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Getting Engaged: Assisted Play with a Humanoid Robot Kaspar for Children with Severe Autism

Tatjana Zorcec[1(✉)], Ben Robins[2], and Kerstin Dautenhahn[2]

[1] University Children's Hospital, Skopje, Macedonia
tzorcec@gmail.com
[2] University of Hertfordshire, Hatfield, UK

Abstract. Autism is a developmental disability defined as deficits in social communication and interaction and presence of restricted, repetitive behaviors, interests and activities. A recent study from April 2018, estimates autism's prevalence to be 1 in 59 children. The symptoms are manifested as continuum or spectrum, from mild to severe manifestations, demanding different degrees of support in the daily life. Children diagnosed with autism may benefit from early interventions when adjusted to their specific needs. The aim of the study described in this paper was to explore the possible added value of the humanoid robot Kaspar as an intervention tool, in therapeutic and educational purposes in children with autism or robot-assisted play in the context of autism therapy in a hospital setting. This paper provides case studies evaluation of some interaction aspects (i.e. learning basic emotions (happy and sad) and social skills (greetings) etc.) between two young children with severe form of autism and Kaspar. An observational analysis of the skills and the behavior of the children was undertaken across the one year trials. They interacted very fast and quite spontaneously with Kaspar which made a solid ground for achieving our goals-social communication skills as greetings, social interaction skills as eye gaze, learning emotions etc. Our preliminary conclusion is that children are learning in this robot-assisted play, enjoy interaction with a robot, gain and learn quick new knowledge, show much more communication, initiative and proactivity, improve their behavior and generalize some of the learned information in real life.

Keywords: Robot assisted play · Child-robot interaction · Autism

1 Introduction

Autism spectrum disorder (ASD) is a developmental disability defined as deficits in social communication and interaction as well as presence of restricted, repetitive behaviors, interests and activities [1].

A recent study from April, 2018, estimates autism's prevalence to be 1 in 59 children or 1 in 37 boys and 1 in 151 girls [3]. The symptoms are manifested as continuum or spectrum, from mild to severe manifestations, demanding different degree of support in the daily life. Children with autism have variety in needs,

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capacities and interventions. Therapeutic objectives differ for each child and change over time which requires tuning and personalization of the objectives. This makes autism a heterogeneous disorder.

Children diagnosed with autism benefits from early interventions when adjusted to their specific needs [20]. Although, some children achieve progress from therapies in some areas, prognosis in general is poor. Children with autism will become adults with autism with difficulties in independent living, professional and social life [10].

Technology, as a supporting tool in interventions, education and daily living of people with autism, has proven to be valuable tool in the hand of researchers and practitioners [2, 7].

1.1 Robots as Assistive Technology for Children with Autism

In recent years, many research studies have shown that the use of robots, as a supporting tool in the development of various skills and knowledge in children with special needs, is quite beneficiary [11, 16, 17]. Mobile robots like IROMEC and QueBall [12, 15] and humanoid robots like Kaspar, Robota, Milo and Nao [4, 5, 9, 13, 14, 19] are especially used to help children with autism develop various skills and mediate interactions with peers and adults. Furthermore, other robots have been used to engage children with autism in play activities like artificial pets (baby seal robot Paro and the teddy bear Huggable) [8, 18] and the small cartoon-like robot Keepon [6].

1.2 Why Using Robots for Children with Autism?

Robots can provide individualized approaches for a specific child's needs. For ASD children, they provide predictable, safe and reliable environment and this experience can be less terrifying for them than interacting with a human being. Many ASD children have difficulty in making eye contact or typical social interaction. It's not comfortable or easy for them to do it. It's a problem that affects their social life as well the lives of their families. But why are ASD children more interacting with robots than with humans? Researchers think it's because robots are not as complex as people, and can be made with human-like, but very much simplified features, i.e. simplified appearance, less complex facial expressions and simplified basic behavior. In addition, as any other children, children with ASD like toys too. Furthermore, the use of robots is based on our intrinsic desire and motivation for technology. Autistic children can learn with more ease and less effort, and social interaction will no longer be as challenging. Furthermore, robots enable social interaction that can be generalized in daily living.

1.3 The Robot Platform-Kaspar

Kaspar is a child-sized humanoid robot that is using bodily expressions (movements of the head, arms, and torso), facial expressions, gestures and prerecorded speech to interact with a human. Kaspar has been developed by the University of Hertfordshire, Adaptive Systems Research Group, a multidisciplinary group that conducts pioneering research into artificial intelligence and robotics. The Group studies how humans and machines interact with each other. Building on research that stretches back to 1998, the group has developed Kaspar into a working prototype that has met with significant success in trials with autistic children in various settings. Kaspar is a 60 cm tall robot that is fixed in a sitting position (see Fig. 1).

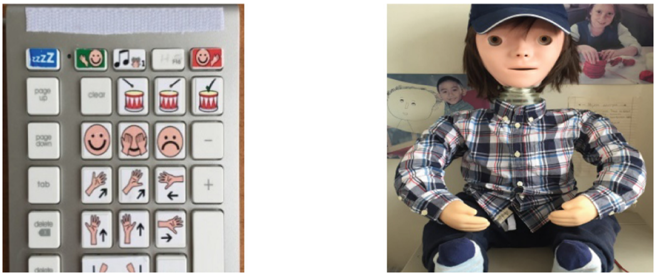

Fig. 1. Wireless keypad for manual control (left); The Kaspar robot (right)

Kaspar has been purposefully designed as a robot with simplified, realistic human-like features offering a predictable form of communication, making social interaction simpler, non-judgmental and more comfortable for the child. As a three-dimensional, physical object, it provides children with the opportunity for safe, physical engagement and exploration of Kaspar's features and behaviors in a non-judgmental manner.

Kaspar has 11 degrees of freedom in the head and neck, 1 DOF in the torso and 5 in each arm. Kaspar's head can tilt, move from side to side, and up and down. Kaspar's face is made from a silicon rubber mask that covers a plastic frame and includes eyes that can move from side to side, as well as and up and down, and eye lids that can open and shut. The mouth is capable of opening, smiling and portray happy and a sad expressions. In addition to the above, Kaspar's torso can move from side to side. Kaspar is mounted with several touch sensors on cheeks, torso, left and right arm, back and palm of the hands and also soles of the feet. These tactile sensing capabilities allow the robot to respond autonomously when being touched, allow it also to give feedback according to the style of the interaction, encouraging certain behaviors and discouraging inappropriate behavior. The robot could also be operated by a remote controlled keypad which can be used by the accompanying adult e.g. a therapist/teacher/parent or by the children themselves who interact with it.

Kaspar can engage children with autism in a variety of therapeutic/educational games, e.g. turn-taking, joint attention and collaborative games, cause and effect games etc. The robot can also hold objects (e.g. fork, spoon, tooth brush, comb etc.) in order to play games where children can learn about food and hygiene etc.

2 Kaspar Trials Set-Up and Procedures

The trials took place at the University Children's Hospital-Skopje, Macedonia. Prior to the trials, Kaspar was programed with movements and speech phrases in the Macedonian language by the clinician. In order to provide a safe environment where the child will feel comfortable, the trials were designed to permit free interaction with Kaspar in a familiar room, in a present of the parent and the clinician.

Some of the play scenarios included imitation games, learning emotions, turn taking games, learning animals and animal sounds, learning sounds and words, hygiene and food. Touching different robot parts causes different reactions and movements of the robot and this setting was used in all other scenarios e.g. Kaspar can react to the style of interaction with appropriate feedback and facial expressions. For example, soft touch or tickling on the left foot will cause the robot to smile and say "this is nice, it tickles me", touch on the torso will cause a loud laugh saying "ha, ha, ha", hitting or punching will cause the robot to have a 'sad' expression, turn the face and torso away to one side, cover the face with the hands and saying "ouch-this hurts".

Kaspar was placed on a chair, connected to a laptop. The clinician was seated next to the robot. The children were brought to the familiar room by their parents. If the child showed a sign of anxiety or appeared not interested for interaction, the sessions were interrupted. One video camera was recording the trials. Kaspar could respond autonomously to different tactile interactions, as well as be operated remotely via a wireless remote control (a specially programmed keypad), either by the clinician or by the child himself. Each trial lasted as long as the children were comfortable staying in the room. The average duration of each trial was approximately 20 min.

3 Observations of Interactions with Kaspar

We present a case study of two young children with autism in their engagement with Kaspar. The first child was a boy, who has been diagnosed for severe form of autism at the age of 26 months in November, 2016. He was non-verbal child, with poor eye contact, poor social communication and interaction, stereotyped behavior, restricted and repetitive behaviors, interests and activities, auto aggressive behavior, poor playing skills and no joint attention skills, and he had sensory difficulties. He started with various early interventions. The second child is a girl who has been diagnosed with a severe form of autism as well at the age of 24 in December, 2016, with similar symptoms as the boy but without sensory problems and auto aggression. They started sessions with Kaspar in January, 2017.

We will present our observations in some of the play scenarios and goals during a one year of intervention.

A. Familiarizing sessions

Kaspar was introduced to them in January 2017, with sessions once to twice per week, depending on the child's response and frequency of other therapeutic interventions. Initially we started with simple exposure to the robot and gradually moved to more complex engagement. The images in Fig. 2 below are taken in the familiarizing sessions with Kaspar.

In these first sessions children were ignoring the robot and wondering around the room. They didn't show any discomfort, just no interest to interact, so the sessions were lasting from 10–15 min where the robot was saying "Hi, my name is Kaspar, let's play together", singing child's songs, making laughing sounds and "expressing" happy

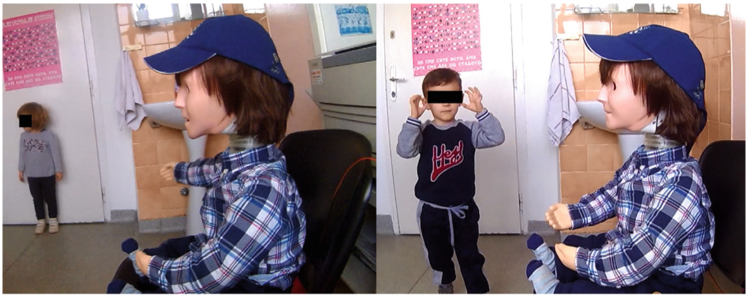

Fig. 2. Initial sessions with Kaspar

feelings. Gradually, in repeated encounters with Kaspar, those two children started interacting with the robot.

B. Imitation games

After 3–4 familiarization sessions, the children started approaching the robot with a smile, seating on a chair in front of Kaspar, ready to interact, and both showed an intensive interest in Kaspar and some initiation of physical contact with a co-present adult. We started with imitation games that were simple and fun for the children (Fig. 3).

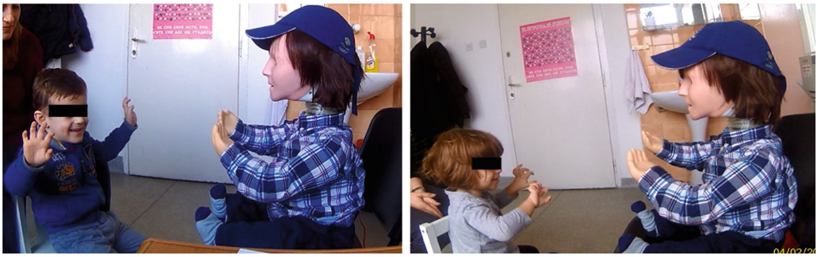

Fig. 3. Imitation games with Kaspar

In these games Kaspar was singing a very popular Macedonian children's song with movements appropriate to the lyrics, while the children were imitating its movements. The children played with enjoyment and with happy facial expression whilst making eye contact with Kaspar. The song would not be played again until the child gave any sign of a desire for repetition (e.g. nodding for "yes" or making a sound that means "more").

C. Learning skills of greetings

One of the main goals in the trials with Kaspar was to learn social skills and make generalization in real life. Greetings as "Hello", "Hi, how are you?" and "Goodbye" were part of every session (Fig. 4).

After the children learnt to practice the greetings with Kaspar, they then practiced it with the therapist and parent that were present at the session, with a goal to practice it in real life with other people too. This behavior involves a smile and a proper eye contact (Fig. 5).

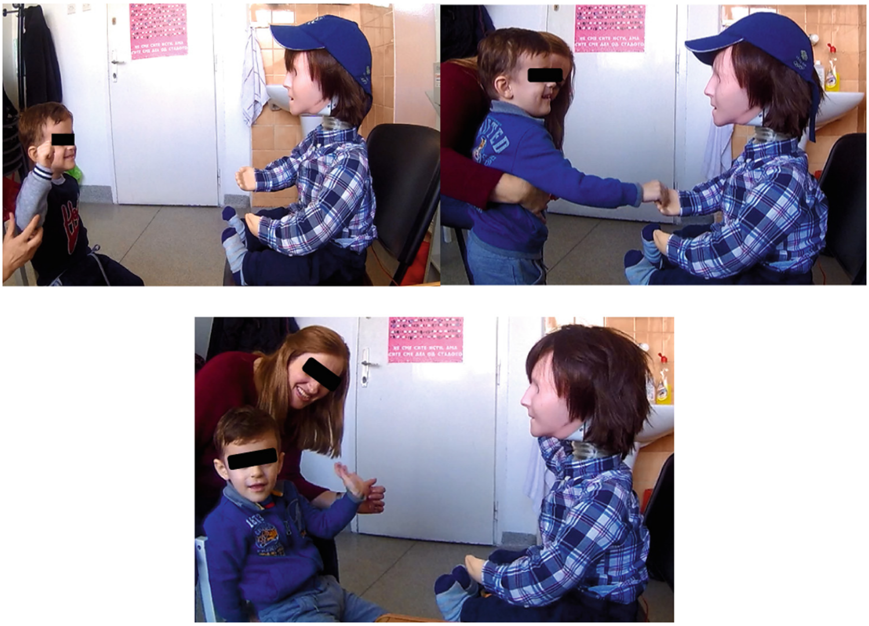

Fig. 4. Practicing “Hello”, “Hi, how are you?” and “Goodbye”

After 10 sessions, the children started using greetings in their everyday life without anxiety, resistance or discomfort. At present, when entering and leaving the lab room, both children are using these gestures to salute the practitioners.

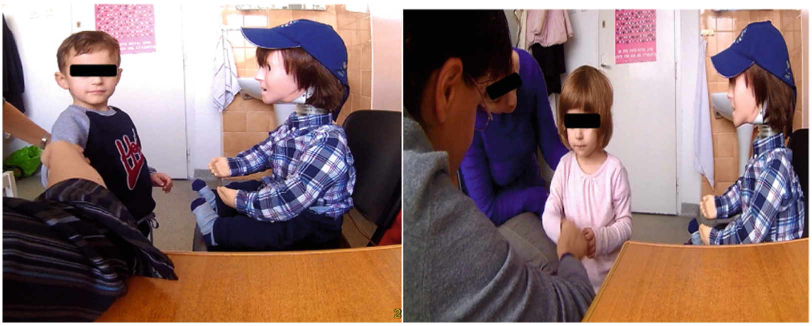

Fig. 5. Practicing handshake

D. Learning emotions

An additional and very important goal in the sessions with Kaspar was to learn to recognize basic emotions (sad, happy, hurt and afraid) and to respond appropriately.

It can be noted that in the initial tactile interactions with Kaspar those two children were behaving in some forceful way (poking Kaspar’s eyes or grasping it very firmly), especially the young boy. This initial “aggressive” behavior repeated for some sessions despite Kaspar’s responding with a “sad” or “hurt” expression (Fig. 6).

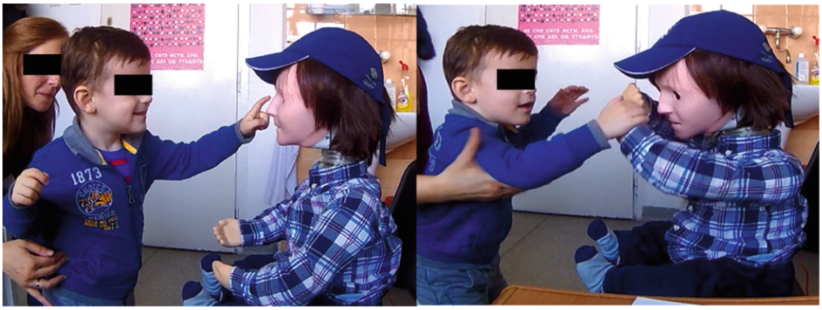

Fig. 6. Child’s interact in forceful way

After acknowledging that this type of behavior is hurtful and unacceptable by co-present adults, this behavior drastically declined. In the following sessions the children were learning how to make Kaspar happy or laugh again. It was stimulated to do it with gentle touch on the hand or by tickling its foot (Fig. 7).

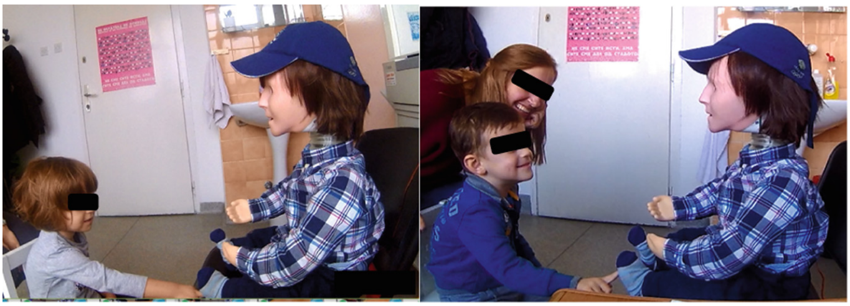

Fig. 7. Comforting Kaspar with tickling

One of the most important feelings to learn was happiness. It is interesting to notice that the children learned much easier and faster happy feelings and expressions than the negative ones (Fig. 8).

Parents of both children later reported that the children now know the difference between happy and sad, especially happy, and use this gesture in real life.

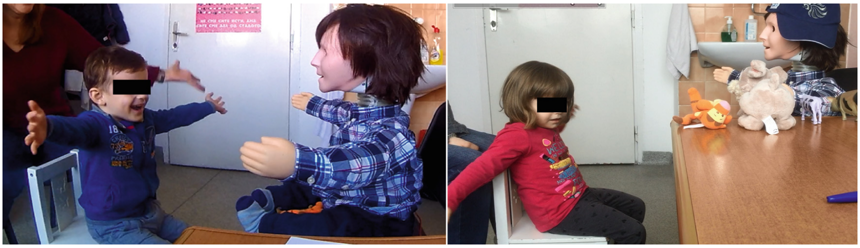

Fig. 8. Recognizing and responding to happiness

4 Discussion and Conclusion

The use of robots in therapy for ASD children is very unique approach that is receiving increasing attention from the scientific and general public. Research in this area is still very young and its pioneering work with innovative ideas on a robot use in a clinical environment.

These case studies presented that some children with a severe form of autism can interact with the humanoid robot Kaspar and learn from that interaction. They get engaged with Kaspar in several ways, developing a repertoire of new knowledge and behaviors. For example they have learned basic social communication skills like greetings (which they didn't do before), and basic emotions that resulted with more calm and happy behavior during the intervention sessions. Furthermore, during the intervention, parents stated that after 8–10 sessions of practicing, greetings as well as recognition and appropriate reactions to happy and sad emotions, are used in daily life too.

The programing and use of the Kaspar robot by the researchers was quite easy and simple. The software allows easy programming of newly developed game scenarios and therapeutic goals. The use is simple and can be adapted to the children's needs and their progress during the sessions.

As the robot assisted play for these children is ongoing, a further longitudinal study on how persistent and continuous this learning effect might be is needed and is planned.

As we mentioned before, autism is an extremely heterogeneous condition and although children with autism share the same core difficulties, each child has an individual set of manifestation. It is expected in some other groups of children to have different responses. Many challenges, due to the nature of the condition, requires a modular approach in designing the assistive technology and play scenarios for child-robot interaction in children with autism, aiming their individual needs. Rigid play scenarios and interventions would not be able to address the variety of behaviors. This paper is an example of a flexible approach in use of robots, where the robot can react autonomously but also the practitioner can guide the robot according to the child's behavior, provoking additional robot responses when needed.

There are numerous positive reasons for using robots in ASD individuals. One is to use their intrinsic interest for technology as a tool to learn, second is that robots are simple and predictable, third is that robots are rather easy for programming and using, forth is the possibility of adapting the robot's behavior making an individual protocol for each ASD child etc. Nevertheless, if we really want to actually make a difference in the lives of children with autism, we need to find a way to expand the findings from case studies to full studies.

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