun" has been removed since this isn't something that could be guaranteed. The sentences have also been moved and rewritten to not lie and guarantee the session will be fun since that isn't a possibility.

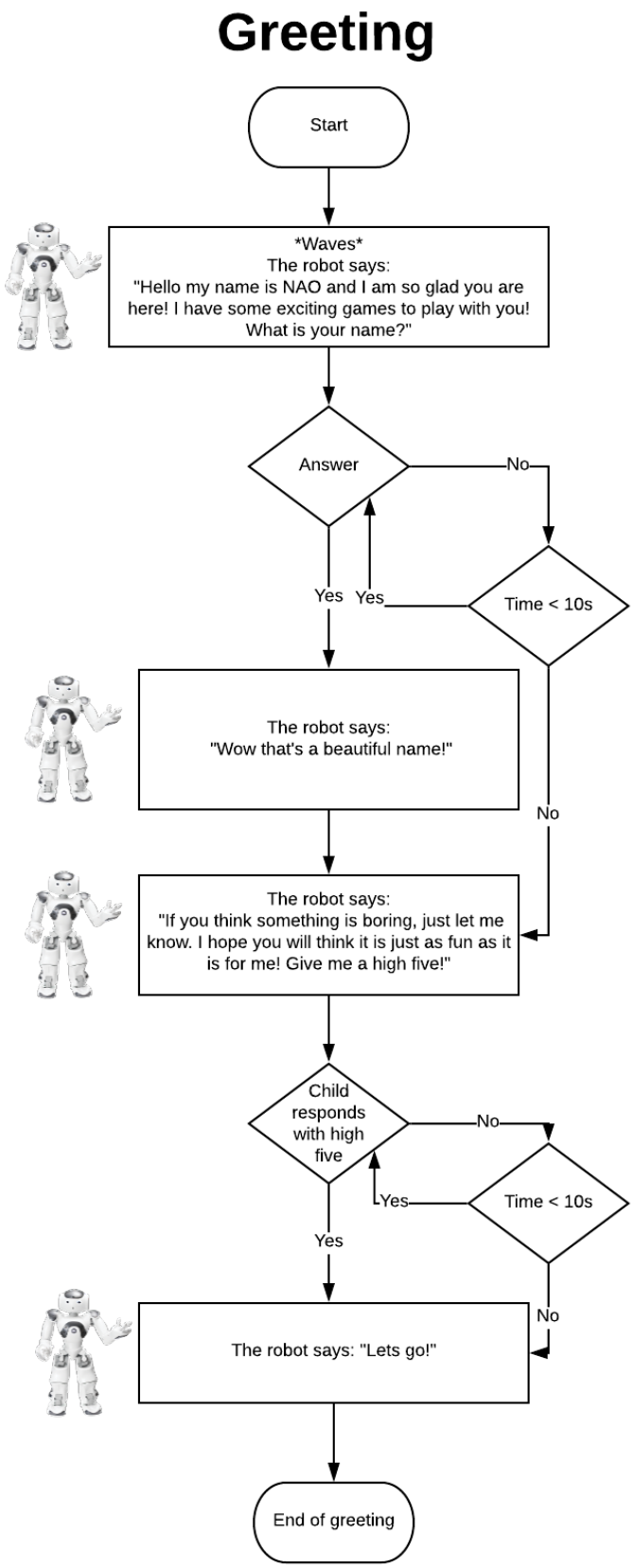

Figure 5: Greeting flowchart. NAO robot, from [5] CC-BY

Task 1

Intention of the task

The intention of the first task is to train the child's ability to make choices. This task is also aimed at keeping the session interesting for the child, as the topic of it is supposed to be one of the child's interests (e.g. vehicles). It is important that all answers are correct. The goal is to get the child to chose one answer, which one does not matter.

Description of the task

The supervisor starts by placing four toy vehicles in front of the child. The toys can be replaced by images of vehicles if no toys are available, but to include more senses it is preferred to have toys, as the child can touch them. The robot will later point at the different vehicles, which makes it important that they are placed in a specific order. From left to right, as seen from the child's perspective, the order should be: car, helicopter, boat and motorcycle.

The task can start when the vehicles have been placed in the correct order. The robot first informs the child that four different kinds of vehicles have been placed in front of the child and asks which one he/she likes the most.

Child's response

No matter which vehicle the child chooses, it is defined as a correct answer. The child can either say the name of the vehicle or point at it/pick it up.

If the child does not answer within 20 seconds, the question will be repeated and the child is given an extra 20 seconds to answer. If the child gives any answer within that time period, it is seen as a correct answer. If the child does not answer within those 20 seconds, it is seen as no answer.

Feedback

The robot will give cheering feedback for both types of answers. It is important to keep the child's interest and not point out that he/she did something wrong. If the child does not give an answer, the robot will say its favourite vehicle.

Changes made from sprint 2

Movement of the robot has been added so NAO points on the different corresponding pictures while presenting the different vehicles.The robot presents the different vehicles by pointing at them. Small changes with the sentences have also been made when NAOs pronunciations have been incorrect or inappropriate.

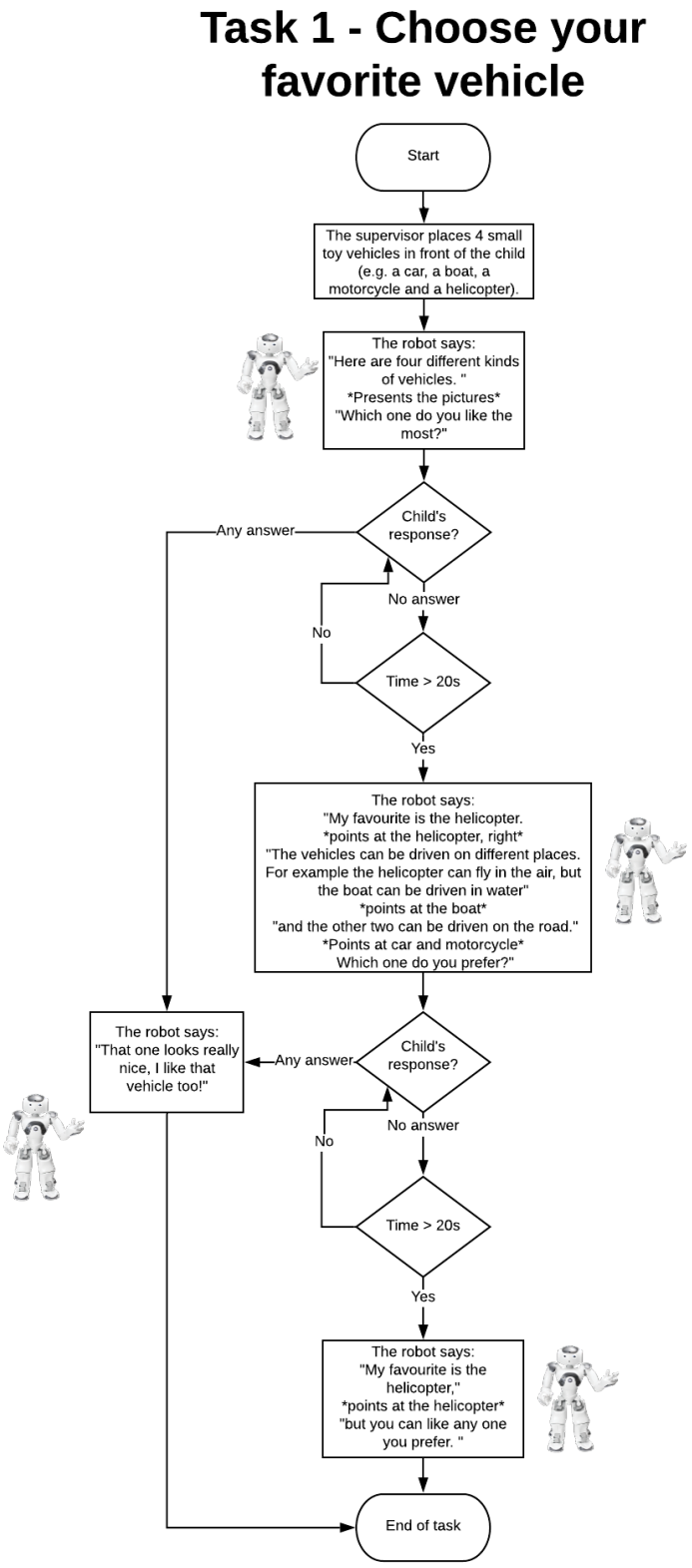

Figure 6: Task 1 flowchart. NAO robot, from [5] CC-BY

Task 2

Intention of the task

The intention of task two is for the child to increase his/her ability to understand and recognise feelings by following instructions.

Description of the task

The child is first faced with two images of children who are expressing the feelings happy and sad. The picture portraying the sad child should be placed to the left, as seen from the child's perspective and the picture of the happy child should be placed to the right. The robot asks which of the children on the picture is David who is happy.

Child's response

The child answers correctly to the question if he/she points at the picture portraying the happy child or by words explaining that picture/child. If the child points at or describes the other picture, that is seen as an incorrect answer. If the child does not answer the question at all within 20 seconds (neither by pointing at nor describing any picture/child), it is defined as no answer and the robot then gives a new clue. If the child doesn't answer the question within 15 seconds (neither by pointing at nor describing any picture/child) it is defined as no answer.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct, incorrect or if the child did not answer. With no answer the child will get a clue and get the possibility to answer the question again. The robot explains how you can see that David is feeling happy.

Changes made from sprint 2

Movement of the robot has been added so NAO points on the different corresponding pictures while explaining them. Anton has been changed to a picture of Anna who is sad to get more diversity of the children included in the session. Small changes with the sentences have been made when NAOs pronunciations have been incorrect or inappropriate.

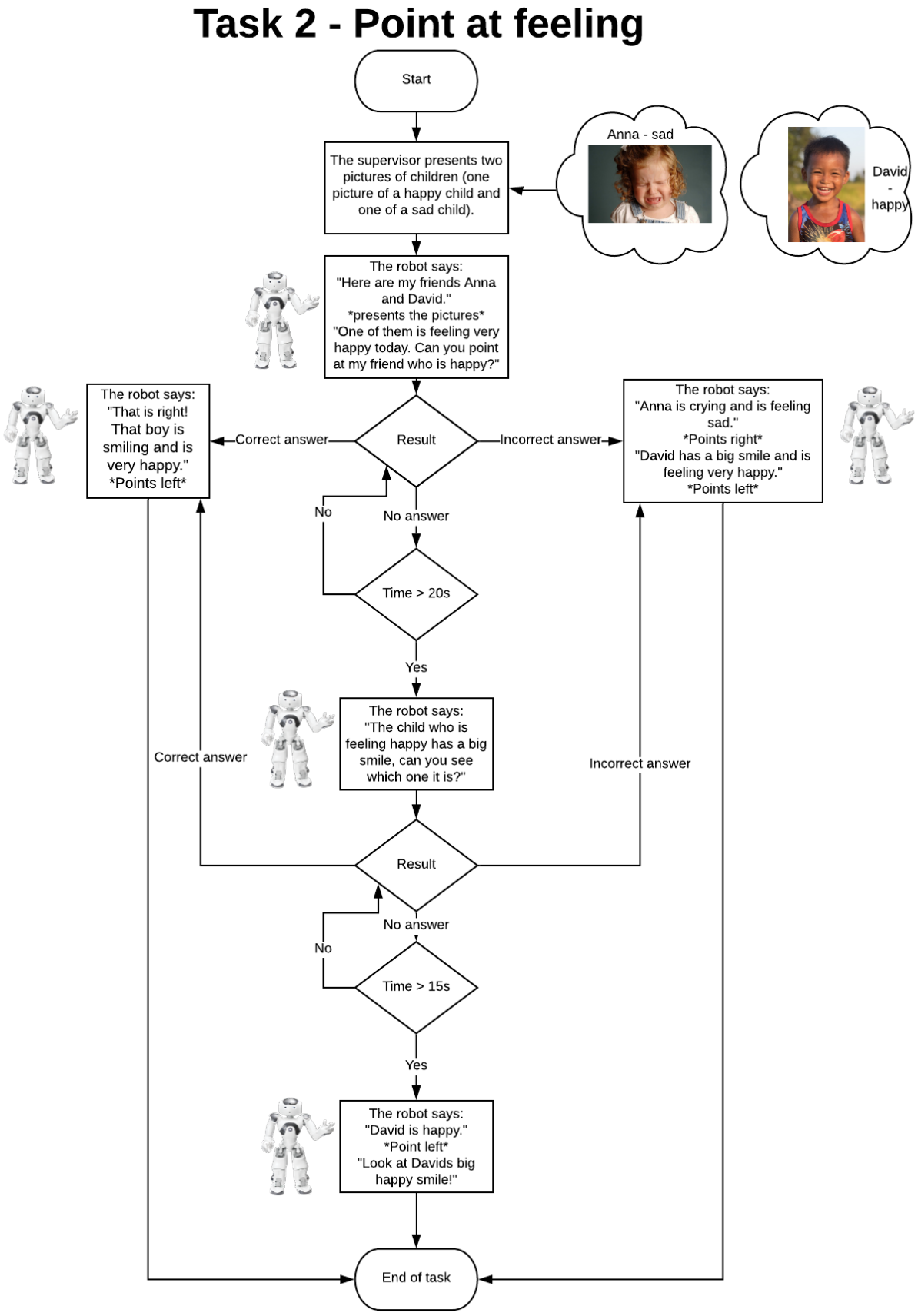

Figure 7: Task 2 flowchart. NAO robot, from [5] CC-BY. Sad child Anna, from [6] CC-BY. Happy child David, from [7] CC-BY-SA

Task 3

Intention of the task

The intention of task three is to increase the child's ability to recognise feelings. The child first has to identify what feeling the child in the story, told by the robot, is feeling and recognise that feeling through pictures. This task is very similar to task two, but this task also focus on learning to distinguish a feeling that a person can feel in a specific scenario.

Description of the task

The supervisor starts by placing two pictures of two children portraying the feelings happy and angry. The child is then told a told a story, about John in a specific scenario, by the robot. The picture portraying the happy feeling should be placed to the left and the angry feeling to the right, as seen from the child's perspective. The robot asks the child "Did this make John happy or did this make John angry?".

Child's response

The child answers correctly to the question if he/she points at the picture portraying the happy child or by words explaining that picture/child. If the child points at the picture portraying the angry child that is seen as an incorrect answer. If the child does not answer the question at all within 20 seconds (neither by pointing at nor describing any picture/child), it is defined as no answer.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it is correct, incorrect or if the child do not answer. The child is told that cats make John happy since he loves cat which clarifies the answer.

Changes made from sprint 2

Movement of the robot has been added so NAO points on the different corresponding pictures while explaining them. Small changes with the sentences have been made when NAOs pronunciations have been incorrect or inappropriate.

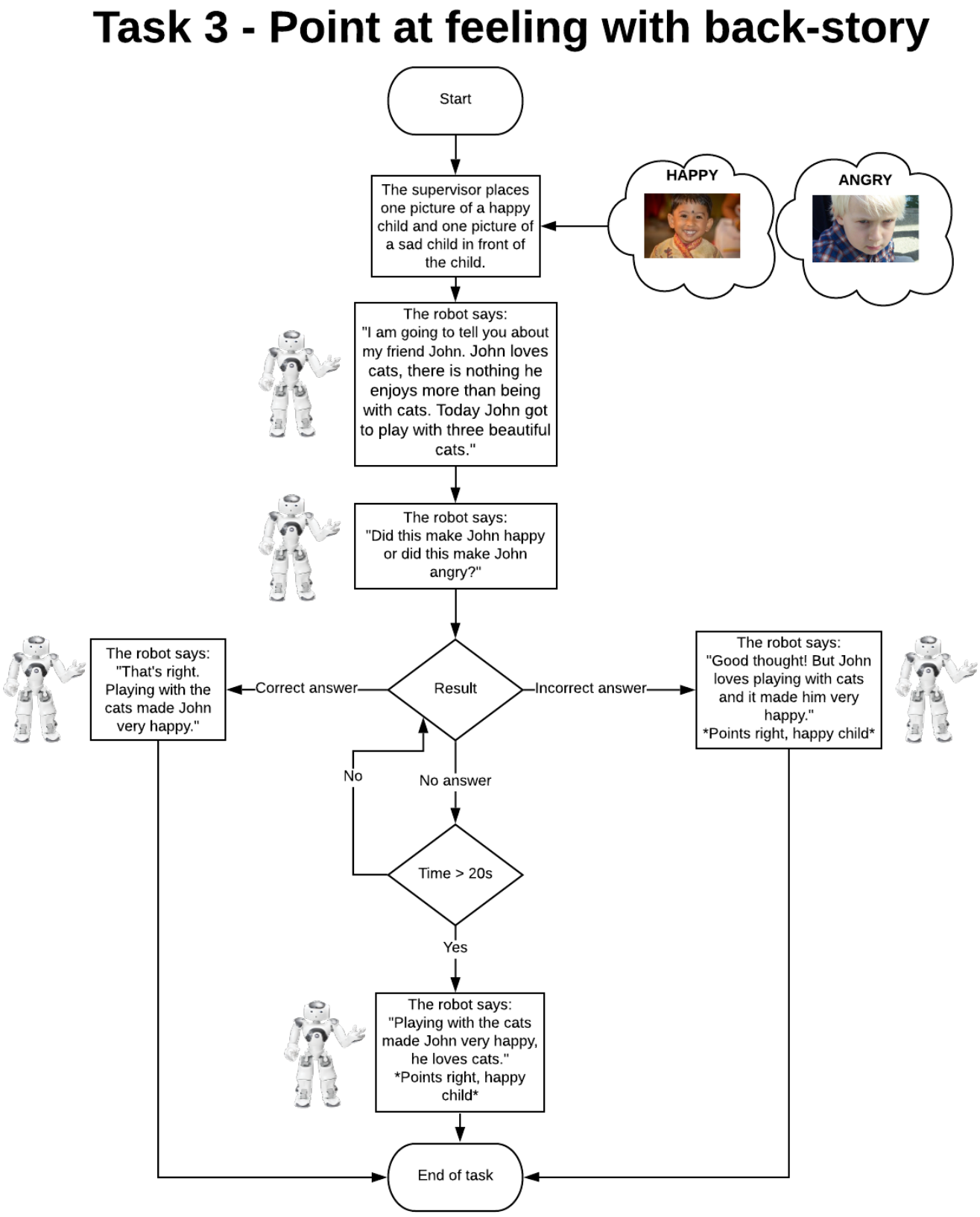

Figure 8: Task 3 flowchart. NAO robot, from [5] CC-BY. Happy child, from [8] CC0. Angry child, from [9] CC-BY.

Task 4

Intention of the task

The intention of task four is to train the child's ability to make a choice as well as try to make it interesting since it focus on the child's interest. The child has to make a choice of what vehicle could make the sound the robot plays up. The choice to include sound is to activate several senses.

Description of the task

The supervisor places four pictures of different vehicles on the table. The order of the pictures are irrelevant. The robot tells the child about a scenario and play up a sound of a vehicle. The robot then asks the child which vehicle she/he thinks passed by.

Child's response

Any answer in this task is correct. If the child answers within 20 seconds the response from the robot is happy and encouraging. If the child doesn't answer within 20 seconds the robot says:"Which of the vehicles in front of you do you think passed me by?" and plays the sound again.

Feedback

The child will receive encouraging answer on any response. If the child doesn't answer after 20 seconds the robot asks again and after that the child has 10 seconds to answer the question before the robot will continue with the next task.

Changes made from sprint 2

Small changes of the sentences have been made when NAOs pronunciations have been incorrect or inappropriate.

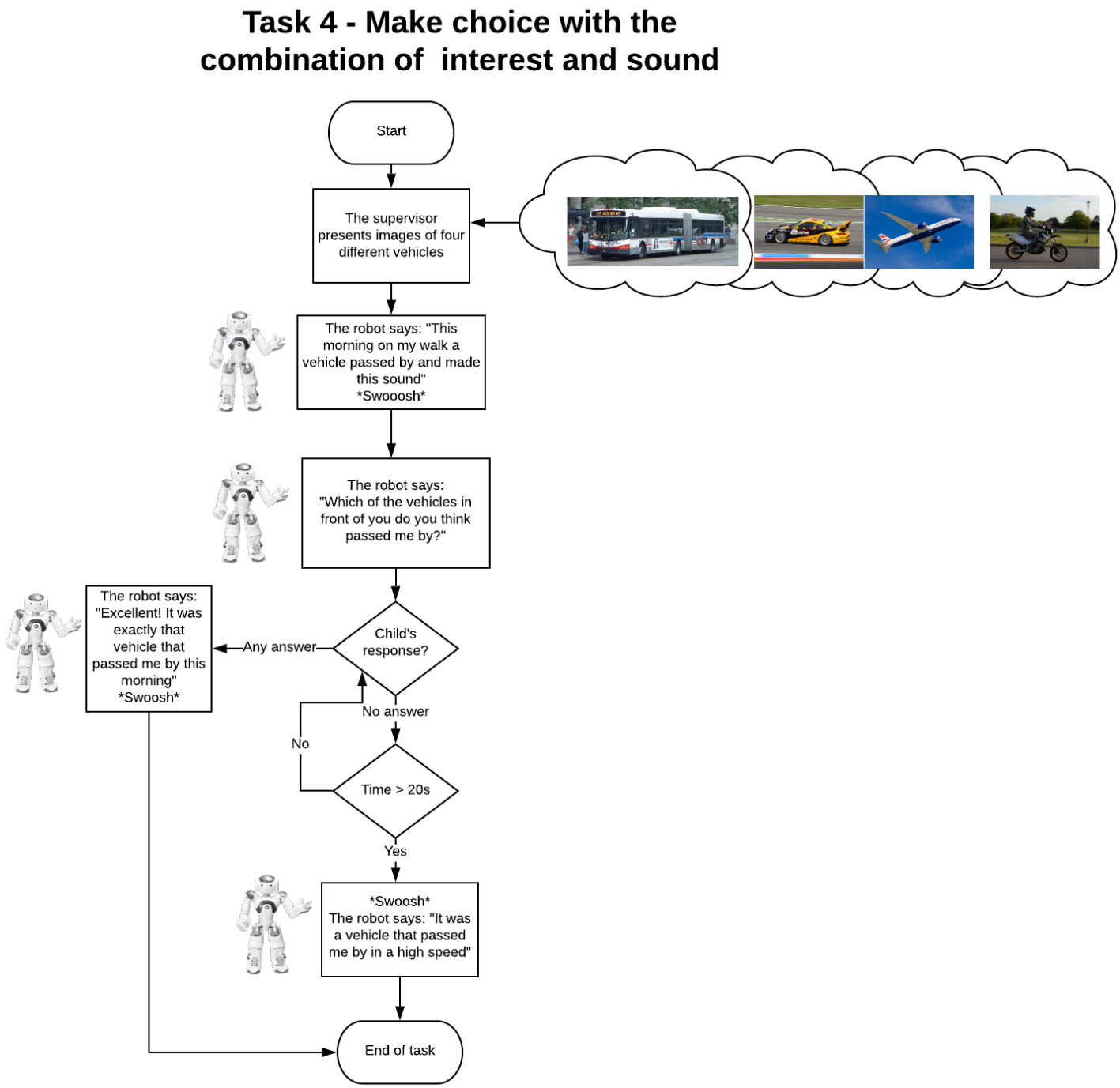

Figure 9: Task 4 flowchart. NAO robot, from [5] CC-BY. Bus, from [10] CC0. Car, from [11] CC-BY-SA, Airplane, from [12] CC0. Motorcycle, from [13] CC-BY.

Task 5

Intention of the task

The intention of the fifth task is to increase the child's ability to recognise feelings. The child first has to identify what feeling shown in the image a child is expressing and then decide which other child in the image is expressing that same feeling. The goal is to get more general understanding of how a feeling can be expressed.

Description of the task

The child is first faced with several images of children with different emotions. The order of the pictures should be from the robots' right to left happy guy, surprised child, sad child and happy girl. The child is told by the robot what the picture to the right, the happy boy, portrays but is not told what feeling the child in the picture is expressing. The robot asks the child "Can you tell me which one of these children feel the same way as John?".

Child's response

The child answers correctly to the question if he/she points at the picture portraying the other happy child or by words explaining that picture/child. If the child points at or describes another picture, that is seen as an incorrect answer. If the child does not answer the question at all within 20 seconds (neither by pointing at nor describing any picture/child), it is defined as no answer.

Feedback

The child will receive feedback for all answers but it will vary, depending on if it was correct, incorrect or if the child did not answer. The child is told what feeling the first child is expressing as well as which other child is expressing the same feeling.

Changes made from sprint 2

Movement of the robot has been added so NAO points on the different corresponding pictures while explaining them as well as gives a cheerful gesture when the child answers correctly. Two of the pictures have been changed to children with the same emotions as previously but to girls instead of boys. This to get more diversity of the children included in the session. Small changes of the sentences have been made when NAOs pronunciations have been incorrect or inappropriate.

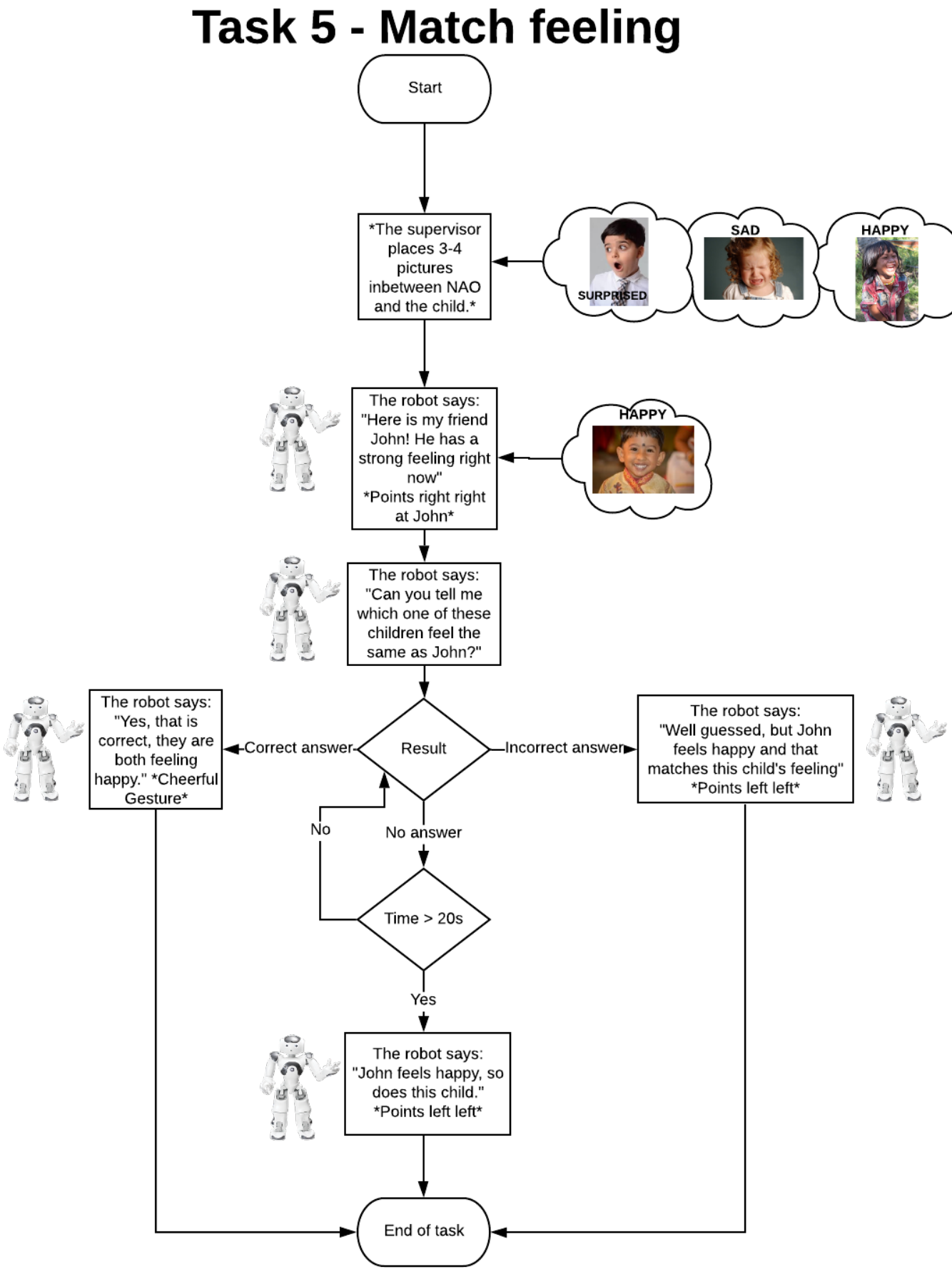

Figure 10: Task 5 flowchart. NAO robot, from [5] CC-BY. Surprised child, from [14] CC0. Sad child, from [6] CC-BY. Happy child (top), from [15] CC-BY-SA. Happy child (buttom), from [8] CC0.

Task 6

Intention of the task

The intention for the sixth task is to increase the child's ability to both make choices as well as recognise feelings. First of all the child needs to recognise it's own feeling during the session, and then choose the corresponding picture of a child that matches that feeling. This helps the child recognise how other children are feeling by referring to their own feelings.

Description of the task

The child is presented with images of other children who express different feelings. From the robots' right to left the order is a happy child, a sad child and an angry child. The child is told that he/she should point at the child who feels just like he/she does.

Child's response

The child could make three different responses. Either the child points at a positive feeling (happy, laughing, content), a negative feeling (crying/sad or angry) or the child doesn't provide any answer at all. If the child does the latter, the robot will encourage the child by providing clues such as describing all the feelings that are presented as well as pointing at them.

Feedback

Pointing at a positive feeling will make the robot react happily. Pointing at a negative feeling makes the robot sad, yet hopeful for a happier response next time. Not pointing at anything at all makes the robot point at a happy child and says that the next time they play this game they hopefully feel that happy.

Changes made from sprint 2

The robot now moves in this task by pointing on the different corresponding pictures while explaining them. Two of the pictures have been changed to children with the same emotions as previously but to girls instead of boys. This to get more diversity of the children included in the session. Small changes of the sentences have been made when NAOs pronunciations have been incorrect or inappropriate.

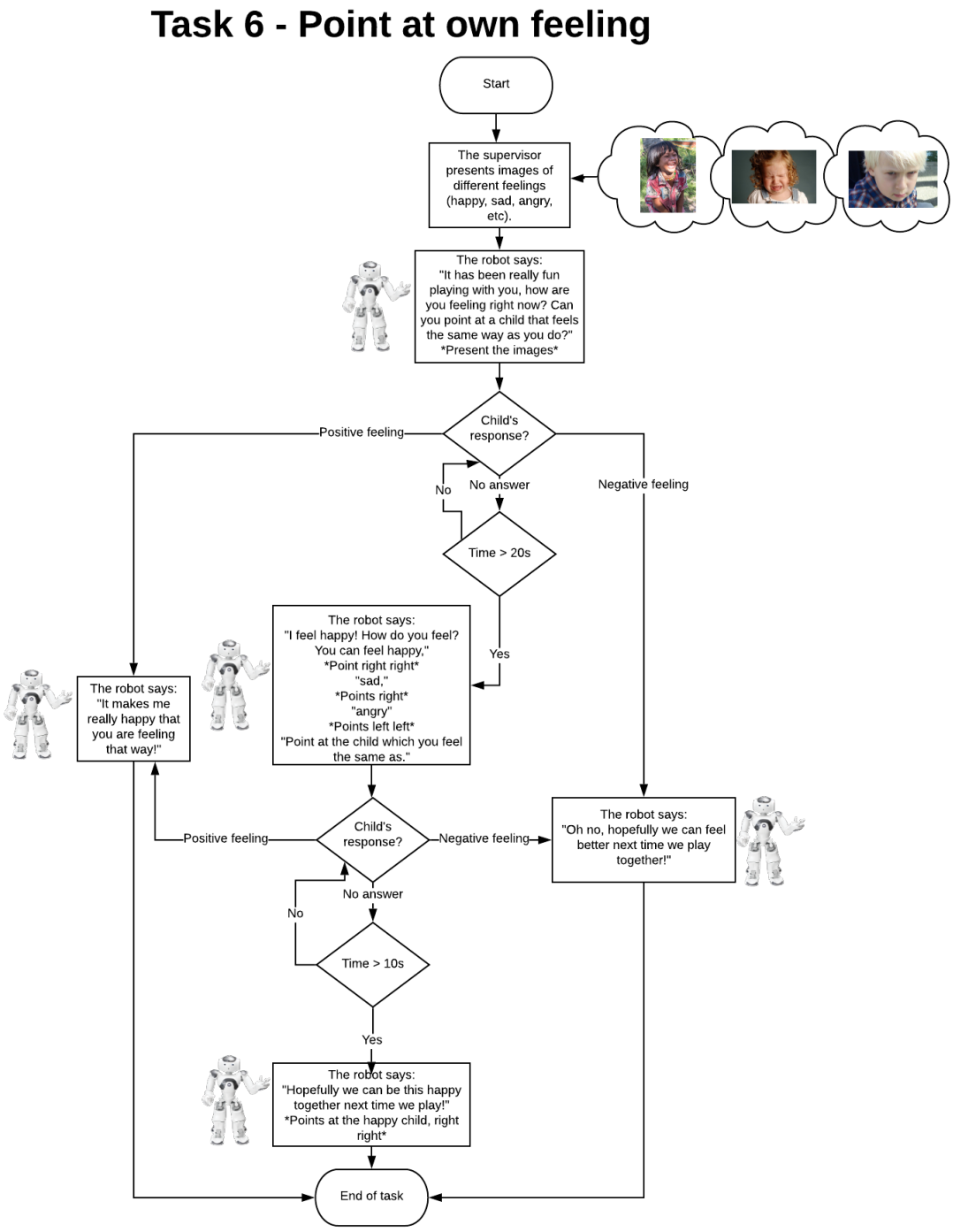

Figure 11: Task 6 flowchart. NAO robot, from [5] CC-BY. Happy child (top), from [15] CC-BY-SA. Sad child, from [6] CC-BY. Angry child, from [9] CC-BY.

Goodbye

Intention

The goal of the sub-routine *Goodbye* is to make it clear for the child that the session is over and tell him/her that he/she did a great job.

Description of the sub-routine

The sub-routine only consists of one part, where the robot tells the child that he/she did a good job. The name of the child is included, to make the child feel special. The phrase "Hope I'll see you soon again" is included to inform the child that it is possible to work with the robot again.

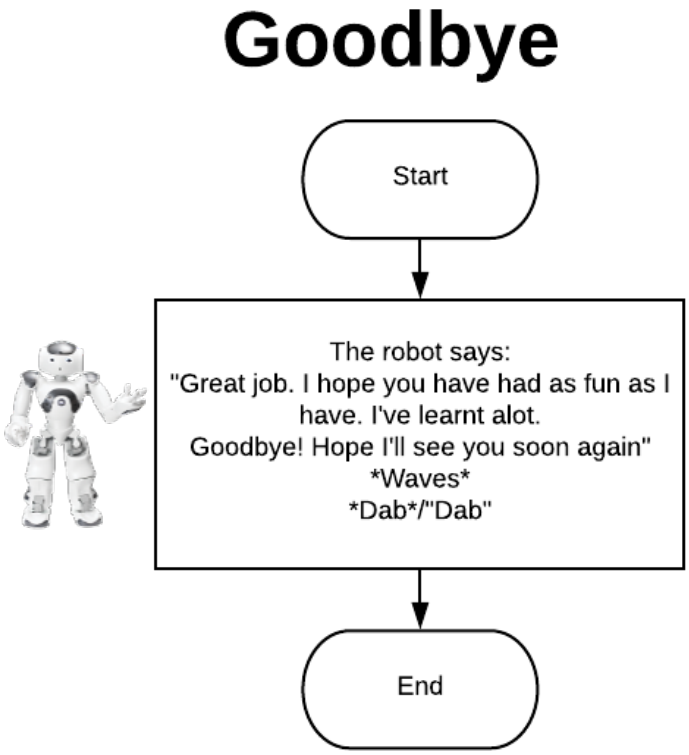

Figure 12: Goodbye flowchart. NAO robot, from [5] CC-BY

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Movie Sprint 3

The movie "*Session with NAO: Sprint 3*", created during the third sprint, shows an example of a session. The movie includes both the robot and the GUI and it can be viewed on the following link:

`https://www.youtube.com/watch?v=Fzp68hgYKAs`