Can Social Robots Actually be Used in Special Education? Designing an Easy to Use and Customizable Game for Robot Therapy for Children with Autism

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***Abstract*— Using social robots in therapy for children with autism spectrum disorder (ASD) has proven to have positive effects on diminishing ASD-related symptoms. Yet, the uptake of these robots in social therapies is low, due to high workload and different priorities of the therapists. The aim of this research was to increase the usage of robots in therapy for children in autism, by introducing a robot-supervised activity which requires low effort from the therapists. As a result, this paper features the design of a boardgame that is supervised by a NAO robot. The game includes elements of Pivotal Response Treatment (PRT). Within the game, through different assignments, the children can develop their social skills in a fun and playful way. The game is designed from the perspective of non-technically skilled experts, like occupational therapists. Differently from existing efforts that mainly focus on end-user programming, we propose design solutions to make it easy for these professionals to use the robot. A user confrontation shows that this proposed robot-supervised game allows the therapists to fully focus on the therapy and the development of the children. Guidelines of how to design robot-based therapy–ready games are proposed.**

***Keywords*—Robots for Children with ASD, Tangible games with robots, Uptakes of robots in therapies.**

I. INTRODUCTION

The use of social robots can be very diverse and has multiple different possibilities, such as being used in educational or therapeutic context, or being used to enhance the social interaction and wellbeing of a person [4] [6][16][20]. Enriching educational and health-related applications of robots with social rewards is especially important because both health and education should be personal and reassuring for people. Several good developments in this direction exist [3][4][14][15][23], however most remain restricted to the research environment and are not yet implemented in the everyday practice of therapists and educators.

This research is inspired by the challenge which occupational therapists at the institution for children care, Levvel[1], were facing. They were convinced to purchase a ZORA robot (which is a NAO robot equipped with an additional software layer from the ZoraBots company) to use in their therapy for children with autism spectrum disorder (ASD), but unfortunately, they stopped using this robot. This is actually a common problem - the companies see an opportunity to sell robots if they develop a software that makes the robot a bit easier to use, and they apply a strong marketing strategy to sell the robot. However, research on how to successfully introduce the robots in practice is lacking behind. The major efforts in this direction are to develop end-user interfaces that are thoroughly tested and re-designed, such as [2][11][17][18][25]. We take a complimentary approach to use design methods to create existing technical solutions to fit better in the daily practices of the therapists. This proposed approach needs to deal with the implementation challenges of robots, such as the busy schedules of the therapists and being occupied with many children and tasks, which previously caused them to stop using the robot.

Next to the above-mentioned challenges there is also a lack of products (add-ons) which therapists can use in combination with a social robot, so the robot can engage in embodied interaction, and not be solely used as a conversational partner. There are many studies which have shown that the application of robots in different domains is useful yet, when searching for products, it seems like all designs, which are previously made, are solely for a specific research purpose. Therefore, our aim was to develop easy to reproduce products and robot behaviors to increase the potential use of the robot in therapy for children with ASD. The activity should support both the therapists in their training routines and the children in the development of their social skills. This should be an additional tool which complements the training provided by the therapists and supports them to use the social robot.

To answer these requirements, we designed the robot-supervised game: Robot & Me. This game has been designed through a collaborative design process together with the occupational therapists of Levvel. Robot & Me is an easy-to-use, robot-supervised game which allows children with ASD to train their social skills and does not require additional effort from the therapists (e.g. controlling the robot). This means that the therapists can fully focus on the training of the children [19]. The robot will guide the players through the game, by introducing the game and explaining the different assignments. A social therapist will mediate between the children to encourage social interaction, to

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support the training of social skills, such as understanding emotions and asking questions, in a fun and playful way.

II. Related Work

A. Autism Spectrum Disorder

Autism spectrum disorder (ASD) is a developmental disorder which affects the social interaction, behavior flexibility and communication abilities of a person [10][24]. Behavioral therapies are the most effective practices to help people with autism to improve these skills. Pivotal Response Treatment (PRT) is a therapy in which the focus lays with different key areas (pivots) [22]. These key areas are: motivation, response to multiple cues, self-management and initiation of social interaction [5][23][28], and if trained, improvements are seen across other areas of social skills, communication, behavior and learning. PRT therapy requires high levels of personalization to each child and is most successful when provided at a young age [27].

B. Social robots and ASD

Social robots are being used in multiple application areas, but one of the most promising remains to be training of persons with ASD [13]. There are multiple reasons of why it is interesting to investigate the possibilities of implementing social robots in therapy for children with autism. At first, contrary to people, robots are predictable, and they mostly do not have dynamic facial expressions and eye movements. This may decrease the threshold of the interaction with the robot compared to humans [9] and makes robots appealing to children with ASD [5]. Using humanoid robots rather than social robots with other embodiment can be more helpful in social skills training for children with ASD, because these robots resemble humans, and can bring to generalization of the learned skills to real-life social interactions [2]. The study of Robins et al. showed that the usage of a social robot Kaspar over a longer period of time, helped children with ASD to develop their social skills [26]. Newer studies performed randomized controlled trials that proved that the use of robotics in PRT is an effective treatment component in diminishing ASD-related symptoms and improving general clinical functioning in young children with ASD [5][23][28]. Based on the potential of these findings, we can conclude that there is a need to integrate the use of social robots in therapy for children with ASD in the routines of the therapists.

C. The robot platform and programming

The social robot used in this project is the humanoid-robot NAO (Figure 1), with software that can be controlled with the custom-provided Choregraphe programming environment, enhanced by an additional software layer build by ZoraBots Company. The ZORA software layer is targeted on healthcare applications and provides a tool for healthcare personnel that is intended to easily program and control the robot [21][29]. Several other more advanced software solutions that aim easy use of robots by end-users, as well as some advanced end-user development tools such as TiViPE software, have been successfully used in health applications [2][3][5][28] and as an end-user programming tool [7][8]. Other software solutions exist that aim to make the robots more accessible to end-users, see for instance [11][18][25]. With the current study we aim also to help companies who develop software for end-users by providing a process and content that the ad-hoc developed software can be useful in practice and be used independently by therapists.

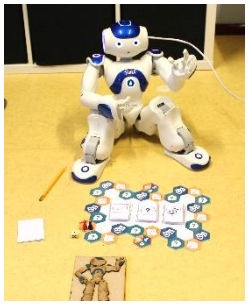

Figure 1. The set-up of the Robot & Me game including the NAO robot.

D. Social robots and therapy design

Many studies focus on the design of social robots [1] [9][13], yet all of these studies propose new ways to design robots or to design new robots to use in different application areas e.g. therapy for children with ASD [9]. Other research utilizes existing artefacts in combination with the robot, to facilitate therapy [3]. There has been little focus on designing add-ons for robot interaction. We argue that the usage of social robots can be enhanced when introducing designs that make the interaction with the robots more embodied, and thus engaging for children, since it will provide opportunities for natural and tangible interaction.

III. Robot & Me Design

The aim of the research described in this paper is to increase the usage of social robots for the specific context of PRT therapy, by designing add-ons and interactions aiming to enrich the human-robot interaction, without increasing the programming complexity of the robot. We designed the Robot & Me game, which is supervised by a NAO robot, equipped with ZORA software, and allows social therapists to provide a tool that helps children with ASD to develop their social skills in a fun and playful way.

First, we defined and observed several challenges which the social therapists experienced when working with the NAO robot. The most important one is inability to work with the robot, due to being non-technically skilled and being occupied by other activities and therefore not being able or interested to dive into the controls of the robot. The biggest disadvantage the therapist saw in the use of a robot with the ZORA software was that two persons were needed to perform an activity with the robot and the children. As most activities require the use of a text-to-speech module to

make the robot talk, one person was needed to control the robot and another person was needed to guide the children. Therefore, the main objective of the design should be the ease of use of the robot, allowing the therapists to use the robot more often during therapy.

A. *Robot & Me game*

Robot & Me is a multi-player game consisting of a board game and a puzzle which will provide an opportunity for the children to learn about turn-taking and working together [3][12]. The game is played between a child and the robot and possibly other children or caregivers/therapists and consists of a gameboard and a puzzle. The goal of the game is for the players to collect all the pieces of the robot puzzle (Figure 2), each piece of the puzzle is obtained after completing an assignment from the gameboard shown in Figure 3.

Each space on the gameboard (Figure 3) relates to an assignment named Asking, Acting or Drawing. The design of all assignments is inspired by the PRT therapy. Table 1 shows the instructions for each assignment, as given by the NAO robot, and its relation to ASD therapy.

Figure 2. Two different version of the robot puzzle.

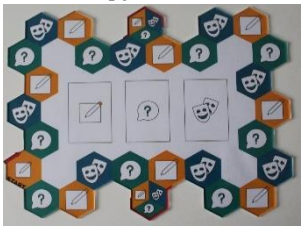

Figure 3. The gameboard. Every icon represents a category of the assignment.

After rolling the dice and moving the pawn accordingly, the player will get an assignment card which corresponds to the space the player has landed on. The player will scan the QR-code on the back of the assignment card (Figure 5), which will initiate the robot to explain the assignment. Once the therapist decides that the assignment has been executed well (depending on the skills of the child) the therapist will press one of the sensors of the robot. The robot will finalize the assignment with a compliment and a (funny) remark and the player will get to choose a puzzle piece. Once the puzzle is finished, the game ends.

Figure 4 shows a flowchart of the game. Color coding shows which actor takes each action at different moments in the scenario.

Table 1. Categories of the assignments of the game, their instructions and relation to the provided therapy.

Assignment	Instructions	Relation to Therapy
Asking	*Can you ask the other player something about…? (e.g. family, school, sports etc.)*	Develop self-initiation and learn to ask questions to someone else [22].
Acting	*How do you express yourself when you are…? (happy, sad, angry etc.)*	Learning to understand emotions and how you and others react [22].
Drawing	*Draw the word on the assignment card, the other player has to guess what you are drawing by asking questions.*	Developing self-initiation and asking questions [22].

B. *Ease of Use*

To ensure that using the robot would not be complicated for the therapists, we focused on the ease of use of the design. We will discuss in the following paragraphs how this has been taken into account.

1) *Ease of use for social therapists*

As observed by De Haas et al. [19] due to the occupation of the occupational therapists and the presence of multiple children during the therapy, the therapists do not have the time to both focus on the development of the child and to control the robot at the same time. While De Haas focused on increasing the autonomy of the robot, we explored how a good design can optimize and simplify the interaction. For instance, in order to limit the use of text-to-speech interaction, which is slow and prone to typing errors, we chose to work with QR-codes, which are used nowadays in many applications, such as internet banking and others, so most adults and even children are acquainted with their use. The different interactions of the robot that include speech and movement combinations, can be pre-programmed, and downloaded as a QR-code. Each QR-code is presented on a card that can be scanned either by the child or by the therapist (Figure 5). The robot scans the code and will perform the interaction which links to the code. This allows the therapists to focus on the children, rather than on controlling the robot. An example interaction is described in Table 2.

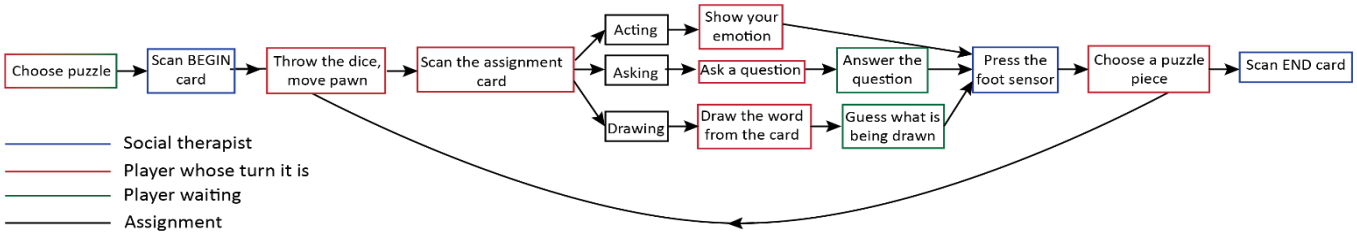

Figure 4. Flowchart of Robot & Me game. The color coding depicts the terms of the different actors. The interaction can be extended to multiple players.

Table 2. An example assignment in the category Acting. The behavior is pre-programmed in the ZORA software. The animation behavior uses pre-programmed actions from the ZORA software, such as being angry. The action 'Emotion animation' allows NAO to use its hands while talking, which makes it more natural. The audio is what NAO says with a consistent speech tempo and volume.

Behavior NAO	Action NAO	Audio NAO	Relation to the game
Speech	Emotion animation	You have the assignment Acting. How do you act when you are angry?	Explain assig-nment
Wait	Wait behind left- or right foot sensor	-	-
Speech	Emotion animation	Well done! I can be angry at times as well. When I'm angry I act like this.	Compliment and react to assignment
Animation	Sitting	*'Emotions – Negative Angry 1'*	-
Speech	Emotion animation	You may get a puzzle piece. The next player may take its turn.	Finalize assignment

2) Design for flexible use

To allow the therapists to fit the game into the therapy of different children, the game was designed to be flexible in several ways. The gameboard was designed to only have a beginning and no finish (Figure 3), therefore the duration of the game is flexible, depending on the number of puzzles which will be completed. Other puzzles can be used with the game, that can be related to the child's interest. Next to this, to adapt the game to the specific needs of the child(ren), the therapist can choose to vary the number of players (e.g. play in teams, act as a player in one-on-one training or have multiple children in the game), shift the focus of the assignment and/or add extra challenges to the assignments (e.g. start a conversation based on the assignment or let the other players react to the assignment as well). Additionally, a guide on how to add and change the assignments was provided to the therapists, allowing them to adapt the game to the wishes and needs of an individual child.

IV. Pilot Tests and Outcomes

The game was piloted in several settings. Here we will discuss the outcomes of the tests and the proposed design guidelines for designing add-ons for robots.

A. Explorative testing with social therapists

The game was firstly played with three occupational therapists, a snapshot of the test is shown in Figure 5. The aim of this test was for the therapists to get familiar with the game, to understand how they are supposed to interact with the robot and to provide an informed opinion whether the children would understand and enjoy the interaction. The occupational therapists reported that the working of the game was easy to understand and to execute. They shared their predictions of how the children would react to the game and to the actions and utterances of the robot. This sparked new ideas for the therapists of how to start using the robot.

B. Confrontation with the children

The Robot & Me game was also played with the children at Levvel (Figure 6). This play session was the first time for the children to see and interact with the robot. This also generated a lot of enthusiasm for the children as they had never seen a robot before and were intrigued by its abilities. What was seen during the game was that the children understood what was expected of them. They were able to scan the QR-codes and execute the assignments. The therapist who was present noticed that all children liked playing the game, even the children from whom she was not sure at first whether they would like to play it.

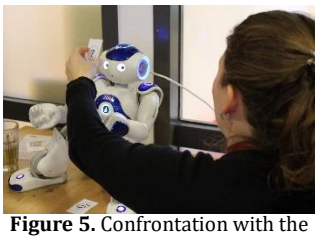

Figure 5. Confrontation with the therapists. One of the therapists scanning the QR-code.

Figure 6. Confrontation with the children.

C. Design guidelines for add-ons for robots

This research provides an example of how to easily increase the usability of the robot by designing add-ons for existing robots and not by increasing the autonomy of the robot and therefore the programming complexity. These add-ons should be designed with a clear purpose and for a defined target group in order to ensure that the design will fit the purpose. In our case, a game that is flexible to personalization and easy to reproduce. Here we will discuss some guidelines to design add-ons to support robot-human interaction.

1) Using the strengths of the robot

When designing an add-on for a robot, one first has to explore the existing features and how these can be used for the designated purpose. In our case we used the ability of the robot to scan QR-codes and response to touch of its sensors. By scanning the QR-codes we were able to avoid having to use text-to-speech teleoperation by the therapists, so they can devote their attention to the training of the children, rather than controlling the robot. The usage of touch sensors allowed us the pause the behavior of the robot and to continue when touching one of these sensors. This allowed us to only use one QR-code per assignment and integrating all elements of the assignment (explanation of the assignment, compliment, and finishing the assignment, see Table 2) in one behavior. This also reduced the number of actions needed to control the robot during the game.

2) Fitting the activity to the context

The add-on should fit the intended activity which it should support or substitute. In our case, the game supports social skill training for children with ASD. Through collaboration between the designer and the social therapists, the whole game was designed for specific

purposes, which are listed in Table 1. All assignments relate to the PRT therapy which is used at this institution. Since the game is made for multiple players, the children will have to collaborate to collect all of the puzzle pieces and they will learn to wait for their turn, which is not related to this therapeutic method but an important skill for these children. The presence of the therapist also encourages a more in-depth discussion with the children about the execution of the assignment.

3) Long-term use

The users of the activity will continuously change. Eventually, new therapists will come to work at the facility, as well as interns can be employed. Additionally, different children will be subjected to therapy, all with their own level of development and set of challenges to learn skills. To ensure that the activity will fit each user, a way to adapt the game should be introduced. For the Robot & Me game, a handbook was written containing information about the interaction with the NAO robot, equipped with the particular software, and a manual of how to control the robot and how to adapt the game. This is an additional way to supporting the social therapists and encouraging the use of the robot during therapy.

V. Discussion

We presented a design-based approach to reduce the ease of use and increase the flexibility towards personalization of social robots in therapy settings. The add-ons and interaction design guidelines that aim to ease the uptake of robots in everyday practice of occupational therapists were proposed. The Robot & Me game was developed, and user confrontations showed that it is fully experiential and can easily be played with both occupational therapists and children diagnosed with ASD and this concept can easily be reused with other robots that have QR scanning function and in different facilities for training children with ASD.

By motivating children to play games that are especially designed to target specific skills, they may willingly work on developing their social skills by executing the different engaging assignments. The ease of use of such a game can also motivate the therapists to invest time and use the robot during therapy, despite their busy schedules. Further research should test the usability and the engagement with the game by different children and caregivers. Next to the proposed design approach to ease the uptake of social robots in everyday practice, we believe that increasing the autonomy of the robots and making robot programming more user friendly remains the main road towards the actual use of these robots in practice.

VI. Conclusion

Robot & Me is designed to be an addition to the social skills therapy provided for children with ASD. The game has been designed in collaboration with social therapists from the facility. Their previous experience with the NAO robot equipped with ZORA software was taken as baseline for this project, and may differ with other software and programming interfaces, as reported in [3][7][8][11]. The aim of this research was to propose a design method to increase the usability and the user experience with social robots with the available technology and end-user programming tools.

We have developed a single game that does not require a lot of preparation or additional tasks from the therapists. The game can be used in different contexts and number of players, so it provides an example of how to use readily existing features of the robot to create novel games and interactions.

We can conclude that designing add-ons to existing robots is an easy way towards successful enrichment of the interaction with the robot as an additional dimension to the development of robot autonomy.

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