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Robot-assisted therapy: considering the social and ethical aspects when working with autistic children

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***Abstract*—When implementing robot-assisted therapy (RAT) for children with autism it is not enough to simply plan for the technology that will be used. This paper elaborates on the social and ethical implications that need to be taken into consideration when working with autistic children. A particular set of protocols is presented, and we discuss how we implemented those steps in an autism study with the NAO humanoid robot.**

I. INTRODUCTION

Autism is a lifelong developmental disorder that manifests itself with a wide range of cognitive disabilities [1][2]. Individuals who fall on the autism spectrum have an impaired way of sensing the world around them – they perceive other people differently, they sometimes develop certain repetitive actions and rituals, and they can be prone to some learning difficulties. Autism symptoms first present themselves in early childhood and impact the children's development of socio-emotional skills. Autistic children struggle with receiving and giving social cues, and being unable to interact with the teacher and their peers in the classroom makes it difficult to fit in with the class and learn new skills. For these reasons, autism therapy is most effective if started when the child is in primary school.

A prerequisite to planning a therapy is comprehending the symptoms autistic children might demonstrate in the classroom and at home, as well as understanding how they evolve into learning problems. One of the golden standards for early autism diagnosis is the DSM-5 manual of criteria [3], which categorizes the symptoms in two main groups:

1. *Deficits in communication and social interaction*: issues with socio-emotional reciprocity, non-verbal communication, forming and maintaining relationships
2. *Occurrence of restricted, repetitive actions, interests and behaviors*: repetitive speech, movements and/or use of objects, excessive adherence to routines and rituals, resisting changes, abnormally intense interests, hyper/hypo– sensory reactivity

From with these groups of symptoms, defectologists have extracted the following learning difficulties in school [1]:

- difficulties in extracting relevant cues and information, issues with attention span
- inability to properly express themselves via language
- difficulties with comprehending abstract thoughts and concepts
- impaired social cognition, inability to share and understand emotions, difficulties with imitation
- issues with planning, organizing and solving problems

These become the points researchers need to address in a therapy study if attempting to help autistic children overcome their learning and interaction difficulties. Making the learning process easier for autistic children means that the teacher has to present them with a minimal amount of social cues and information, display a great deal of patience when explaining abstract concepts to the child, as well as be able to calmly repeat the instructions several times if needed. These are precisely the kind of requirements which first gave way to the idea for using a robot as an educational toy or substitute teacher. With their sensory and social simplicity, robots are safe and friendly objects from which autistic children can benefit greatly while playing or learning [4][5].

Many humanoid robots have been used in studies for autism-related RAT – NAO, Kaspar, Troy, the Lego NXT Mindstorm robots. While all have been implemented in RAT, there have been some subtle differences - implementing a robot as a substitute teacher [6,7] **vs.** using the robot as a reward for successfully learning something with a human teacher [8]; having sets of different exercises targeting several areas [6,7][9] **vs**. engaging in a continuous turn-taking imitation games [10,11]; having the robot follow a strict set of modules with no modifications [8][11] **vs.** taking the modular, individualized approach where the robot's actions are tailored to fit each of the children's specific needs [10][12]. As evidenced, there are many ways the robot van be programmed to fit the needs of the RAT study, but that is only one of the steps in the process.

II. NONTECHNICAL ASPECTS OF HRI STUDIES

Any study that has a human-robot interaction (HRI) element in it (and even more so when the target group are children) has got to carefully consider the nontechnical questions that might be raised before getting to the main programming stage. In our paper, we discuss the two major groups of implications in detail:

1. Social aspects

Planning to implement a humanoid robot as the social component in an autism therapy plan questions the point of what can be considered as a social robot. Several definitions

exist on this subject, differing only slightly by the list of requirements about the robot's abilities [13]:

- ability to interact and communicate with humans while following their social and behavioral norms
- ability to express and perceive human emotions, communicate with high-level dialogue, use natural cues (touch, eye gaze, gestures), establish and maintain social relationships
- ability to imitate human or animal behavior and communicate (verbally or nonverbally) on several levels – tactile, kinesthetic, sensory, emotional, cognitive and social

These criteria encompass most of the requirements for a socially assistive robot, but in addition to them there's one more feature that needs to be considered - safety. For the robot to be engaging to the autistic child it is not enough to simply fit the social expectations about its interaction abilities, it also needs to have a friendly appearance, to not be physically imposing (i.e. to be the size roughly of a human toddler or slightly larger), and to have plainly colored and sturdy body that will be the right balance between too mechanical and too humanoid. Following these basic requirements for a robot in autism therapy ensure the children will find it engaging [14].

2. Ethical aspects

There are several distinct issues from an ethical standpoint when implementing humanoid robots in autism-related RAT:

- *Level of emotional attachment* – autistic children might develop emotions and attachment for the robot if they are led to believe it is an independent being capable of intelligent interaction and attachment [15]. This is even more observable in studies where the robot interacts autonomously (i.e. the modules are fixed and there's no human controller present), or in cases where there is total teleoperation of the robot. The children getting attached to the robot and then having the study end might be detrimental to their health and undo all the previous work. This is solved by following an approach where the child clearly perceives the robot as a friendly educational toy instead of a substitute for a human friend.
- *Use of robots in as human substitutes in therapy* – there are studies done on the general population about whether it is ethical for robots to be included in therapy with children, and whether it is ethical for robots to replace humans in therapy and teaching [13]. The results show that while a large percentage (85%) agree that it is ethically acceptable to include robots in some way in therapy, only 26% agree that the robots should serve as replacements for the human teachers in therapy, and instead insist the robot be completely teleoperated or used as a toy.
- *Standard ethical protocol in HCI/HRI studies* – when working with any group of human participants in these kind of studies, the target group needs to be briefed on the standard ethical guidelines and protocols [16]. Namely, all of the participants need to agree to join the experiment of their own free will (in studies such as ours, the parents give consent for the children), they have the liberty to exit at any point they might wish to, their safety and wellbeing are guaranteed, and all of the data collected during the study is confidential and if used in publications the privacy of the participants is of the highest priority.

III. IMPLEMEMENTATION

From the previous section it becomes evident that a more formalized approach is needed when attempting an RAT study in order for all of the abovementioned issues to be addressed. Shamsuddin et al [17] have proposed a structured set of ten procedures to be considered when embarking on a RAT study. For our project, which was on a smaller scale (six children and lasting eight weeks), we loosely combined the ten steps in six distinct groups of procedures to be used as guidelines. The steps were planned out as following:

A. Establish aim of HRI and form a multidisciplinary team

Our aim with this study was to try a new approach to help autistic children with learning. A motivational factor here was that in our country there is still strong stigma against mentally disabled people (and children in particular), which incentivized us to help the children overcome some of their learning and communication difficulties via robot-assisted therapy. The multidisciplinary team we formed consisted of roboticists, defectologists from the center for assistive technology "Open the Windows" who helped us select our participants, and the children's parents.

B. Subject selection based on diagnosis and other criteria

Since this was going to be a study focusing on robot-assisted therapy for autism, the only inclusion criteria was that the children fall somewhere on the autistic spectrum. Since we selected our participants from the children that were already visiting the center for regular therapy, we knew for each of them their autism diagnosis, and the defectologists selected the initial group of eight children for the study. The two exclusion criteria we had were extreme fear/discomfort from the robot and insurmountable language barrier, for each of which we excluded one child. There was brief consideration whether to have physical disabilities as a third exclusion criteria, but we reconsidered and just adjusted the exercises for the children who needed it.

C. Ethics approval, briefing and consent from parents

The ethical issues noted in the previous section were all discussed and addressed with the parents and the defectologists. The decision to have an engineer and a defectologist present at all times and be visibly interacting with and controlling the robot was consciously made as to diminish the effect of the robot being perceived as an independent being. The other ethical concerns were addressed by communication with the parents directly: the children had complete liberty to leave the study at any point, the use of their personal information was strictly controlled – the parents requested for

the children to be referred by their initials instead of their full names and allowed us to disclose their ages, nationality and gender, as well as any other medical conditions the children had for the purposes of further results analysis.

D. Assessment of needs and robot programming

Our study followed the modular approach - we started with a fixed set of exercises and then adjusted them mid-classes according to each of the children's abilities and reactions. The technology used was the NAO humanoid robot. The modules were designed in accordance with the specified requirements from the defectologists. The modules consisted of exercises for improving communication and interactions skills, exercises concerned with the concepts of body awareness and possession, exercises for improving spatial awareness and orientation, and exercises for understanding the concept of colors. The exercises were designed so as to include all of the important features needed for autism therapy – turn taking when interacting, imitation games, physical exercises, tactile elements, introducing new concepts via easily understandable commands, and focus on learning proper interaction protocols.

E. Child-robot interaction in experimental set-up

The classes spanned over eight weeks and took place in the center's classrooms where the children had their usual therapy classes, taking up either the first or last 10-15 minutes from their normally scheduled classes. Each child was accompanied by their defectologist, and at the beginning by one or both parents as well, with the goal of providing them with a familiar and safe environment, and to downplay the possibly frightening effect of meeting NAO for the first time. NAO was seated on a table in the classroom facing the child and the other people present and it performed the exercises interactively with the child, while a roboticist was connected to NAO via laptop and monitored the situation for any modifications needed.

F. Data analysis

When planning the exercises we also had to plan what kind of approach would we follow for results evaluation. Attempting a strictly quantitative analysis model is difficult in any child-robot study, and even more so in autism studies. In the end, we went for a mixed method approach – quantitative measurements were taken only in regards to the time it took the children to complete a whole set of exercises, whereas the qualitative analysis was performed mid-classes and amounted to monitoring the children's reactions to the robot and the exercises, with the purpose of being able to quickly adjust the modules if needed and help the children accomplish them faster and with more ease.

IV. Results and Conclusion

By adhering to the protocol steps we explained above, we minimized the possibility of any complications that might have occurred in an experiment with a target group as specific as ours, while simultaneously ensuring an improvement in the children's abilities. The positive outcome of our experiment was also due to our multidisciplinary team, which even though brought in more factors to consider in the planning phase, was still a crucial point towards achieving a more balanced project.

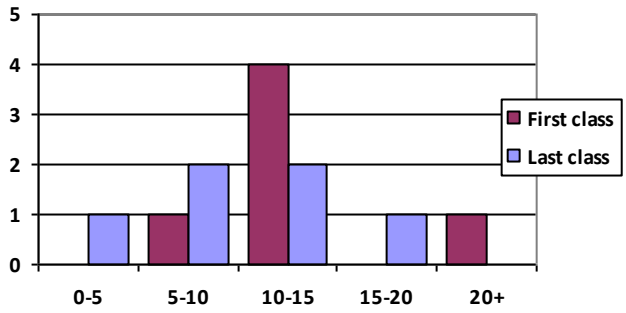

Fig. 1. Comparison histogram of the children's performance evaluated in amount of time (in minutes) for exercise completion.

Figures 1 and 2 show the results we obtained from our quantitative evaluation, illustrating the differences between the time (in minutes) it took the children to complete the set of exercises in their first and last class with NAO. The positive change is easily observed – while at the beginning most of the children needed at least 10-15 minutes to finish the exercises, by the end of our study half of the children finished them in less than 10 minutes. Additionally, what we noted with all of the children was a decreased fear from NAO and increased interest in engaging the robot by themselves.

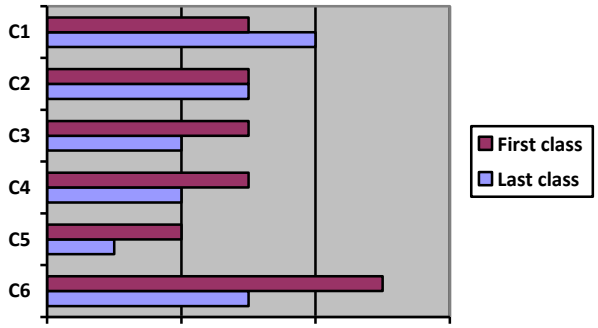

Fig. 2. Comparison of the first and last class performance for each child.

In this paper, we sought to demonstrate how considering all the different aspects when embarking on an RAT study can positively influence the outcome. By carefully defining and following our guidelines in the planning phase, we ensured that the eight-week long experiment went without any obstacles and negative developments, and we ultimately reached our goal, which was to help the children in our target group improve their learning and communication abilities.

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