Mobile Technologies Serious Games for the Development of Social Skills in Children with Autism Spectrum Disorders, in Enhanced with Socially Assistive Robots Interventions

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Abstract. The aim of this study is to present some of the benefits of serious games in the development of social skills in children with Autism Spectrum Disorders (ASD), and how those can be enhanced when Socially Assistive Robots assist in the interventions. Six Kindergarten and Elementary children with ASD played mobile and board games with six children of Typical Development (TD) while assisted by a teacher to verify previous researches that show that serious games can increase interest in children with ASD to participate in activities with their peers. Similarly, all children responded better at presenting socially acceptable behaviors, when playing serious games but were supported by the socially assistive robot Daisy, which also incorporates mobile technologies.

Keywords: Social robots · Serious games · Autism Spectrum Disorders · Social skills · Interactive mobile technologies

1 Introduction

Autism Spectrum Disorders (ASD) is a neurodevelopmental disorder characterized by severe deficits in social skills and persistent stereotypical behaviors (Landrigan et al. 2012). These characteristics affect children's with ASD socialization and interactions with their peers (Zoghbi and Bear 2012). An increasing number of children around the world are within the spectrum of autism (Blaxill 2004; Olds et al. 2013; Scassellati 2005; Wong et al. 2014). Recent studies have estimated that the prevalence of children in the spectrum is 1 in 59 children (CDC 2017).

Playing games and interacting through more structured environments, such as the one that rules set when participating in board or mobile games, is rather challenging in children with ASD (Jasmin et al. 2009). Games is one of the most important activity in every child's life, as it is about one's innate ability to interact, connect and learn through a pleasant process (Reynolds et al. 2011).

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This is why it is a main learning tool for all the essential functions as a child grows older. Children with ASD benefit nonetheless from game activities despite the fact that the way they engage in those, present some peculiarities and differences with the "conventional" way that children with typical development (TD) involve and interact Loftin et al. 2008). Social rules, which are informally embedded in the games, as well as the reflection of participants' movements and behaviors, can support children's social-interactivity in the autism spectrum, even in cases of children of non verbal communication (Wolfberg et al. 2012). On the other hand, aiming to develop skills, changing attitudes or accomplishing cognitive goals through gaming, leads us to Serious games, which can be described as "digital games and equipment with an agenda of educational design and beyond entertainment" (Park et al. 2012). Taking into account deficits, surpluses, the stereotypes and predominantly the heterogeneous of the autism spectrum, research suggests that interactive technologies and specific serious games while applied in children with ASD they: (a) increase focused attention; (b) increase the overall attention span; (c) increase the sitting behavior; (d) increase fine motor skills; (e) increase generalization skills (from computer to related non-computer activities); (f) decrease the agitation; (g) decrease the self-stimulatory behaviors; and (h) decrease the perseverative responses. (Boucenna et al. 2014).

Playing games on smartphones, pads, and tablets for educational purposes is becoming popular these days for children with ASD and have the second highest percentage as devices (Zakari et al. 2014). Papers that review and evaluate serious games for children with ASD (Zakari et al. 2014, Grossard et al. 2017) refer that serious games target mainly social abilities for ASD, emotion recognition and production (Grossard et al. 2017). Grossard et al. mention that many serious games for ASD require skills which prohibit accessibility to a large portion of those on the spectrum (e.g. reading skills, difficult oral comprehension, attention to faces and eye-contact, etc.). Also regarding the design of the serious play for ASD, Whyte et al. pointed out the necessary characteristics that enhance motivation to play and support generalization of learning. These elements include: immersive storylines, goals directed around targeted skills, rewards and feedback about goal progress, increasing levels of difficulty, individualized training, and the provision of choice (Whyte et al. 2015). Almost the same characteristics of serious games design are considered crucial by Grossard et al. and were used in order to review 31 serious games in ASD that were designed to improve social skills.

Meanwhile, some of the above characteristics are met in robot assisted interventions in ASD and specific with Socially Assistive Robots (SAR). Socially Assistive Robots (SAR) in the last decades have made crucial efforts (Huijnen et al. 2016) to motivate children with ASD to willingly participate in team activities, such as games. More specific, special interventions that exploit features and characteristics of SAR have been designed in the aim of assisting people with ASD to trespass some of their deficiencies especially in what comes to their social skills and reach some educational goals (Cabibihan et al. 2013). Robins and colleagues (2006) suggested that SARs can promote triadic interactions among themselves, a child with ASD and a human experimenter. In their study presenting robots as social mediators, they showed that SARs are able to assist in socialization with peers, even with other children with ASD, in novel ways (Robins et al. 2009).

The aim of this article is initially to support the idea that mobile game-activities are a motivation for children with ASD to participate in team games, as mobile technologies tend to offer a controlled environment with minimal distractions, and their use is therefore attractive for the education of children with ASD. Then we are going to investigate whether a SAR, that its design and development is based on interactive mobile technologies, can join in the serious games' interventions and enhance their positive effect in the development of social skills in children with ASD.

2 Experimental Design

The hypothesis of this research is that Daisy robot, a huggable semi-autonomous robot can boost the efficiency of serious games to motivate children to participate in team games and interact in a socially acceptable manner with their peers. To test the hypothesis, a two-phase experiment was designed (Level 1 and 2) (Fig. 1).

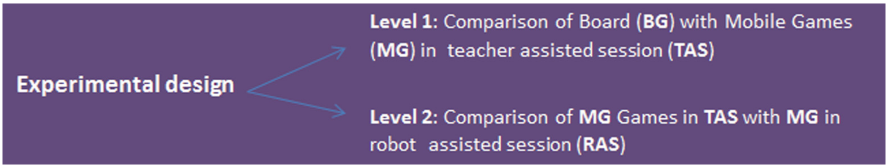

Fig. 1. Experimental design

At first 6 children with ASD tried to engage with 6 children of TD (in couples), in board and mobile games instructed by their teacher, to detect if board or mobile games motivated children more, to follow rules and participate in shared activities. The type of game (mobile or board) that succeeded better results was later tested again, but instead of the teacher, a robot instructed and motivated children to play. The dual purpose of the research was to define whether:

- children with ASD engage more in board or mobile games and
- SAR is able to motivate them more to engage and fulfill game activities.

To determine whether the two different sets (instructed by the robot vs. instructed by a teacher) elicit different responses in the same activities, a single case experimental design was held.

3 Participants

Fifteen people participated in this research. Specific twelve children, aging 6–9 years old; six of them with ASD and six of TD. They were all attending public schools and the six children with ASD were also supported by teachers that were promoting their inclusion in the general classroom. Those teachers (3) participated and contributed in the fulfillment of the research.

Children with ASD. Five boys and one girl were selected. Specifically, three boys (K1, K2, K3) six years old, that were kindergarten students, 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 were in the autism spectrum at the level 1 of severity. They were highly functional but with significant difficulties and deficits in social skills. Data on their IQ were not available.

Typical Development children TD. Two girls and four boys of TD were selected. In particular, a six-years-old girl (T2) attending the Kindergarten that was teamed up with the K2 student. Two boys of six (T1, T3) that were pupils of the Kindergarten who formed a group with children K1 and K3 respectively. A seven years old boy (T4), who worked with the child E1 and was attending the first grade of the elementary school, an 8 years old girl (T5) attending second grade who was teamed up with the E2 student and a 9 year old boy (T6), attending the third grade and collaborated with the child E3 (Table 1). The selected TD children were peers and classmates with the children with ASD that they worked with.

Table 1. Participants and groups formed

Group	*Group 1*		*Group 2*		*Group 3*		*Group 4*		*Group 5*		*Group 6*	
	student	*age*	*student*	*age*	*student*	*age*	*student*	*age*	*student*	*age*	*student*	*age*
Students with ASD	*K1*	*6*	*K2*	*6*	*K3*	*6*	*E1*	*7*	*E2*	*8*	*E3*	*9*
Students of Typical Development	*T1*	*6*	*T2*	*6*	*T3*	*6*	*T4*	*7*	*T5*	*8*	*T6*	*9*

4 Settings

The research was held at the public schools that the children attended and specifically, The selected rooms for the fulfilment of the interventions were quiet and without many stimuli. Around a table three chairs were placed. Two of them side by side at one side of the table for the children and one across the table for the teacher during the teacher assisted sessions. During the robot assisted sessions Daisy robot was placed on the table, with its face looking at the children. On the table was also a tablet and board games for the implementation of the games-activities. The observer sat at the corner of the room, away of sight so that could operate the robot and keep notes without distracting the participants.

5 Procedure

Teacher assisted sessions - **TAS.**
Each one of the six groups of children participated in two sessions during which the teacher (teacher assisted session TAS) asked children to play a board and a digital game (tablet). The selected games were according to children's with ASD interests and abilities. Every group of Kindergarten students played with a wooden abacus (Fig. 2). The teacher instructed the children to alternately place balls of a certain color to the specific abacus stick. The game ended when there were no more balls left. Groups of Elementary pupils played "snakes and ladders". The students had to alternately throw the die, count squares on the board and move respectively their pawns. The game ended when one of the pawns had reached the finish square. After the board games, a digital game with a Daisy flower, by the free application "Kids Touch Games", was played both by Kindergarten and Elementary students. During this game students had to take out a flower's petals by dragging them alternately until there were no petals left.

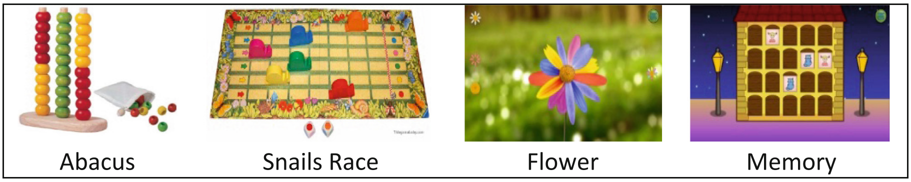

Fig. 2. Games for kindergarten children during TS and RS

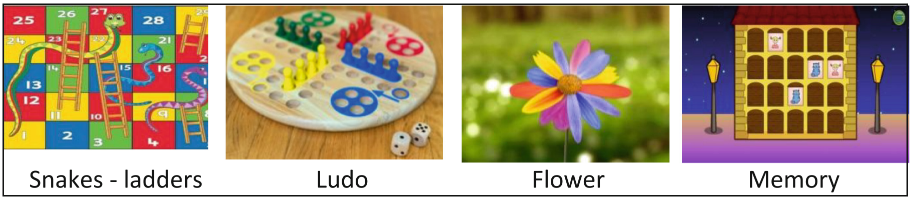

Fig. 3. Games for elementary children during TS and RS

Robot assisted sessions - **RAS.**
During the robot assisted sessions (RAS) in order to avoid the possibility that the scores of the children were affected by the repetition of the same games, different games from the TAS were chosen, but of similar goals and difficulty. Both Kindergarten and elementary students played the "Memory" game (Fig. 3) of the free application "Kids Touch Games". Children had to choose and turn two cards at a time, until the pairs of same pictures were all revealed. Each session lasted approximately 15 min. The TAS sessions with board and mobile games were repeated twice for every group and the RAS was also repeated twice for every group, to make sure the scores of the children were not random. Before the main sessions with the robot, there was a familiarization

phase during which every child with ASD interacted with the robot, chatted with it and played games, in order to feel comfortable and secure and not to be stressed during the experimental procedure. Before the robot assisted sessions all children met Daisy robot and interacted with it while playing games and participating in conversations led by the robot. The aim of this familiarisation phase was children to feel comfortable and secure with Daisy so as to participate without hesitation at the robot assisted sessions.

6 Devices

Daisy robot (a mobile technology social robot) was utilized for the implementation of the interventions. Daisy is a flower shaped semi-autonomous robot, like a stuffed soft toy, with light blue and purple color (Fig. 4). 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 lip sync technique. The robot performs sequences of movements and facial expressions, and is remotely controlled, through a mobile app. In addition, a tablet was utilized for the implementation of the digital games-applications.

Fig. 4. The robot Daisy

Data collection – Measurements

To create the observation scale, a tool was modified and utilized that was based on TEACCH's Social Assessment Method (Treatment and Education of Autistic and Communication Handicapped Children (Schopler et al.1990). After editing and modifying the tool, the following skill scales (markers) with their sub-scales were set for testing:

1. Activity in a group: the child's ability to participate in group activities, and remain in them until they are completed (GA)
2. Instructions – Rules : the child's ability to follow basic behavioral rules and guidelines (RI)
3. Turn taking: the child's ability to wait his/her turn in group activities (TT).
4. Reciprocity: the child's ability to share objects, to respect the others and their personal space (R).

Categories and subcategories were rated with the five-point Likert scale (1 = never, 2 = little, 3 = enough, 4 = very, 5 = always).

Scales of frequency were used to monitor the frequency of the aforementioned behaviors. Both the observer and the teacher were taking notes on how children were responding to the markers of the observation scale, and the frequency of the observed behaviors. After each session, the observer and the teacher were discussing on their notes and the Likert scale was applied to the scale's markers with the agreement of both (Table 2).

Table 2. Observation scale

1. Activity in a group
1.a Participates in group activities when instructed (whether the child corresponds to opportunities for team play, frequency and willingness)
1.b Remains in the group during an activity (whether the child is able to stay in a group activity, and to complete it, frequency and willingness)
1.c Urges are needed to stay in place in the team (whether in order to remain in group action, some kind of encouragement, physical or verbal, is required, frequency)
2. Instructions - Rules
2.a Responds to verbal instructions (if the child can follow an instruction to carry out an activity or to execute a command)
2.b Responds to verbal urges (to what extent does verbal prompting motivate the child to execute a command, follow a rule, complete an activity)
3. Turn Taking
3.a Waits for its turn in group activities with one person without touching the other (if, during a group activity of two people, the child is able to recognize when it is its turn and wait for it, without impulsively touching, pushing and pulling the other)
3.b Waits for its turn in group activities with one person without leaving his seat (if the child is able during a group activity of two people to recognize when it is its turn and wait for it, without getting up, either to wander or to do something different)
4. Instructions Reciprocity
4.a Can share materials with others when there is a structured working environment (whether, in an organized activity that requires sharing materials, is able to share them with others, or if she/he grabs them, and refuses to give them)
4.b Respects each other's personal space (whether it does not penetrate into the personal space of the other, in organized or non-organized actions-activities)

7 Results - Discussion

The Wilcoxon signed rank test (at 95% confidence level) was applied to compare the performances of the children with ASD in the three different settings. More specific the comparisons were between

1. Board games **BG** – Mobile Games **MG** in teacher assisted sessions (**TAS**)
2. MG in TAS– MG in robot assisted sessions (**RAS**)

There are statistically significant differences in almost all four observed skills between the comparison of BG and MG under the guidance of the teacher. Specific all children succeed better scores in all four skills that were evaluated, during the MG (Table 3).

Table 3. Paired sample statistics (board games BG - mobile games MG)

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
GA_MG_TAS	6	3.33350	.919033	2.000	4.334
IR_MG_TAS	6	3.75000	1.254990	2.000	5.000
TT_MG_TAS	6	3.58333	.970395	2.000	4.500
R_MG_TAS	6	3.33333	.683130	2.000	4.000
GA_MG_RAS	6	4.77783	.403668	4.000	5.000
IR_MG_RAS	6	4.50000	.547723	4.000	5.000
TT_MG_RAS	6	4.66667	.408248	4.000	5.000
R_MG_RAS	6	4.66667	.605530	3.500	5.000

Test Statistics[b]

	GA_MG_RAS - GA_MG_TAS	IR_MG_RAS - IR_MG_TAS	TT_MG_RAS- TT_MG_TAS	R_MG_RAS - R_MG_TAS
Z	-2.207[a]	-1.841[a]	-2.214[a]	-2.271[a]
Asymp. Sig. (2-tailed)	.027	.066	.027	.023

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

Similarly all six succeed better means when playing MG with the assistance and prompts of the robot (Table 4).

Table 4. Paired sample statistics (MG teacher session TAS – MG robot session RAS)

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
GA_MG_TAS	6	3.33350	.919033	2.000	4.334
IR_MG_TAS	6	3.75000	1.254990	2.000	5.000
TT_MG_TAS	6	3.58333	.970395	2.000	4.500
R_MG_TAS	6	3.33333	.683130	2.000	4.000
GA_MG_RAS	6	4.77783	.403668	4.000	5.000
IR_MG_RAS	6	4.50000	.547723	4.000	5.000
TT_MG_RAS	6	4.66667	.408248	4.000	5.000
R_MG_RAS	6	4.66667	.605530	3.500	5.000

Test Statistics[b]

	GA_MG_RAS - GA_MG_TAS	IR_MG_RAS - IR_MG_TAS	TT_MG_RAS- TT_MG_TAS	R_MG_RAS - R_MG_TAS
Z	-2.207[a]	-1.841[a]	-2.214[a]	-2.271[a]
Asymp. Sig. (2-tailed)	.027	.066	.027	.023

a. Based on negative ranks.
b. Wilcoxon Signed Ranks Test

More specific according to the comparison of the TAS with RAS session for

Activity in a group (**GA**): the TAS mean is 3.3335 while the RAS mean is 4.77783, p = 0.027

Information – Rules (**IR**): the TAS mean is 3.750 while the RAS mean is 4.500, p = 0.028

Turn Taking (**TT**): the TAS mean is 3.5833 while the RAS mean is 4.6667, p = 0.027

Reciprocity (**R**): the TAS mean is 3.3333 while the RAS mean is 4.66674, p = 0.023.

The above results show that children seemed to be more willingly to participate in the serious games activities with their peers when guided by the robot. Furthermore, children with ASD showed increased interest in verbally communicating, providing information about themselves and even initiating a conversation.

8 Conclusion

The involvement of the SAR (Daisy robot) in the implementation of the serious games and the interventions which were aiming social skills development have shown interesting results. The increased interest of children with ASD for verbally communication agrees with previous researches' outcomes, that triadic interactions (child with ASD - robot - another human) can be successfully fostered when initiated by a robot (Stanton et al. 2008). Also, the results verify previous researches that suggest that robots can increase self-initiated social interactions in children with ASD with humans and can also motivate children to present verbal engagement and authentic interaction (Robins et al. 2006). The above are also aligned with the requirement of serious games design to support and enhanced multimodal communication.

The enthusiasm and security that children with ASD felt while interacting with the robot, motivated them to cooperate with their peers, in activities of serious games that promote social skills. The fact that none of the children was hesitant to approach and interact with Daisy robot verifies the surveys that present SAR able to engage children in the autism spectrum in collaborative activities (Robins et al. 2009). Also, with Daisy robot presence, verbally interventions and non-verbal messages (e.g. facial emotions, petal movements, etc.) it was feasible to develop proper environment of Storylines Enhance Motivation, Contextualize Learning, Feedback and Rewards Shape Learning. In this way, core principles of serious game design have been supported and enhanced by the presence of the SAR.

The goal of this study was to determine whether a session with a SAR as a facilitator can enhance the implementation of serious games in ASD, aiming social skills development. Both, serious games and Daisy robot, have been developed and incorporate mobile interactive technologies. Reviewing the results it is observed that all 6 children with ASD performed better in serious games activities when assisted by the SAR. The comparison of the scores suggest children with ASD were more motivated not only to participate in the activities but also to accomplish them, experiencing less stress. Those conclusions confirm previous works that suggest that children with ASD when interacting with robots present willingness to participate in activities and high levels of interest. (Begum et al. 2016).

In conclusion, Daisy robot seems to be able, by utilising mobile interactive technologies, to provide the necessary motivation to the children with ASD for participation, but also to enhance core principles of serious game design and implementation.

The limited sample of six children with ASD does not allow great generalization of the results. Significant data will result from a research in a large heterogeneous sample, the analyses of which will prove the added value of SAR in the development of social skills in children with ASD.

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