Creating a Robot-Supported Education Solution for Children with Autism Spectrum Disorder

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Abstract. We introduce the ROSA project that aims to provide robot supported education in the areas of communication, language, and emotion for children with autism spectrum disorder. The background for the project is reviewed and the basic idea and components of the ROSA toolbox is presented. The initial project activities of the project so far have focused on ethical issues with having a robot assist in teaching children with autism, possible mechanisms for motivation, and performing an initial introduction of the robot to some classes. These activities have provided a good grounding for the future project work.

Keywords: Socially assitive robotics · Robots · Autism spectrum disorder · Children · Ethical reflection · Self-determination theory

1 Introduction

Autism Spectrum Disorder (ASD) is a disorder that is characterized by poor nonverbal conversation skills, uneven language development, repetitive or rigid language, and narrow interests in specific areas. Children with ASD can have difficulty understanding body language and the meaning and rhythm of words and sentences. This can lead to challenges developing social interaction and communication skills, which often form a basis for a child's ability to be independent and work and interact with people. Language skills are vital for education, expressing needs, and participating in society and work life [21].

Programs for improving the communication skills of children with ASD are recommended to: (*a*) begin at preschool and continue through school; (*b*) be tailored to the child's age and interests; (*c*) address communication and behavior; and (*d*) offer regular reinforcement of positive actions [8,20]. Special educators and teacher aids are often required to run these programs, but due to resource constraints, it can be difficult to recruit sufficient staff for these roles in all the schools that need them. Information and communication technology (ICT) resources may increase the quality of the children's support and reach additional children with ASD. We are currently working on a tool to support language development of children with ASD using social robots. Social robots interact

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with people in a natural, interpersonal way, and socially assistive robotics (SAR) assist people by using a robot for social interaction (speech, gestures, and body language) [19].

Robots can be a good match to help children with ASD as robots can elicit motivation, provide physical presence, and a more tailored experience than other ICT solutions [2]. Robots can provide teachers with new tools [12] and deliver predictable behaviors and repetitive feedback. In addition, a robot can help build social behavior skills, teach, or demonstrate socially desirable behaviors to children with ASD who have trouble expressing themselves. Another benefit is that robots do not get angry, tired, or stressed, and they can be tailored to the needs of a specific child and used repetitively [10]. A child-sized or smaller robot is less intimidating than adults, and many children with ASD therefore feel safer interacting with social robots [19]. Children with ASD who had trained with robots paid closer attention during interactions with adults long after the robot training ended [19], and children with ASD were more likely to complete a treatment session when the session included a robot [26]. Other studies reported improved social skills, increased involvement, more positive behavior, and better social interaction [7,10,17,24].

A review of robots in ASD interventions defined four categories of intervention goals: social, communication, maladaptive behavior, and academic skills [2]. Most current studies, however, target only one of these goals, and they normally target only one kind of social robot. Research is needed on how social robots in general can meet the challenge of targeting all or a combination of the goals, in particular combining supporting social skills with language learning. Robots have been shown to be effective in teaching knowledge and skill-based topics, but research is needed on how effectively they teach language [3,13]. To our knowledge, there are no studies of robot-supported development of primary language skills for children with ASD nor any attempt to make the lessons work on multiple kinds of robots. To develop robots in this field, technological and multidisciplinary research is needed in human-robot interaction (HRI), human-computer interaction (HCI), robot-assisted learning, privacy, and ethics.

Our overall objective is to *use social robots to improve language, social, and communication skills for children with ASD*. We are researching how to best apply a robot for this activity by involving teachers, parents, and children in the design process, and to develop a toolbox that the teachers can use to personalize lessons for children with ASD. To meet this objective, we need to understand what possible scenarios work well for teaching children in this diverse group using a robot.

This paper is meant to introduce our research and provide some preliminary results on some of our activities we have already done with the children, parents and teachers. We introduce the toolbox, our activities, and discuss our preliminary findings and where we are going next.

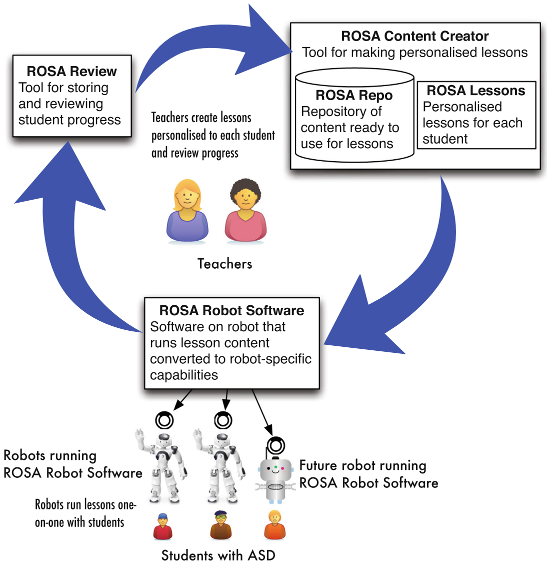

Fig. 1. The ROSA Toolbox consists of three parts: a content creator, software that runs on the robot for interpreting the lessons, and a review panel for teachers.

2 The ROSA Toolbox

We are working on building the RObot Supported Education for children with ASD (ROSA) toolbox to help meet our objective. The toolbox consists of three parts (Fig. 1): (a): ROSA Content Creator, a tool for teachers to easily create tailored one-on-one lessons for children with ASD; (b) ROSA Robot Software runs lesson content from the Content Creator customized to the robots' capabilities; and (c) ROSA Review, a tool for teachers to follow lesson progress and used as input for the next lesson. The goal of the toolbox is to make teachers more effective by providing tailor-made education plans for children with ASD and make it easy to follow the children's progress. For children with ASD, the toolbox's lessons will be tailored to their unique needs, increase the children's motivation for learning and result in children developing better language, social, and communication skills. The robot will present content customized to the robot's capabilities. The ROSA toolbox should provide tailored, motivating educational and communication support by exploring and exploiting the unique affordances of a social robot as an expressive medium and educational tool for children with ASD.

3 Understanding the Potential Users of the System

To ensure the success of the ROSA toolkit, we determined it was important to understand the different ways a robot can help with motivating children with autism. There are also ethical issues involved in having a robot assist in teaching the children. Before building a prototype of the toolkit, we gathered initial opinions on having the children and robot interact together. This activity also exposed some technical issues that must be solved.

3.1 Using Ethical Reflection to Understand Ethical Issues

Having a robot that is assisting in teaching children with autism forces to examine the ethical issues around this. We have chosen to use the *ethical reflection* model [1] to examine this issue. Ethical reflection is a planned and structured process to uncover ethical issues. It consists of six iterative steps. Step 1 states the problem. Step 2 asks what feelings are raised in the affected parties. Step 3 looks at the values and principles that are involved. Step 4 looks at potential laws or regulations that may be relevant. Step 5 examines alternatives that exist, their consequences in the short and long term, and how to prioritize the alternatives. Finally, in Step 6 after reflecting on all the information, one needs to decide what to do and state why. This includes looking at who is affected by the decisions, the consequences, what laws and regulations to consult, and making a plan to implement and possibly evaluate the measure.

As part of this ethical reflection, project partners and the scientific reference group were given a questionnaire that walked each person through the steps. An initial examination of the answers found general agreement on the goal that the robot should help improve teaching for children while taking into account each child's individual needs and the tension between keeping the lessons and robot reliable while doing iterative development on the lessons and robot. The partners discussed the challenge of getting proper informed consent and real user participation in the project from the children, teachers, and parents. Master students are further examining the answers from the questionnaires while the project is working on ways to increase participation with all the groups. We started the latter by presenting the project to the teachers and staff at our partner school and at parents' meetings. We have also held workshops with the teachers to find possible teaching scenarios that can be used to build the ROSA toolbox around.

3.2 Motivation and Motivation Mechanisms

Since the robot will serve as way of keeping children interested in the learning lessons, it is necessary to understand motivation and mechanisms that can help maintain or increase it. This has led us to examine different theories around motivation and how they relate to autism. There were three theories that are most often mentioned: (a) Theory of Mind (ToM) [27] (b)Social Motivation Theory (SMT) [6], and (c) Self-Determination Theory (SDT) [22]. The first two of these theories are in opposition to each other. ToM is the ability to attribute mental states to others to explain and predict behavior. Some argue that children with ASD have slower development of Theory of Mind. SMT is a combination from different disciplines and splits activities into different levels of social behavior, biological mechanisms, and evolution. For proponents of SMT, ASD is not an inability to develop ToM, but a lack of social motivation on all these levels. SMT, however, cannot explain all elements of ASD, something that critics have pointed out [11,18].

We have also investigated the general ideas of intrinsic motivation and extrinsic motivation and how these may be applied to learning goals and children with ASD [16]. Through our examination, we have found that SDT appears to be a good fit for how we should approach motivation in the project. SDT has its basis in the universal psychological needs of autonomy, competence, and relatedness [22]. SDT includes looking at intrinsic and extrinsic motivation through the concept of autonomous motivation and controlled motivation. Autonomous motivation is about having autonomy over your motivation and consists of intrinsic motivation and well-internalized extrinsic motivation. Controlled motivation is a collection of extrinsic motivation and some types of intrinsic motivation like ego. Some of this extrinsic motivation can be controlled through external factors, but also personal choice (self-determination). Applying this theory should mean that we take into consideration things that threaten the children's autonomy as this may ruin their motivation.

One way that we can build motivation it to try and tie rewards to things like circumscribed interests [14]. In addition, we have examined how other research projects have incorporated robots with mechanisms like games [15,23], music [25], unstructured play [4], and touch [5] into sessions between a robot and children with ASD and how well that can build motivation in the children. Our workshops with teachers have also provided some additional insights into how to incorporate these mechanisms into lessons.

3.3 Introducing the Robot to the Children

To get an idea about how the children would interact with the robot, we had the robot make a short trip to the school and introduce itself to the children. The robot, a Nao 5, was running a version of a language program that we have used in a different context [9]. Due to sickness and the pandemic, we were only able to visit a couple of classes, but the children in the classes seemed interested in the robot.

Even though we only could visit a couple of classrooms, it still provided us with a glimpse of some of the technical issues we needed to solve. The language program was not designed for the group of children and exhibited issues in speech recognition. This issue was compounded with problems in network connectivity, even when using the mobile network instead of local wireless, there were parts of the school where the connection to cloud services would drop or be slow. We also noticed some robustness issues with the communication between the robot and the software run on the phone. This provided insight into what needs to be considered to build a reliable system for the teachers and the children. Even though a program worked well in several other schools and group of children, it is not guaranteed to work in all situations.

4 Discussion and Future Activities

The activities so far in the project have shown the importance of including children, teachers, and parents in understanding the context and developing a solution. After several activities, there were challenges with getting all the participants on the same page, but this was solved through explanations. Using the collected information, we are beginning the work on creating prototypes and get feedback from the school about how well this can work in their classrooms. Otherwise, there are still issues around infection prevention during a pandemic. This is especially true for potential co-morbidities for some of the children at school.

On the technical side, there are still many issues that remain to be resolved. One of the biggest issue that we need to address is how to make the system easy to use for busy teachers and robust to problems with network connectivity. Also, while the software works on different generations of the Nao, we also have a goal that the software should work on different kinds of robots as well, and we are still looking to find the other robot.

Although there are many challenges that remain to be solved, we feel that anchoring our work in ethics, choosing a self-determination theory for modelling motivation, and including the school and parents in the design process should make it possible to overcome these challenges.

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