

Intervention program using a robot for children with Autism Spectrum Disorder

Programa de intervenção usando um robô para crianças com Transtorno do Espectro do Autismo

Programa de intervención con robot para niños con Trastorno del Espectro Autista

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Abstract

This study investigated the effectiveness on social skills development of an educational intervention program for schoolchildren with autism spectrum disorder (ASD) using an educational robot. Over the period of a month, four boys with ASD, ranging in age from 7 to 14 years, participated in structured educational scenarios involving the robot “Edison”, which is in the form of a toy car, with the aid of a teacher/researcher. The behavior of the four boys during the sessions was recorded by an observer, using an observation form. The boys appeared to enjoy the intervention sessions, and a positive outcome was observed following interaction with the robot. Specifically, by the end of the month of intervention, all the boys showed improvement in social skills and cooperation skills and a reduction in untoward social behaviors. They showed an increase in eye contact, followed instructions and appeared to understand the social rules better, and in general their interaction with the teacher and with each other was enhanced. In conclusion, teachers can use robots in programs aimed at improving the social and communication skills of schoolchildren with ASD.

Keywords: Educational robot; Autism spectrum disorder; Social skills; Interaction; Communication skills.

Resumo

Este estudo investigou a eficácia no desenvolvimento de habilidades sociais de um programa de intervenção educacional para escolares com transtorno do espectro do autismo (TEA) usando um robô educacional. Ao longo de um mês, quatro meninos com TEA, com idades entre 7 e 14 anos, participaram de cenários educacionais estruturados envolvendo o robô “Edison”, que se apresenta na forma de um carrinho de brinquedo, com o auxílio de uma professora / investigador. Os meninos pareciam gostar das sessões de intervenção e um resultado positivo foi observado após a interação com o robô. Especificamente, no final do mês de intervenção, todos os meninos apresentaram melhora nas habilidades sociais e de cooperação e uma redução nos comportamentos sociais indesejáveis. Eles mostraram um aumento no contato visual, seguiram as instruções e pareceram entender melhor as regras sociais e, em geral, sua interação com o professor e entre si foi aprimorada. Em conclusão, os professores podem usar robôs em programas que visam melhorar as habilidades sociais e de comunicação de alunos com TEA.

Palavras-chave: Robô educacional; Transtorno do espectro do autismo; Habilidades sociais; Interação; Habilidades de comunicação.

Resumen

Este estudio investigó la efectividad en el desarrollo de habilidades sociales de un programa de intervención educativa para escolares con trastorno del espectro autista (TEA) utilizando un robot educativo. Durante un mes, cuatro niños con TEA, de edades comprendidas entre los 7 y los 14 años, participaron en escenarios educativos estructurados que involucraron al robot “Edison”, que tiene la forma de un carro de juguete, con la ayuda de un maestro / investigador. Los niños parecieron disfrutar de las sesiones de intervención y se observó un resultado positivo después de la interacción con el robot. Específicamente, al final del mes de intervención, todos los niños mostraron una mejora en las habilidades sociales y de cooperación y una reducción en los comportamientos sociales indeseables. Mostraron un aumento en el contacto visual, siguieron instrucciones y parecieron comprender mejor las reglas sociales y, en general, se mejoró su interacción con el maestro y entre ellos. En conclusión, los profesores pueden utilizar robots en programas destinados a mejorar las habilidades sociales y comunicativas de los escolares con TEA.

Palabras clave: Robot educativo; Desorden del espectro autista; Habilidades sociales; Interacción; Habilidades de comunicación.

1. Introduction

Children with autism spectrum disorder (ASD) experience significant difficulties in their social interaction. Deficiency in social behavior is one of the main indicators of ASD. Individuals with ASD may present repetitive behavior, limited interests with fixation on a restricted number of specific activities or objects, and a variety of non-socially acceptable behaviors. A wide diversity of symptoms and different types of deficiencies in children with ASD may impede their development of relationships with other people, and difficulties in socialization constitute a common theme in ASD.

The first section of this paper is an introduction to ASD, focusing on its history and the basic characteristics presented by people with ASD. The second section describes the implementation of information communication technology (ICT) and educational robots in interventions with people with ASD. The final section presents a case study of an intervention program, the main objective of which was to determine the outcome of educational intervention with a teacher and with a robot, for improving social skills in children with ASD.

Autism Spectrum Disorder

Because of the wide variation in the nature and the severity of the symptoms, ASD is a condition described as a spectrum of disorders (Gillberg & Coleman, 2000; Quill, 2000). Children with ASD are characterized by multiple forms of developmental disorder, varying in severity. They experience difficulties in communication skills and in mutual social interaction, and they present a variety of stereotypical behaviors, interests and activities. The severity of their difficulties is determined by many factors, and is differentiated by the developmental stage and the mental status of the child.

Information and communications technology in schools

The introduction of ICT in the modern school has induced significant changes in primary and secondary education. In Greece, the utilization of ICT in education has been an important milestone in the educational system. The integration of ICT in schools has the purpose, on the one hand of modernizing teaching practice, and on the other hand of developing creative and critical thinking in the schoolchildren (Bruce, 2008). The modern teaching process aims at the promotion of investigative and cooperative education (Syriopoulou-Delli, Gkiolnta, 2021).

The traditional school techniques in Greece were completely dependent on the teacher, who was regarded as the “expert”, and whose classes resembled a dry report of information, with no use of dialogue, cooperation or doubt on the part of the pupils. This is an educational model which is becoming obsolete in all European countries. The appropriate use of ICT will bring about significant changes in the relationship between teacher and pupils. Modern schools are adapting, changing from teacher-centered teaching to the new pupil-focused teaching model (Syriopoulou-Delli, Sarri, 2021).

The current methods of active teaching, and the technologies utilized in teaching, based on interaction, provide the pupils with the ability to participate, along with the teacher in the planning of educational activities. This method enables the children to discover knowledge and to develop self-motivated learning, and it has exploited new ways of teaching cognitive subjects. The pupils tend to show greater interest in the lessons, because they are able to participate actively, with personal assignments, at the same time developing their skills in the use of ICT. Children with ASD show particular interest in ICT, which they find non-threatening and predictable.

Robots in the education of children with ASD

The use of robots in educational interventions for children with ASD is increasing. Children with ASD manifest elements of a wide spectrum of disorders that may affect their social interaction, communication and imagination, and vary from child to child. With early intervention, all these elements can be modified, to enhance the social inclusion and ameliorate the quality of life of these children.

The introduction of ICTs and the possibilities they have offered in education, and in particular in special needs education raises the question of the ways in which robots can be put to good use in this field. Over the past decade, robots have been used widely in educational interventions for children with ASD, generally with great success. In recent years, robots have been given the ability to accomplish a number of functions, some of which are very similar to those of humans, and they appear to be successful as helpers for increasing social skills in persons with ASD (Diehl et al, 2012).

Many different kinds of robots are now available, with various characteristics, each of which can be used in educational scenarios, according to the teaching goals. The main three categories of educational robot are the humanoid, the non-humanoid and the non-biological. Humanoid robots are based on a human shape, for example a child; non-humanoid robots are similar, but with the shape of an animal, such as a house pet, a parrot, a baby bear or a seal; non-biological robots have no animal characteristics, but take the form, for example of a car, a flower, or even Lego bricks (Mitsea et al., 2020). According to their functions, they can be divided into educational or social robots.

Robots can be given various different roles according to the aims of the intervention and the content and nature of the activity (Mitsea et al, 2020). They can be used for diagnostic purposes with children; early diagnosis increases the chance to enhance desirable behaviors in children with ASD. Robots can be used as part of a play scenario, which helps children with ASD to develop cognitive and social skills, with the potential for generalization when interacting with other children. Robots are useful in remedial activities with the purpose of increasing positive behaviors, including imitation, eye contact, initiation of interaction, taking part in turn-taking games, mutual attention and emotion recognition. They can also be used as a social mediator between the teacher and the child or a group of children. They can educate children in social skills and socially acceptable behavior, with the objective of generalization to other social settings. Robots can educate children, through imitation, how to behave in specific social interactions. In addition, they can play the role of personal assistant to the children, aiding them in coping with whatever difficulties they face.

Educational robots are used in multiple ways to accomplish educational goals. The children learn how to give instructions to the robot, to program it and to mimic it in order to achieve a certain goal. This educational procedure enables the child with ASD to take part in the process of devising, planning and executing a sequence of instructions (Pivetti et al, 2020). In other scenarios the children are required to mimic the robot, or to cooperate with it, or to play with it, in order to complete a specific assignment. Robots can provide the children with motivation, which is very important, because motivation is associated with better outcomes in the educational process, especially when experiential educational scenarios are being used (Saerbeck et al, 2010; Standen et al, 2014)

Robots are used for educational purposes with the objective of helping children with ASD to improve social skills. Robots can promote spontaneous game scenarios and keep the attention focused, and they offer a safe and predictable teaching environment. (Werry et al, 2001; Kozima et al., 2007). Teachers can use robots to create attachment of the pupils with the subject being taught, to elicit inducement for learning and to provide the children with joy and with satisfaction when they accomplish their goals. As the children develop new abilities through robotic intervention, their independence and their ability to seek and consume knowledge are increased (Saatcioglu & Boru, 2015). Robots can be a teaching aid to help children with ASD to participate in group play, enhancing the social skills needed for such activity, and inducing desirable behaviors (Dautenhahn & Werry, 2004).

Humanoid robots are used mostly for intervention in the complex area of social relationships. They are effective tools for teaching cognitive, communicative and social skills to children with disabilities, including ASD (Iacono et al, 2011). They can help to teach complex social interactions, such as identification of personal space, emotion recognition, adaptability and control of speech. They provide the ability to create social scenarios, which are interesting and attractive to the children, and can be given special meaning to induce the children to interact with them (Cabibihan et al, 2013). In addition, humanoid robots can be programmed to mimic human movements and facial expressions. Studies have shown that children tend to maintain eye contact for longer and to imitate more readily in sessions using robots (Ricks & Colton, 2010).

Robots can substitute the human approach and encourage children with ASD to repeat and practice various social interaction scenarios without the anxiety of human contact. In general, robots can provide children with ASD with abilities in self-control, and can become an important teaching aid for the expert (teacher, therapist) helping the child. Various factors, including the appearance of the robot, the way it moves and its facial expressions contribute fundamentally to the success of the educational intervention (Peca et al, 2014).

The introduction of robots in the instruction of children with ASD has brought benefits, but has also raised ethical concerns. One of these is the possibility of emotional attachment when humanoid robots are used in therapeutic interventions. Children with ASD may think that this humanoid robot, with which they play and interact, is an autonomous, independent being, which can react and respond in an intelligent way, and is a friend. One solution to this problem could be for it to be made clear when the robot is introduced that the robot functions as an educational aid and not as a replacement of the teacher (Ntaountaki et al, 2019). Legislation is introduced to regulate the positive and negative aspects of ICT, including the use of robots, but also drones and autonomous driving systems. Such legislation, however, neither delimits nor provides specific instructions to those who program the robots (Villaronga & Albo-Canals, 2019).

Based on the evidence above, it is apparent that robots can be important aids in intervention for children with ASD. Intervention programs with robots to foster cognitive skills in children with ASD have been shown to promote motivation, empathy and self-control in the event of emotions such as anger or fear (Mitsea et al., 2020), and can enhance mimicking, mutual attention, emotion recognition, and facial expression, thus improving social interaction. We conducted a study of the effects of a course of educational intervention, using a robot, on the social and communication skills of schoolchildren with ASD.

Objectives

To determine the outcome of educational intervention with a teacher and with a robot, for improving social skills in children with ASD.

In general, the main goal of the educational intervention was for the children and the teacher to be able to cooperate with each other and for the children to present a higher level of social interaction than at the beginning of the sessions.

The specific characteristics of social interaction observed included the ability to follow instructions, observance of the social rules that regulated the educational games, cooperation with each other and control of their responses to stress.

2. Methodology

Experimental design

A program of educational intervention was conducted by a teacher/researcher with the four boys, using an educational robot. This intervention lasted 1 month and consisted of 20 sessions, some group sessions and some individual sessions, with 6 sessions for each child (twice a week for 30 minutes each).

The group intervention sessions were conducted in the special education center for creative activities (KDAP MEA)

in the town of Xanthi in northern Greece. Individual sessions were programmed to take place in each child's personal space in their homes, organized specifically for the intervention.

Before the sessions started, a first meeting with the children and took place, at which the teacher and the children had the chance to get to know each other and to discuss the process of the intervention. The children were informed about the procedure that would be followed, the number and the duration of the sessions, and they were encouraged to ask whatever questions they wished. This first meeting was very important for establishing a solid foundation for a healthy and meaningful relationship between the teacher and the pupils in the study.

The methodology used is a systematic review and quantitative type of research. The data were collected and reviewed by the researcher. The observer forms were collected and organized by the researcher for use in data analysis, after the difference in social interaction each session. The results were compared to determine after the intervention and between the sessions with the Edison robot and those with the teacher.

Settings

The spaces organized for the study, both the group sessions and the individual sessions, were arranged to be functional and to help the procedures of the study. On one side of the room was the desk on which all the "play scenarios" with the robot or the teacher took place. The teacher or the robot and the child (or 2 children in the group sessions) sat opposite sides of the desk. The robot was pre-programmed by the teacher with all the necessary "play scenarios", so that the children's attention was not distracted during the procedure. Another chair was placed sideways to the desk, giving a clear view for the external observer, who recorded all the procedures of each session.

The educational robot Edison

The robot used in the intervention was a non-humanoid robot in the shape of a toy car, with two wheels, called Edison (Figure 1). It is orange in color, and some parts of its body are made of clear plastic. It is operated by batteries and has some sensors integrated in it that can be programmed for specific tasks - to avoid obstacles, to follow a light, to follow a black line on a piece of paper, etc. The two wheels enable the robot to move fast and to make sharp turns. There is no need for a computer or a tablet to program the robot. There are various barcodes that teacher scans with the robot to program the desired "play scenario". The functions of the robot are programmed by three large buttons. A triangular button is for engaging the programmed "play scenario", a square button is for stopping the robot and the third, round button is for operating the robot to scan the barcode.

Figure 1: Edison robot.



Source: Authors.

Procedure

The intervention was implemented in a combination of group sessions and individual sessions. The 4 boys were divided into 2 separate pairs, for the group sessions. In the individual (one-on-one) sessions, the teacher/researcher with the child and the robot had to carry out the scheduled scenario, and to complete it. In the group sessions, the two children had to carry out the scheduled scenario, with the help of the teacher or the robot and to complete it.

The objective of the individual sessions was for the pupil to be able to understand the given instructions, to follow them and to recreate the moves that were necessary for the completion of the specific “play scenario”. The objective of the “play scenarios” in the group sessions was for the pupils to be able to cooperate, to take part in turn-taking games, to practice social skills and, in general, to exercise social interaction. In both types of session, the main goal was for the children to be able to cooperate with the teacher or the robot, at a satisfactory level of social interaction. Particular attention was given to noting the level of participation of each child in the given “play scenario”, with the teacher or with the robot, and his reactions, including possible withdrawal and/or leaving the room where the study was carried out.

In the first session the objective was for the teacher and the children to carry out all the “play scenarios” according to the schedule. The subsequent sessions included implementation of the “play scenarios” with the participation of the educational robot Edison. The robot had to follow two different play scenarios. In the first, the robot had to follow a race circuit drawn with a black line on a large piece of paper, and in the second to avoid obstacles that were placed in front of it by the child.

In the last week of the intervention, the same “play scenarios” were enacted, but without the use of the robot, only by cooperation between the teacher/researcher and the child or between the two children. In this last week, it was very important for the neutral observer to record possible changes in the interaction of the children with the teacher and with each other, in their social skills and in their response to stress.

Data recording section

A trained external observer completed an observation form for each child, for each session (Table 1). Only one observation form was used for this study. Before the intervention sessions, the observation form was explained to the observer, who then watched each session, with the observation form in front of him. Each time the child manifested one of the behaviors listed, the observer noted it the relevant box, and also noted any additional information that seemed important. Specifically, the observation forms were used to record the frequency of specific behaviors during the session (Zirpoli, 2005). The behaviors monitored were that the child was able to understand the given instructions and to recreate the moves. In the group sessions the behaviors monitored were that the child was able to cooperate and to take part in turn-taking games. In addition, each child’s response to stress was recorded.

Participants

The participants in this study were four boys diagnosed with ASD, ranging in age from 7 to 14 years. Two were pupils at a state special needs primary school and two were attending an inclusion class in a state secondary school, in the region of Eastern Macedonia and Thrace. All four children were also attending speech therapy and psychotherapy or physiotherapy sessions after school. The criteria for choosing the participants for this study were:

1. Age from 7 to 14 years
2. A diagnosis of ASD from a certified organization, specifically that the child has high functioning autism (Asperger’s syndrome)
3. Advanced linguistic ability: They must be able to form a sentence of at least 3 to 5 words.

A session with the parents of each participant was programmed, at which time the parents were informed about the intervention, its purpose, the procedure to be followed and the expected results. Non-structured interviews were conducted with the parents of each boy, to collect information about his special interests and possible weaknesses, in order to construct a profile, to choose the most appropriate activities for the intervention. The profiles of the participating boys are shown below.

Pupil profiles

Pupil 1 (age 7 years and 8 months). He is in the first grade of the state special needs primary school, and attends speech therapy sessions in the afternoons after school. His ASD diagnostic report noted adequate fine and gross motor skills for his age. He can hold the pencil the right way and is able to use both hands for most actions. The vocabulary he uses is limited for his age, and he often repeats the same words over and over. He has weaknesses in processing information and in organizing certain activities. It is difficult for him to play games in a group with other children, and he usually plays alone, with toy cars, trains, etc., although he is not able to stay in focus with a specific toy or activity for any length of time. He is not able to express his feelings, or to laugh or cry appropriately. If he is very happy about something he claps his hands. When something happens that makes him sad, he reacts by leaving the room, to get away as far as possible from his teacher or therapist.

Pupil 2 (age 10 years and 3 months). He is in the third grade of the special needs state primary school, and attends speech therapy and physiotherapy sessions in the afternoons after school. He was diagnosed with ASD a year ago, when he was in second grade, and has not been able to receive an individually planned intervention program like the other children. His diagnostic assessment noted adequate fine and gross motor skills for his age. He has no difficulties holding the pencil the correct way or paying attention in class. His vocabulary skills are adequate for his age, but as he sometimes repeats the same words or phrases, he appears to have limited linguistic ability. When he is tired, or after a demanding physical activity, he has difficulty in paying attention in class. He has a hard time following instructions and processing certain information. He has some difficulties cooperating with other children and to play group games. In his free time, he plays games on a tablet, usually games with cars. It is not easy for him to express his feelings, by appropriate laughter or crying. When he is very happy, he tends to laugh very loud in a monotonous way. When he is feeling pressure, he reacts with a loud shout and usually leaves the classroom or the therapist's room.

Pupil 3 (age 13 years and 5 months). He attends the inclusion class of the second grade of the state secondary school, and has speech therapy and psychotherapy in the afternoons after school. His diagnosis of ASD was made at the age of 10 years, from when he has been receiving an appropriate individually planned intervention program, like the other children with ASD. His vocabulary skills are adequate for his age, but he has limited linguistic ability, because he tends to repeat same words and phrases. His fine and gross motor skills are adequate, and he has no problem paying attention in class, apart from when he is tired in the end of the school day. He can follow instructions easily and he is familiar with his neighborhood and with some basic social rules; he can walk alone, to visit friends or to buy something from the local convenience store. He shows no specific difficulties in social interactions with children of his age. In his free time, he usually plays group sports with his friends on the neighborhood playground, and he is a member of a local football team, in which he plays once a week. He is usually good at expressing his feelings, but his laughter and crying are somewhat monotonous, not like the other children of his age. When something happens and he is afraid, or if he is feeling pressure, he has a tendency to react by leaving the room he is in, or the classroom.

Pupil 4 (age 14 years and 9 months). He attends the inclusion class of the second grade of the state secondary school and, recently, speech therapy and psychotherapy sessions in the afternoons after school. His ASD was diagnosed in the age of 12 years, when he first attended secondary school, from when he has received the appropriate individually planned intervention

program, like the other children with ASD. His vocabulary skills are adequate for his age, but he has a limited linguistic ability, because he tends to repeat the words and phrases. His fine and gross motor skills are adequate and he has no problem paying attention to class, apart from when he is tired at the end of the school day. He can follow instructions easily and is familiar with some basic social rules, and he is able to cooperate with the other children his age in classroom. In his free time, he usually plays sports games on his computer and twice a week he attends robotics classes in a municipal facility. He is usually good at expressing his feelings, but his laughter and crying are different from the other children his age. When he is afraid of something or when he is feeling pressure, he says so, again and again, in an intense way, and stops whatever he was doing.

Table 1: Observation form used in educational intervention sessions for improving social and communication skills in children with autism spectrum disorder.

Pupil's name:			Observer:	
Number of session:			Date:	
Session type: Teacher Robot				
Behavior - Target	Yes	No	Sometimes	Notes
Did the child show signs of joy or anticipation before the session started?				
Did he show any interest in asking what you are going to do this time?				
Did he try to isolate himself and not participate in the activity?				
Did he understand and follow the instructions the teacher gave him?				
Did he cooperate with the teacher or the other child during the group sessions?				
Could the child maintain eye contact with the teacher or the robot?				
Did the child try to start a conversation or a new activity with the teacher or with the other child after the session completed?				
Did the child try to approach the teacher or the robot with the purpose of starting a new activity?				
Could the child concentrate and to carry out the activity based on the instructions?				
Did he show interest in repeating the activity?				
Did he show interest in the next session?				
Fill in a "+" in the "Yes", "No" or "Sometimes" column accordingly if and in what degree the student showed the specific behavior.				

Source: Authors.

Observer congruence

To ensure reliability of the study results, at the end of each session the teacher/researcher and the observer discussed

the study progress and the data gathered, to ensure the reliability of the information noted.

3. Results

During the sessions with the repetition of the educational scenarios and the constant guidance from the robot, the children practiced their social skills regularly throughout the month of intervention. In each session the children practiced their social interaction and showed greater willingness to cooperate and to follow with focused attention the instructions given by the educational robot. According to the results, the children were more willing to approach the robot and to sit next to it. The study findings were that, after the sessions with the robot, there was increase in social interaction and communication of all four children with ASD with each other and with the teacher. By the end of the sessions the children were observed to cooperate for a longer amount of time with each other, and with the teacher. Specifically, at the beginning of the sessions they interacted with each other for 6 to 10 minutes and at the end of the intervention this interaction increased to approximately 15 to 20 minutes.

The children were more receptive to the social circumstances of the study, whereas in the past, according to the parental interviews, the children had not been really interested and had displayed negative behavior. In the sessions with the robot Edison the children did not try to distance themselves. In the first session with the teacher, it was observed that the children tried to distance themselves 3 times on average, while in the last session, they tried only once to become isolated. They managed to reduce their negative behavior in their interaction with the robot and the other children. This demonstrated that robots can contribute to interventions designed to improve the social skills of children with ASD.

They all understood and managed to follow the instructions given, and they appeared very interested in repeating the activity. The children repeated the activity twice, on average, in the first sessions with the teacher and after the intervention with the robot they repeated the activity 6 times on average. The four children often asked spontaneously which activity they are going to do next time. The chosen educational scenarios had positive outcomes in helping the children overcome their difficulties in social skills. They showed progress in learning the social rules that regulated the educational games.

4. Discussion

The therapeutic possibilities nowadays for children with ASD are improving, and with the help of therapists and teachers, many of them reach adulthood able to live a normal and independent life. Children with ASD must often practice hard to understand their surroundings and it may require great effort for them to cope with life, even with their acquired cognitive and mental skills. Accordingly, the state needs to improve the educational experiences provided for them and to prioritize the education of people with disabilities, to equip them with skills for the future, and not confine their assistance to health and financial benefits.

The special needs teachers and the health professionals who are involved in teaching and caring for children with ASD wish to be successful in what they are doing. A major premise for success is early diagnosis of ASD, and early, specialized educational intervention. Early intervention leads to good results. The parents of children with ASD, from the early years of their children's lives, when first abnormal behaviors appear, feel anxiety, uncertainty and guilt. At that time the parents most need clear information about the condition, and social support, but this support should be continuing.

The purpose of this study was to determine the difference between the intervention with the teacher and the robot according to the improvement of social skills in children with ASD. Specifically, the goal was to determine whether robots can aid children with ASD to practice their social skills, to improve their social interaction, to follow instructions and observe the rules of an activity, to seek the goal, and, generally, to accommodate multiple stimuli, just as they have to cope with in everyday life.

According to their improvement of social skills, this study showed that the schoolchildren with ASD participated with greater willingness in the intervention with the educational robot than with the teacher. The children showed 30% improvement in eye contact and greater involvement on completing the educational scenarios were observed after sessions with the robot. The children cooperated for a longer amount of time with each other and with the teacher, specifically at the end of the intervention, the duration increased to approximately 15 to 20 minutes from 6 to 10 minutes in the first session. Other studies also report that children with ASD display a greater percentage of eye contact when they interface with an educational robot rather than a person (Tapus et al. 2012, Kim et al. 2013).

Each child with ASD selected to participate in this study showed greater interest in the sessions with the robot than in the sessions with the teacher. According to the observation forms, the children were more willing to approach the robot and to sit next to it. These results validate other studies that showed that children with ASD tend to approach a robot more readily than a person and to interact physically with it (Kozima et al. 2007).

Children with ASD are observed, in general, not to initiate social interaction or to approach other people (Wing, 2000). Our study indicates that the educational robot Edison could provide the triggering event for children to approach and start a social interaction with it. The study children, who all were reported in their profiles to find social interaction difficult, all approached the robot spontaneously and tried to start a play scenario with it. This happens because the robot displays in a simple, non-threatening way how the child can interact with the robot to play with it, which is easier for children with ASD to comprehend. In addition, children did not tend to get bored, or to receive multiple stimuli, or to get frustrated, situations that usually lead to expression of negative behavior (Kozima et al. 2007; Yun et al. 2016).

In most of the sessions, the study children were observed to express spontaneously, with both speech and gestures, their happiness and their desire for playing. The observer paid close attention to their specific reactions, because, according to the annotated bibliography of Gonela (2006), children with ASD cannot express easily their emotional and mental status. It was noted that the educational robot Edison managed to keep the children interested, and because of this they communicated with the robot to a greater degree than with the teacher. The children expressed their happiness and willingness to continue playing in the sessions both with the robot and the teacher, but in the sessions with the teacher they expressed their joy in different ways and their interest was less. These results are similar to those of other studies, which show that the verbal interaction of children with ASD increased when interacting with a robot. (Kim et al. 2013; Pop et al. 2014).

Children with ASD often cannot become involved in or focus their attention for a long time on a specific task. They focus their attention for a longer time on what they find interesting, but find it difficult to focusing on something that is not so interesting for them or on someone talking to them (Boucher, 2009). According to the data from the observation forms, the involvement in the educational scenarios was greater in the sessions with the robot was present than in the sessions with the teacher. The children repeated the given activities only twice at the beginning, but this increased to 6, on average, after the sessions with the the robot. Concerning mutual attention, even if the children did not have particular difficulty in interacting or following instructions, almost all the time they showed greater interest in the sessions with the robot than in those with the teacher. Other studies confirm these findings and indicate that robots, with their simple design and controlled movements attract the attention of the children more readily, resulting in improvement of their social skills (Bharatharaj et al. 2017).

In the sessions with the robot Edison the children did not try to distance themselves, to become isolated, and as a result not participate in the educational scenarios, which sometimes happened in the sessions with the teacher, although not to a great extent. In particular, in the first session the children tried to distance themselves 3 times on average, but in the last session, only once. These findings are similar to those of Stanton and colleagues. (2008), who showed that children create a stronger and more structured interaction in a game with robots than with a toy of similar appearance in sessions with the teacher. Fewer stereotypical behaviors appeared, so the children could stay focused on the educational procedure. Observation

of the play scenarios provided an indication of how well the child followed the instructions, measured by the number of repetitions needed to complete the required movements. The children followed instructions more readily in the sessions with the robot.

The purpose of this study was not to replace the teacher with an educational robot, but to create a different role for the teacher, who can provide enrichment of the educational intervention with the aid of robots. The educational procedure can thus be focused mainly on those skills in which the children with autism experience difficulties.

5. Conclusion

All participants in this study showed great interest in the educational content of the sessions and willingness to cooperate with the teacher, and with the other child in the group sessions, in completing the activity in the play scenarios. They all showed increasing eye contact with the teacher at the end of the study and increasing focus on the robot. In the sessions with the teacher the eye contact was noted to be 4 times on average, and after the sessions with the robot this increased to 7 times on average each session. Also, they wanted to start a new conversation or a new activity when the session was completed.

It is not known if the positive results, namely the improvement in social skills and behavior observed during the intervention will have a long-term effect. It would be beneficial to repeat the educational scenarios often, both the same or similar scenarios, with the use of robots and in general play scenarios, to the strengthen social skills with the use of ICT. The repetition of such scenarios in a structured educational context on a weekly basis may be required to maintain the positive behaviors in children with ASD and ensure generalization of the acquired skills. Investigation is needed on the maintenance and generalization of these behaviors.

Another limitation is that the study children received educational intervention only in the programmed sessions, and there was no generalization of the educational process. The children might perform differently in other settings and other social interactions or in non-programmed social scenarios. In addition, their acquired social skills have not been tested in spontaneous everyday life social situations, and with people, who are unknown to them.

Further studies on the educational use of robots and their influence on social skills and social interaction need to be conducted, because to date they appear to provide a certain and effective educational aid for teaching children with ASD. The studies should have clearly defined goals and good means of measurement of change, taking into account that the capabilities of children with ASD vary widely degree of the success of an intervention will differ from person to person. In addition, in future research on educational robots it is necessary to explore the generalization of acquired skills to the “real-life” situation, and the long-term effects of the educational interventions. To date, however, all the data are encouraging, and indicate that the use of robots is a very hopeful field in the education of children with ASD.

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