Using Daisy robot as a motive for children with ASD to participate in triadic activities

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Abstract

Indepent studies in various settings indicate that interventions with Socially Assistive Robots, might help children with Autism Spectrum Disorder (ASD) to participate in activities that demand cooperation and communication skills. The purpose of this article is to present the benefits of robot assisted interventions in the development of social skills in children with ASD. The research took place in Greek Kindergarten and Elementary schools, during which six children with ASD participated in triadic activities, with and without the assistance of the Daisy Robot. The results showed statistical significant differences in three of the four skills (activity in a group, turn taking, and information) that were measured before and after the interventions with the robot.

Keywords: Socially Assistive Robots, Autism Spectrum Disorder, Daisy Robot, triadic activities

Introduction

Autism Spectrum Disorders (ASD) is a neurodevelopmental disorder characterized by severe deficits in social skills and persistent stereotyped behaviors (Landrigan et al., 2012). These characteristics affect people's with ASD socialization and set obstacles to the initiation and involvement in any social interaction (Zoghbi & Bear, 2012). An increasing number of children across the globe is being diagnosed with ASD (Blaxill, 2004; Olds et al. 2013; Scassellati, 2005; Wong et al., 2014); the most recent estimate of incidence according to the Centers for Disease Control and Prevention (CDC) is 1 in 59 (CDC, 2017).

In Greece there is no systematic official data on the prevalence of autism, but according to the Hellenic Society for the Protection of Autistic People it is estimated that 150,000 people in Greece are in the autism spectrum. This number corresponds to the ratio of 1 to 166 people. Specifically, 1/42 boys and 1/189 girls are born with autism spectrum characteristics. Such proportions, which are gradually increasing, make it necessary to find methods to support people with ASD to their social inclusion.

What essentially distinguishes the neurology of individuals with autism spectrum is not completely clear, however, research shows that there is a high level of neural synapses and responses in people with ASD, which can cause chaotic and intense intake of environmental stimuli (Gillberg, 1999). Since they receive more information from their environment, they often experience sensory overload (Landrigan et al., 2012). Due to the heterogeneity of the spectrum, children with ASD exhibit mild to severe characteristics of the disorder (Georgiades et al., 2013). However, a common feature across the autism spectrum is the significant deficits in social skills that are responsible for the inability to perceive and interpret other people's typical routine (Dawson et al., 2004; Baron-Cohen et al., 1994), or the need for personalized educational environments, which aim to help students with ASD develop the skills needed for a successful daily life or even the transition to a working place (Tsiopela & Jimoyiannis, 2017).

Some children with ASD have a normal or even high IQ, while others have comorbidity with varying degrees of mental disability. They tend to respond to sensory stimuli impulsively and have a strange interaction with objects and an adhesion to them (Feinstein, 2011). Their main impairments, according to the Diagnostic and Statistical Manual of Mental Disorders (DSM-5) can be summarized in the following paragraphs (DSM, 2013).

Some children with ASD may be cut off from society, while others may be excessively active and willing to approach other people, but in strange and unusual ways. Many have attention or concentration problems and difficulty in adjusting to changes (Wall, 2007). Their strange reactions are their way to respond to the stimuli they receive; they tend to feel annoyed by proximity and by others touching them (Kennedy et al., 2014). Every new social interaction may cause them anxiety, so they withdraw and continue with their familiar activities (Lu et al., 2010).

In an attempt to overcome these special characteristics of ASD, programs using Socially Assistive Robots (SARs) were pioneered, and significant benefits were observed in the development of social skills in the ASD population following specific interactions with robots (Pennisi et al., 2016; Tapus et al., 2007). Taking this into consideration, the basic aims of this study was to ascertain whether a robot is an efficient mediator in motivating children with ASD to participate in a triadic group that fulfills activities and / or games with a child of Typical Development (TD) and their teacher.

Socially Assistive Robots in interventions for ASD

A socially assistive robot is a system that provides assistance in a particular assistive context by employing interactions that include the use of speech, facial expressions and gestures. Is a powerful interactive tool that provides assistance to the user in a social rather than physical interaction context (Seifer & Mararic, 2005). SARs are enhanced with motivational, social, pedagogical, and therapeutic capabilities and so they are able to promote personalized care and rehabilitation to large populations such as the elderly and children with social and developmental disabilities, in order to improve their quality of life (Mataric & Scassellati, 2016). SAR is defined as the intersection of Assistive Robotics (AR) and Socially Interactive Robotics (SIR). AR refers to robots that assist people with physical disabilities through physical interaction, while SIR are robots with a task to promote a form of interaction with humans for the sake of the interaction itself (Fong et al., 2003). SAR on the other hand provide assistance (like AR) in the form of a social interaction (like SIR). Especially, they provide assistance and measurable progress in rehabilitation, learning, social skills improvement etc. (Seifer & Mararic, 2005). It has been shown in many cases that SAR help children with ASD to develop communication skills by providing motivation for communication, and by facilitating them to express their own emotions as well as to perceive and understand the emotions of others (Cabibihan et al., 2013). The robot is able to engage in activities with the user (child), fulfilling clinical roles, and return simultaneous feedback, with the minimum direct participation of a trained professional (Mavadati et al., 2016).

Emotions

Several studies have been conducted that define the advantages of SAR's utilization for children with ASD who need to be able to deal with a variety of social situations, and to be exposed in a variety of emotions (Baron-Cohen et al., 1985). SAR can create situations and simulations that are specific and consistent. In a SAR environment, children can be assisted in the identification of situation-based emotions in others, can get accustomed to, learn and practice various different emotions (Pop et al., 2013). Moreover, the recognition and expression of emotions is crucial to the development of social interaction (Aresti-Bartolome et al., 2014).

Motivation

When interacting with robots, children with ASD show enthusiasm, and they learn to consider the robot as an enjoyable, well-tolerated team-mate. They present increased interest that is expressed by high levels of attention, joint attention, increased imitation ability, verbal response and willingness to participate in social activities (Begum et al., 2016). By attracting children's interest towards a particular task, robots can be great motivators (Pennisi et al., 2016). The use of friendship groups, playing games based on the interests of the child, especially in the context of alternative communication techniques such as robots, are associated with positive outcomes in the development of social skills (Chapin et al., 2018).

Secure and proper environment

SARs are predictable and simple in their interactions (Dickstein-Fischer et al., 2018). Robots' function can be consistent as they can be programmed. Their behavior is customized to match the interests of each child, and to avoid anxiety triggers that could stimulate negative reactions or denial of cooperation (Thill et al., 2013). As robots are applied in a controlled manner, with movements and voice that do not vary unexpectedly, stressful situations that could trigger "meltdowns" can be diminished and even avoided (Cabibihan et al., 2018). When interacting with a robot, children with ASD demonstrate less anxiety and show reduction in repetitive stereotyped movements (Michaud et al., 2007). Children feel more secure and become engaged with a robot that provides human-like activities in embodied interactions, without the unpredictability of human expressions (Scassellati et al., 2012). Robotic movements elicit visual priming, considered to be a precondition for imitation, which is a major deficit in children with ASD (Begum et al., 2015).

Joy

Children with ASD interact more easily with robots than with humans because they enjoy playing with mechanical devices, facilitating in this way their engagement, not only in free-form associative play, but also in cooperative play that is more organized and complex (Wainer et al., 2010). In the study of Scasselatti and colleagues (2012), increased levels of attention and novel social behavior (joint attention, imitation) were observed when children with ASD interacted with robots, which could provide novel sensory stimuli in comparison to humans or inanimate toys (Kim et al., 2013). One study even described children with ASD occupied in activities with a robot showing an affective enjoyment and engagement similar to that of children of typical development (Begum et al., 2015).

Mediators and social interaction

Robins and colleagues (2006) suggested that SARs can promote triadic interactions in novel ways acting as social mediators among themselves, such as in Robins et al. (2018). Long periods of interaction with robots in repeated trials have been shown to help children with ASD develop basic social interaction (Chevalier et al., 2017), as they appear to be a medium that assists the children to initiate contact. It is like to behave with robots as children of typical development do when they meet strangers (Duquette et al., 2008) or interact with human partners (Begum et al., 2016).

In studies that compared the interactions of children with ASD with a robot and with a human, the robots appeared to achieve better results in developing skills of shared attention, visual contact and proximity (Duquette et al., 2008). They also resulted in skills of participating in group activities with a peer (Pliasa & Fachantidis, 2019; Fachantidis et al., 2019). Compared with a computer display or parents, robots seemed to be more efficient stimuli (Lee & Obinata, 2013; Pennisi et al., 2016).

The above results indicate that SAR can have a significant role in motivating children with ASD to participate in triadic activities. Since some main deficits of children with ASD concern skills of participating in group activities, providing information, turn taking and following instructions, it would be interesting to verify whether a SAR can help children develop such skills (Schopler et al., 1982).

Methodology

Research hypothesis

The hypothesis of this research is that the Daisy Robot is able to motivate children with ASD, 6-9 years old, to sufficiently participate in triadic game activities. The other members of the triad are a child of Typical Development (TD) and the teacher. The aim is to help children with ASD improve their social skills in a group activity. The activity involves turn taking, providing information and following rules and instructions.

To test the hypothesis, the response and reactions of each child with ASD was measured and compared in the same activities, while observed during two different settings. Each child with ASD participated in activities (discussion and game activities – both with board games and digital games) as a triad with a children of TD and their teacher, under the following two settigns:

A. With no robot: Children with ASD participated in triadic activities with children of TD and their teacher (setting A).
B. With robot: Children with ASD participated in triadic activities with children of TD and their teacher in Robot-Assisted (RAS) session (setting B).

After the setting A, a three step intervention took place for each group (Table 1). All sessions, in these three steps, were RAS, by using the Daisy robot. The measurements of the setting B took place during the last step of the RAS intervention (third step).

The performance of the children with ASD was measured under the two different settings A and B.

Equipment and Materials

In an attempt to motivate children with ASD to participate in the triadic game activities and assist them to obtain the social skills needed to fulfill, the Daisy Robot was utilized in order to mediate interactions among children with ASD, typical development children and their teacher. Daisy is a semi-autonomous robot in the shape of a flower that resembles a stuffed soft toy, with light blue and purple color (Figure 1).

The face of the robot has two eyes with discreet eyebrows that blink and look around and a mouth that speaks words and phrases with the lip sync technique. The robot has about 400 preinstalled phrases categorized according to their meaning. In particular, the following categories of phrases were added: greetings, acquaintance, routine, emotions, numbers, colors, rewards, games. Through text to speech recognition techniques, any other desired expression can be incorporated. The robot performs sequences of movements and facial expressions and is remotely controlled.

Board games were utilized for tangible play and a tablet for the implementation of the digital games.

Table 1. Steps of the intervention per team

Step	Number of sessions	Duration of each session	Duration of Step
1	2	15 mins	1 week
2	2	20 mins	1 week
3 (Setting B)	1	20 mins	1 day

Figure 1. The Daisy Robot

Participants

Twelve children, six to nine years old participated, six of them with ASD and six of TD. All children were attending Greek public schools (Kindergarten and Elementary) while the six children with ASD were also supported by teachers who were promoting their inclusion in the general classroom. Those three teachers also participated to and contributed in the fulfillment of the study.

Five boys and one girl with ASD were selected. Specifically, three boys (K1, K2, K3) six years old from the kindergarten, a seven years old girl attending the first grade (E1), and two boys eight (E2) and nine (E3) attending second and third grade respectively. According to the inclusion criteria, all the children could verbally communicate and according to their diagnoses (from Greek Children Diagnostic and Treatment centers) were in the autism spectrum at level 1 of severity. They were highly functional but with significant difficulties and deficits in social skills. Data on their IQ level were not available.

Two girls and four boys of TD were selected. Six triad groups were formed, as it is shown in Table 2.

Settings

The study was conducted at the schools the children were attending, in the city of Thessaloniki, Greece. Specifically, the activities took place in the inclusion classrooms, which were quiet enough without many sensory stimuli. A desk was used for the activities. Three chairs were placed, one for each participant. For the RAS sessions, the Daisy Robot was placed on the table, with its face looking at the participants (Figure 2). A tablet and board games were also set on the table. The researcher sat at the corner of the room, away from the participants so she could operate the robot, observe and keep notes without distracting the participants.

Table 2. Groups and participants

Group	Group 1 Teacher 1	Group 2 Teacher 2	Group 3 Teacher 2	Group 4 Teacher 3	Group 5 Teacher 3	Group 6 Teacher 3
	Pupil (age)	**Pupil (age)**	**Pupil (age)**	**Pupil (age)**	**Pupil (age)**	**Pupil (age)**
Students with ASD	K1 (6)	K2 (6)	K3 (6)	E1 (7)	E2 (8)	E3 (9)
Students of TD	T1 (6)	T2 (6)	T3 (6)	T4 (7	T5 (8	T6 (9)

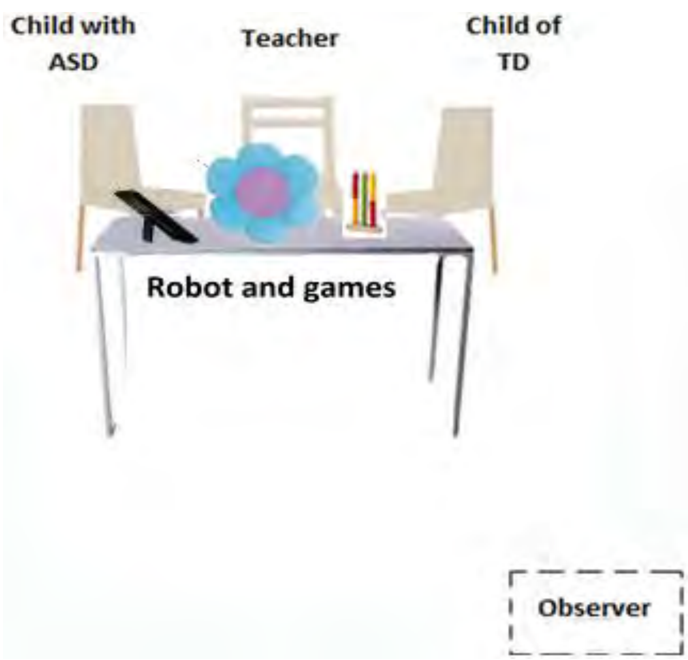

Figure 2. Research setting

Procedure

Initially, in order to measure the performance of the children with ASD before the intervention, children with ASD participated in activities under the conditions of setting A of the experimental design (children with ASD play triadic activities with children of TD and their teacher, with no robot). Each of the six groups engaged in conversational patterns, during which they had to answer and set questions of familiarization, to describe previous experiences and to narrate stories. Specifically, children with ASD were encouraged to state their name and the names of family members, to talk about favorite habits, to address questions to the teacher and to the TD child.

Afterwards, all three participants (child with ASD, child of TD and the teacher) played a board game and a digital game at a tablet (Figure 3). The Kindergarten groups played a game with a wooden abacus. A wooden abacus, a pile of cards with different colors and a pot with balls of different colors were placed in front of the participants. The participants were instructed to pick a card from the pile, choose the ball of the color indicated at the card and place it on the abacus stick.

The Elementary school groups played the board game “snakes and ladders”. According to the game rules, children and teacher had to alternately throw the dice, count squares on the board and move respectively their pawns. The game ended when a pawn of a player had reached the finish square.

Abacus *Snails race* *Digital game*

Figure 3. Games during Setting A

The last part of the session was a digital game (the free application “Kids Touch Games”), during which the participants had to take out a flower’s petals by dragging them alternately until there were no petals left on the flower.

The teacher, during the activities of setting A, was encouraging and urging the children to get involved in the conversation and provided the instructions of the games and the reminders of the rules. The activities (topics of the conversation and games) were designed with respect to children with ASD interests and abilities, according to unstructured interviews of their teachers and to the diagnosis from pediatric centers.

The intervention

A three-step intervention was designed and implemented. During step one, which lasted for two sessions of 15 minutes each, interaction between the Daisy Robot and the child with ASD was initiated and established. The first contact with the robot was spontaneous. The robot was placed on the table before the entrance of the child in the room, so that the child could notice and approach the robot alone, with no any interference from the teacher. The scenario of the spontaneous discovery of the robot was expected to trigger the child’s interest and motivation to engage them with the robot. The robot was activated, blinking and scanning with its eyes for two minutes, waiting for the child to notice and approach it. In case that a child showed no interest to the robot, Daisy addressed the child by saying hello and stating its name: “hello, my name is Daisy”. Once the child reacted, the robot started asking questions (personal, routine and knowledge questions). At this phase, the children interacted with the robot through conversation and activities by following simple instructions and levels of graded difficulty. The aim of this step was for the child with ASD to perceive the robot not as a toy or a tool, but as a whole entity, a perception enhanced by the intimacy and connection with the robot that the child established through the extended interaction.

During step two of the intervention, which lasted for two sessions of 20 minutes each, the teacher entered the previous step team. The acquaintance of the teacher with the robot was fulfilled as the robot asked questions directly to the teacher or addressed questions about the teacher to the child, so that the child could give information about the teacher. After this familiarization phase, the robot asked the child - teacher pair to play the board and the digital game of the previous step, during which all instructions, reminders, guidance and encouragement to both were given exclusively by the robot. So, the robot had the role of the teacher/facilitator and the teacher had the role of the team-mate. The presence of the teacher in this step ensured the smooth conduct of the game, as the teacher knew the child's habits and what was likely to irritate or help him/her to work better, so as possible anxiety triggers to be avoided.

During step three of the intervention, the B setting took place (children with ASD play triadic activities with children of TD and their teacher in robot assisted sessions). That was the step for the evaluation and lasted for a session of 20 minutes. The TD children of the A setting came again into the groups. The Daisy Robot created the conditions for discussion and exchange of information through questions and set the rules for both the board games and the digital games with the tablet. During this step, the Daisy robot was reminding rules and providing prompts, while the teacher had the role of the team-mate of the two other children (with ASD and of TD), forming a triadic group.

To avoid the possibility that the scores of the children were affected by the repetition of the same games, different games (board and digital) with similar goals and difficulty were introduced by Daisy. The kindergarten pupils played the board game “snails race” during which every child alternately, threw a dice and moved his/her snail on the board matching the indicated by the dice color. The game was over when a snail had reached the finish line (Figure 4).

Snakes and ladders ***Ludo*** ***Memory***

Figure 4. Games during Setting B

The elementary pupils were introduced to the game “Ludo” (Figure 4). According to the rules the Daisy robot set, every child had to move his/hers pawns towards the finish by throwing the dice and counting the blocks that their pawns should move, until all of them were at the finish position. The digital game for both groups of kindergarten and elementary children was chosen to be “Memory” (Kids Touch Games) (Figure 4). The children had to choose and turn two cards at a time, until the pairs of same pictures were all revealed.

Data collection – measurements

In order to create the observation scale, a tool based on TEACCH's Social Assessment Method (Olley, 1986) was modified and utilized. That tool is in accordance with assessments techniques (Watson, 1988; Schopler et al., 1990).

Scales of frequency were used to measure the behaviors below. After editing and modifying the tool, the following skill scales (markers) with their sub-scales were set for testing:

1. Activity in a group (GA): the ability of the child to participate in group activities and remain in them until they are completed.
2. Information (IN): the ability of the child to give and ask for information about himself, objects and other people, the ability of answering questions using one word or a clarifying way.
3. Turn taking (TT): the child's ability to wait his/her turn in group activities.
4. Instructions – Rules (IR): the child’s ability to follow basic behavioral instructions and rules.

Analyses of the categories in subcategories and their explanation are presented in Table 3. Categories and subcategories were rated with the five-point Likert scale (1 = never, 2 = little, 3 = enough, 4 = very, 5 = always). In the calculation of the total score of category 1 “Activity in a group”, the score of negative item subcategory 1c “needs propts to stay in place” has been reversed.

To ensure the credibility of the study, the researcher and the teacher were both taking notes on the observation scale. The notes concerned the way children were responding to the conversation routine, their participation in the games activities, and what was the frequency of the observed behaviors. After the end of each session, both the observer and the teacher compared their notes and the Likert scale was applied to the scale’s markers with the agreement of both of them.

Results

Child K1 at the initial evaluation phase (setting A) during which he interacted with a TD child and his teacher, under the guidance of the teacher, was able to provide information about himself, mainly in questions such as: what is your name, what is your father’s name?, while he found it difficult to give information that were referring to his favorite objects or habits. He named some of the objects, but with the exception of the marker that he said it’s an object we use in order to write or draw, he refused to give information about the use of any other of the objects and he even stood up several times showing discomfort. In addition, when he was given a picture to describe, he observed the picture only for few seconds and just named some of its objects he recognized. During the game activities, he followed some of the rules – instructions, while several urges were needed for K1 to participate and remain sited.

On the contrary, during the Robot-Assisted (RAS) session (at the third step of the intervention – setting B), K1 significantly responded while describing himself or the given objects. When Daisy asked him to describe the previous picture K1 remain sited and rather patiently observed the picture, he named most of its elements and he even tried to describe the relationship of the people presented in the picture (mother and son). During the game activities he almost followed all of the rules – instructions, and without prompts he remained sited and with enthusiasm he fulfilled the games (Figure 5).

Table 3. Observation scale – The 4 categories and their subcategories (items)

1. Activity in a group - GA
The child
1a participates in group activities when instructed (corresponds to opportunities for team play).
1b remains in the group during an activity (is able to stay in a group activity, and to complete it).
1c needs prompts to stay in place in the team during an activity (in order to remain in group action some kind of encouragement, physical or verbal, is required).
2. Information - IN
The child
2a provides information about him/herself (if they are able to provide information about themselves, whether those are related to descriptions of their characteristics or to descriptions of their actions).
2b provides information about others and about objects (is able to provide information about objects and others, whether those are related to descriptions of characteristics or to descriptions of actions).
2c gives explanatory answers (is able to clarify his/hers replies, related to explanations of situations or attributing cause to situations)
2d is able to describe images (is able to describe pictures, without just naming the pieces that compose it).
2e provides information about space and time, weather, etc. (is in the position to provide information without receiving extra clarification about time, space the weather etc.).
2f asks for clarifications (is in a position to ask for explanations when asked to describe a condition/situation).
3. Turn taking - TT
The child
3a waits for his/her turn in group activities without touching the other (if, during a group activity of two people, the child is able to recognize when it is his/her turn and waits for it, without impulsively touching, pushing and pulling the other).
3b waits for his/her turn in group activities without leaving his/her seat (if the child is able during a group activity of two people to recognize when it is his/her turn and waits for it, without getting up either to wander, or to do something else).
4. Instructions / Rules - IR
The child
4a responds to verbal instructions (if the child can follow an instruction to carry out an activity or to execute a command).
4b responds to verbal urges (to what extent does verbal prompting motivate the child to execute a command, to follow a rule and complete an activity).

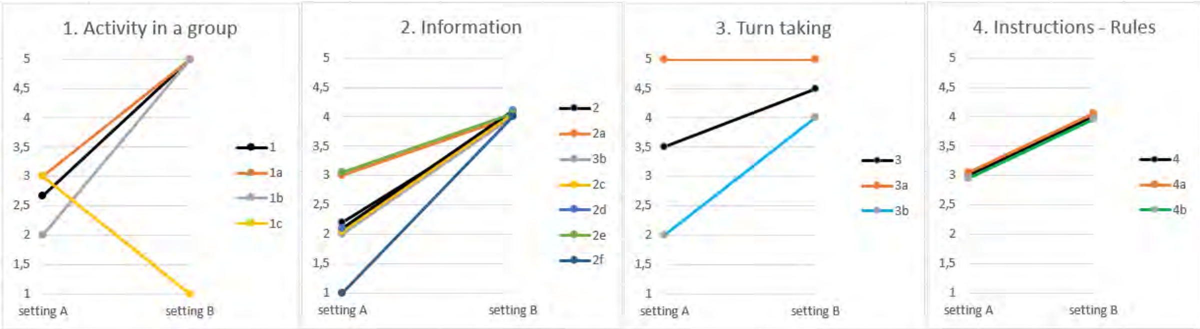

Figure 5. Child K1: Comparison of child's performance between setting A and B

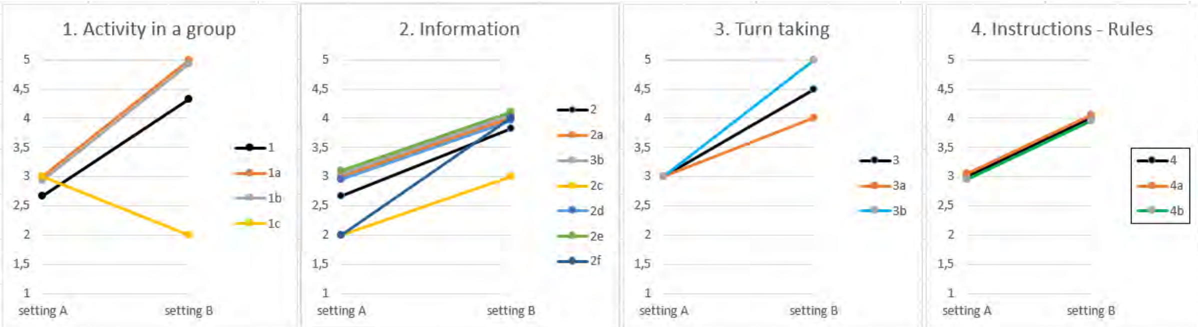

Figure 6. Child K2: Comparison of child's performance between setting A and B

During the initial assessment (setting A), child K2 was facing difficulties in following rules during the game activities and also had a moderate response to verbal reinforcements in order to remain sited (several times he even seemed to ignore any verbal instruction or encouragement given). K2 was able to share some information about himself but seemed indifferent when he was asked to describe his appearance. He described some of the objects given and when he was asked to describe a picture after almost a minute of observing it and repeated questions of the teacher he was able to name enough of its elements. During the game activities several verbal urges were required so as to remain sited and close to the table that the board and digital games were held and two times he even tried to grab the tablet from his teammate.

During the RAS assessment (setting B) child's K2 excitement with the robot was obvious enough as he remained sited during the whole session and managed to follow almost every rule especially during the game activities. With much enthusiasm, he was responding to the robots questions providing information about himself. When he was asked to describe the same picture as before, in a more descriptive way he named some of the elements of the picture and he even said referring to the Daisy "look there is the sun, it is morning". During the game activities he only once tried to take the tablet away from his teammate but he was able to wait for his turn during the board game with impulsive reactions (Figure 6).

K3 child during the first assessment (setting A) was rather impulsive. With difficulty he remained sited throughout the whole session, while he was not willing to participate in the game activities. After several urges he managed to follow some of the instructions and to take part for a small period of time at the games but he almost always was standing up and several times was trying to grab objects from his teammate. He gave few information about himself or some objects and when he was given a picture to describe, at first he threw it away, but when the teacher handed it again asking him to describe it, he was repeatedly just saying "some little kids" that where at the picture. He never asked for any clarification regarding the rules of the games or a question he seemed not to understand.

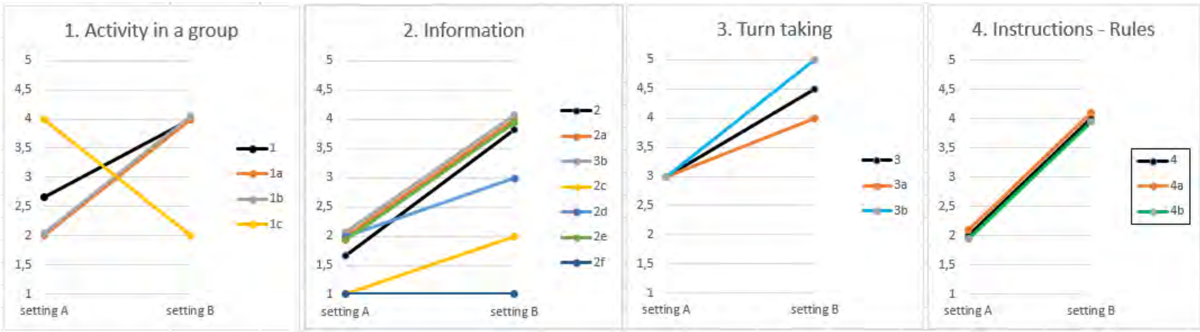

Figure 7. Child K3: Comparison of child's performance between setting A and B

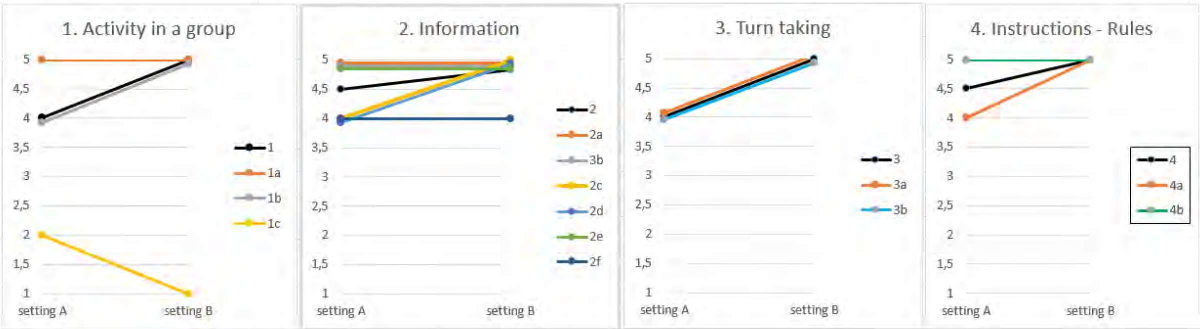

Figure 8. Child E1: Comparison of child's performance between setting A and B

During the RAS and especially at the beginning (step 1 of the intervention) K3 child was hesitant to sit close to the robot, he started to feel more motivated when the robot started to ask him questions. At the step 3 of the intervention (setting B) he answered almost all of the questions that were referring to the description of himself and he described almost all the objects that he was asked to. He participated in the games after few prompts and he remained at his seat almost throughout the session. He even tried to describe the picture after Daisy's several prompts, by naming some of the objects that were presented. He still didn't ask for any clarification (Figure 7).

Child E1 was the child that had the least improvement comparing with the other children. That was because as can be seen in the graph (Figure 8) the scores of E1 were already too high at the initial assessment (setting A), during which she only had a small difficulty to remain at the group during a game as she was impatient while waiting for her turn. At the third step of the intervention (setting B) and after Daisy's prompt "You should remain sited and wait for your turn", she was able during the RAS to fulfil games and patiently wait for her turn. Even when she was feeling urged to stand up she was repeating to herself "You should remain sited and wait for your turn" (Figure 8).

Child E2 during the first assessment (setting A) comfortably enough provided information about himself, about the weather and the date but rather difficult and unwillingly he named or described given objects. He easily described almost all of elements of the picture but he needed several prompts in order to start describing it. He participated in the game activities but some verbal urges were needed in order to remain sited and even once he impulsive ran towards his teammate.

During the RAS (setting B), the excitement he felt while interacting with the robot was rather obvious as he was describing to his teacher how hesitant he was to meet the robot again and play games with Daisy. He described himself, all the given objects and picture. He followed all of the instructions and needed no urge to remain sited and wait for his turn (Figure 9).

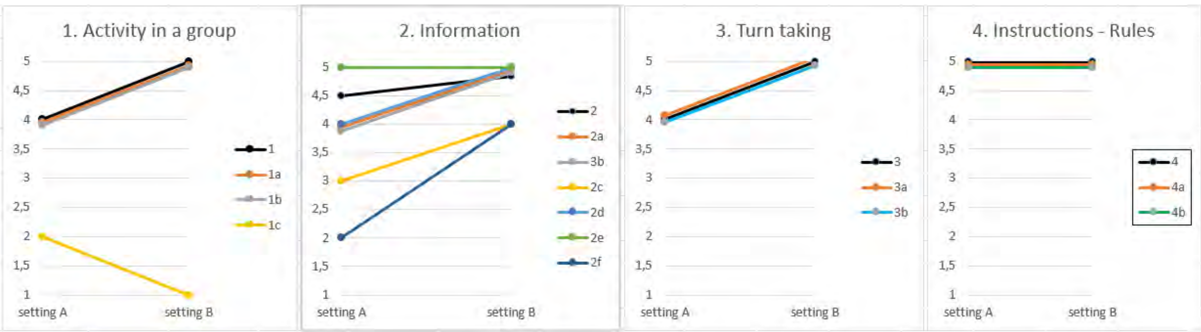

Figure 9. Child E2: Comparison of child's performance between setting A and B

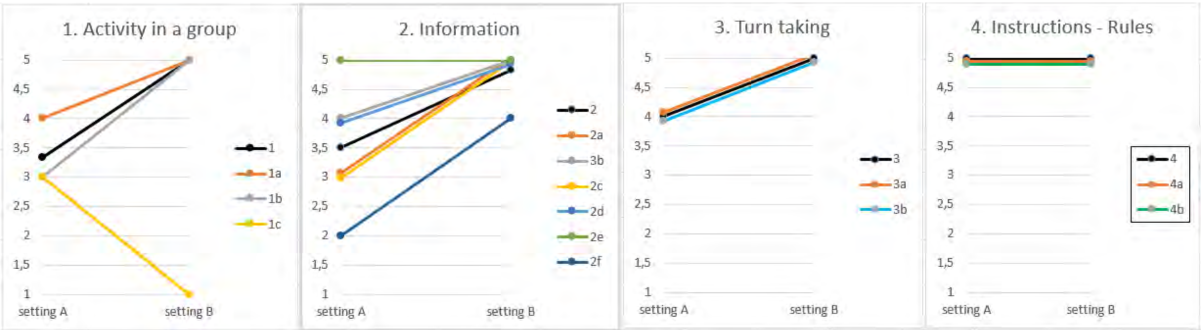

Figure 10. Child E3: Comparison of child's performance between setting A and B

During the initial evaluation (setting A), child E3 did not show any particular discomfort with the proximity of the teacher or the other child, but sometimes he was standing up and was responding to the questions while moving around the classroom. The same thing happened during the games (at which he participated after several urges) when he was standing and walking while waiting for his turn. He described almost all of the objects that he was asked to but he had significant difficulties in providing information about himself. He only stated his name and some of his favorite games, while he seemed to ignore some questions (for example questions referring to the names of his parents and description of his appearance). His response time was relatively slow.

During the RAS (setting B), child E3 responded to every questions describing himself and every object he was asked to, he participated willingly and with excitement to the games (board and digital) and responded to the questions followed every rule and he not once left his seat or moved around the classroom while waiting for his turn (Figure 10).

To summarize the results, concerning the performance of the children with ASD between setting A and B, we see that in the first three categories (activity in a group GA, information IN and turn taking TT) all children presented a clear increased performance in setting B. In category Instructions – Rules IR, only at Kindergarden children we see increased performance in setting B, while at Elementary children the performance between setting A and B was almost eaual. The above are also depicted at the mean values – overall scores per category. Before comparing the overall scores of the categories, Cronbach's alpha was used to assess the reliability - internal consistency, of the items of their subcategories per setting. The test result showed high reliability A> 0.7. This result makes it possible to compare the mean scores of children per category. In Activity in a group (GA) the RAS session (setting B) performance mean (M=4,78) was higher than the initial (setting A) performance mean (M=3,33) and similar are also the cases for Information (IN) (setting B performance mean M=4,19 was higher than the setting A performance mean M=3,07) and for Turn Taking (TT) (setting B performance mean M=4,67 was higher than the setting A performance mean M=3,58). In all previous three categories, the non-parametric Wilcoxon signed rank test show statistically significance (at 95% confidence level). Regarding the skill of following Instructions – Rules (IR), the initial (setting A) performance mean was 3.75, while the RAS session (setting B) performance mean was 4.19, but with no statistically significant difference.

Discussion and Conclusions

The aim of this study was to investigate whether interventions with a socially assistive robot and specific with the Daisy robot, can efficient facilitate children with ASD to be part of a team, engage and fulfill triadic activities.

The enthusiasm that children with ASD experienced from the robot's presence and the security they felt during the interaction with Daisy motivated them, so as to participate adequately in triadic activities that promoted social skills. This is in line with Begum's findings (2016), suggesting that robot mediated interventions promote interest, enthusiasm and attention of children with ASD.

None of the children seemed to feel threatened by the presence of Daisy, reacted impulsively or refused to cooperate. The particular observation comes in agreement with Robins et al. (2005) as well as Diehl et al. (2012), who suggested that children with ASD can feel more comfortable while interacting with robots, as the reactions of the robots appear to be more predictable and consistent than those of humans.

Furthermore, the children with ASD showed increased motivation in verbal communication, as they provided information about themselves and were trying to introduce their teammates (children and teachers) to the robot and even attempted to initiate a conversation. The particular finding is in accordance with Stanton et al. (2008), who suggested that SAR mediate successfully the communication and interaction among children with ASD and TD.

The analysis of the results showed the improvement in children's performance after the interventions with Daisy in three of the four observed skills (activity in a group, information, turn taking). These results confirm previous findings of Scassellati and colleagues (2012), who pointed out that there is an increase in user engagement and improvement in social skills, while interacting with robots. The comparison concerning the skill of following Instructions – Rules, showed no statistical significance. The reason seems to be that the mean was already high enough also at the initial measurement (the children had high scores in the observed items from the beginning).

In conclusion, the Daisy robot with its consistent and not impulsive but predictable behavior, seems to be able to provide an environment that respects the heterogeneity of ASD, in which children are motivated to be part of a group, integrate activities and develop social skills. This conclusion supports the hypothesis of the study, namely that the Daisy Robot, a huggable semi-autonomous robot is able to motivate children with ASD, 6-9 years old, to sufficiently participate in triadic game activities with a child of typical development and their teacher.

Even if the Daisy robot, according to a previous study (Pliasa & Fachantidis, 2019) seems to motivate efficiently children to participate in dyadic activities compared to a teacher, still more research is needed. For example, comparative interventions with and without the Daisy presence and assistance could be conducted, to investigate whether Daisy is a significant factor that promotes successfully social skills in children with ASD. Although there are promising results, the limited sample of the six children with ASD does not allow generalizations. Since the autism spectrum is very wide, interventions with the Daisy robot would be of great interest to be applied in children with different speech characteristics and level of functioning. Significant data which will result from interventions in a large, heterogeneous sample, would verify, the added value of Daisy robot in the development of social skills in children with ASD.

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