A full-body interactive videogame used as a tool to foster social initiation conducts in children with Autism Spectrum Disorders

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ABSTRACT

Background: Game-based interventions that involve the use of technology have shown to facilitate motivation and learning processes in children with Autism Spectrum Disorders (ASD). The purpose of this observational study project was to conduct a feasibility study to compare the amount of social initiation conducts performed during a full-body interaction videogame versus the amount of social initiation conducts occurred during a free-play activity in children with ASD. We hypothesized that the videogame could elicit a higher number of these conducts and therefore could be proposed as a tool to promote social initiation skills.

Method: A total of 15 children (ages 4 to 6) participated in four sessions with two sections: playing with the videogame Pico's Adventure and free play time. Social skills conducts were codified according to an observational scale.

Results: Results show that the videogame elicited more social initiation conducts than free play in children with ASD when they were playing alone or playing with a peer. Furthermore, it showed to be as effective as free play in promoting social initiation while playing with parents. The videogame was also effective in reducing repetitive behaviors and increasing gestures.

Conclusions: Considering all these results, the videogame could be considered as an appropriate tool to foster social behaviors but future work is needed in order to obtain further data that supports this hypothesis. Finding new attractive types of treatment would be useful to complement more traditional therapies.

Key words: Autism Spectrum Disorder, Social skills, full-body interaction, observational scale.

INTRODUCTION

Autism Spectrum Disorders (ASD) are serious neurodevelopmental disorders that involve impairments in reciprocal social interaction and social communication, combined with restrictive interests, repetitive behaviors and sensory abnormalities (American Psychiatric Association 2013). This condition is a lifelong disorder that has a significant impact on the child or adult, and their family. According to recent research, the estimated prevalence of ASD is about 1.47% to 2,64% with a relation male/female close to 5 /1 (Kim et al. 2011; Baio 2014).

Regarding treatment, the National Autism Center's National Standards Project (2015) recommends approaches such as cognitive-behavioral interventions, natural teaching strategies, parent training and social skills training. However, there is still little evidence on the effectiveness of these treatments, which often require high continuity and intensity (Boyd et al. 2014). Consequently, new methods to improve the effectiveness of treatments are being searched. Within this context, game-based interventions and the use of technology have shown to facilitate motivation and learning processes in ASD (Charlton et al. 2004; Brown and Murray, 2001; Goldsmith and LeBlanc 2004), therefore the use of digital games is being explored as a complement of traditional treatment methods (Goh et al. 2008; Maskey et al. 2014).

Interactive technologies that involve the whole body action, also known as full-body interaction technologies (Pares et al. 2005), have shown to be effective in promoting learning processes (Casas et al., 2012), social skills (Rajendran et al. 2013) and generalization (Malinverni 2012). Including interventions based on interactive virtual environments is useful to promote social skills in people with ASD (Trepagnier 1999; Parsons et al. 2006; Mora-Guiard et al. 2016). An important advantage of virtual environments is that they allow the creation of controlled social environments, such as a "virtual café" (Parsons et al. 2004), where people with ASD can practice their social interaction abilities in a safe context (Parsons and Cobb 2011) and discuss their social responses afterwards (Parsons et al. 2006).

In addition, interactive virtual environments are useful to promote symbolic play (Herrera et al. 2008) and social interaction in younger children with high functioning ASD. Fengfeng and

Tami (2013) tested a social interaction program with four children with ASD (9-10 years old). The program involved activities such as recognizing gestures and facial expressions of a virtual character, as well as responding and maintaining interactions at the school dining room or during a birthday party. According to results, participants showed an increase in abilities related to social initiation, response, greeting and ending of a conversation during the intervention.

All these findings support the hypothesis that the use of full-body interactive virtual environments might be effective to promote social interaction abilities in children with ASD. However, research studies are still only preliminary and they commonly use reduced samples. Therefore, more research is needed in order to obtain appropriate conclusions (Ramdoss et al. 2012). Moreover, these studies have been mainly addressed to older children, teens, or young adults. Our approach addresses the need for early intervention in children with ASD and our hypothesis is that young children (4 – 7 years old) are still not capable of exercising these social skills. Rather, our focus is directed towards a previous step in socialization, namely, social initiation. Our goal is therefore to make young children understand the need and benefits of initiating a social contact and interaction.

The purpose of this observational study project was to conduct a feasibility study that investigates whether a full-body interaction videogame could be proposed as a tool to promote social initiation skills in children with ASD. In order to achieve this goal, our proposal was to quantitatively compare the amount of social initiation conducts performed during a videogame that involves a full-body interactive virtual environment versus the amount of social initiation conducts occurred during a free-play activity. These social initiation conducts are understood as behaviors that aim to start social interactions, such as: looking for others and approaching them, achieving eye contact, showing joint attention, starting social communication and producing any verbal or gestural behavior for communicative goals. Specifically, the following target behaviors are addressed in the game: use of instrumental and conventional gestures, stimuli discrimination, turn-taking, imitation, joint attention, vocalization, recognition of basic emotions and cooperation.

It was hypothesized that the video game would elicit a higher amount of social initiation conducts with respect to an equivalent free play activity. In addition, we were also interested in evaluating the impact of the videogame on reducing maladaptive behaviors, such as stereotypes or repetitive behaviors.

METHOD

Previous phase and current goals

The study was part of the European Project M4all – "motion based adaptable learning activities for children with motor and intellectual disabilities" (http://www.m4allproject.eu/). Our own project included two phases that were both developed through collaboration between Pompeu Fabra University and the Multidisciplinar Autism Spectrum Disorder Unit (UnimTEA) of Hospital Sant Joan de Déu (HSJD), in Barcelona.

The present study was the second part of our complete project. During the first phase, an inclusive design approach (Participatory Design) was used in order to develop a Kinect-based game for high functioning children with ASD (Malinverni et al. 2014). Five participatory design sessions were carried out with four children with ASD (9-10 years old), who were guided by four researchers. As a result, the game "Pico's Adventure" was developed and an initial exploratory study with 10 children with ASD showed that the game was effective at eliciting social initiation conducts (Malinverni et al. 2016).

The main purpose of the second phase was to build on the previous exploratory study and evaluate the feasibility of the game Pico's Adventure as a tool to elicit social initiation conducts, in comparison with other situaciones and using specific measuring instruments.. We were interested in increasing the sample and comparing the amount of social initiation conducts performed during the game Pico's Adventure versus social initiation conducts during a free-play activity, using an observational scale.

Participants

After approval by the review board of the Research Committee of Hospital Sant Joan de Déu (Barcelona), subjects were recruited by psychologists from the UnimTEA of HSJD. Psychologists contacted children already diagnosed by the aforementioned unit and children from associations for parents of children with ASD.

Participants were selected through inclusion criteria based on age range between 4 and 7 years old and diagnosis for Autism Spectrum Disorder according to DSM-5 criteria. The choice of this age range was supported by the fact that our ultimate goal in the future was to achieve intervention tools that could be used in young children with ASD. Most studies that use technology to promote social skills in ASD have been directed to adolescents or young adults (Parsons et al. 2006) and only few studies have evaluated the use of virtual games in young children with autism (Herrera et al. 2008).

Diagnoses were confirmed using the Autism Diagnostic Observation Schedule (ADOS; Lord et al. 2000) and the Autism Diagnostic Interview-Revised (ADI-R; Lord, Rutter, & Le Couteur 1994). In order to be included in the study, subjects had to obtain cognitive capacity above 70. Exclusion criteria included parental report or evidence of neurological disorder that could interfere with their interaction with technology (e.g. epilepsy), behavioral problems that could incapacitate the subject to participate in the study and pharmacological change during the time span of the study.

A total of 20 children with ASD were initially enrolled. However, during the experimental study five subjects dropped out for family reasons. This situation interfered with the treatment plan in one case, when there were not enough participants to play in pairs during the last session. As a consequence, one subject played in the last session with his younger brother and the data related to this session was excluded from the analysis.

The final sample consisted of 15 boys with ASD between the ages of 4 and 6 years (age: M = 5.69; SD = 0.988; IQ: M = 94.40; SD =17.79). The recruited children were randomly divided into two groups: the first group (initially 10 children, finally 7 children) participated in the experiment in May 2014; the second group (finally 8 children) participated in June 2014.

Materials & Design

Diagnostic instruments

Diagnosis of Autism Spectrum Disorder was confirmed through the Autism Diagnostic Interview-Revised (ADI-R; Lord et al 1994) with parents and the Autism Diagnostic Observational Schedule- Generic (ADOS; Lord et al. 2000), which was administered to children. Furthermore, intellectual abilities were measured with the Wechsler intelligence scale for children: Fourth edition (WISC-IV; 2003), the Wechsler Preschool and Primary Scale of Intelligence - Third Edition (WPPSI-III; 2002) or the Kaufman Assessment Battery for Children (Kaufman and Kaufman 1983).

Configuration of the videogame

The configuration of the game is based on the Kinect sensor (a special type of camera). The child is located in front of a display (in our case a 42" television) and the Kinect, approximately 3 meters away from them. This allows the Kinect sensor to detect the child's movements and actions, as well as capture his whole body image. The system then generates the game environment using the virtual landscapes, objects and the main character Pico, and inserts the image of the child within the game as one more element of the environment. This allows the child to see himself playing within the virtual world and allows him to understand where in the game his actions will have an impact. It works as if it were a digital mirror that reflects the user's image within a new virtual world.

Data gathering instruments

a) Observational instrument for quantitative video coding

The experts of the ASD Unit elaborated an observational instrument for quantitative video coding. The instrument was aimed at quantifying the number of occurrences of target conducts according to pre-established categories and was elaborated through a progressive

refinement procedure. Starting from an initial checklist used in the previous exploratory study (Malinverni et al. 2016), a first version of the instrument was elaborated. Three researchers tested this first version by using it during one month of direct observations of the sessions. Defined categories were therefore related to the following criteria: social initiations, responses, interlocutor, gestures and aids. A detailed description of the used criteria, defined categories and operational definition of each category is provided in Table 1.

(TABLE 1)

The designed observational instrument was used for quantitative behavioral observation of the child while playing with the game Pico's Adventure as well as during the free-play activity with toys. Four researchers, trained for observation of child behavior, performed the video analysis. To evaluate the reliability between the four coders an initial training was performed until reaching a good inter-rater reliability calculated (>0.85) through the Intraclass Correlation Coefficient (ICC). During the training, coders had an "expert rater" (a psychologist with larger experience) who previously coded several videos and were used as models and set criterion before moving forward. Once we had confirmed the reliability of the data, all raters coded all behaviors and they discussed results after each session.

The analysis was performed on 5 minutes video slots using Lince, a software for systematic video observation (Gabin et al. 2012). Time slots were selected according to a pre-established timing based on the appearance of different play mechanics in the game (each slot represented a different part of the story). Formally 6 video slots for each child were selected for the game and three corresponding video slots for each child were selected for the free play activity (see Table 2).

(TABLE 2)

Free play sessions were recorded with a hidden camera focusing on the play area. Videogame sessions were recorded with a program that captures in a video file the sequence of images generated by the game system and ultimately displayed in the visual output system (the television). As described above in the configuration of the system, thanks to the Kinect sensor, the game image contains the virtual elements and character of the game as well as the image of the child as if he were part of the virtual environment. With this system, the video obtained from the game capture shows all activity in the game, the corresponding behaviors and responses of the child, as well as his expressions and vocalizations.

b) Observational instrument for qualitative evaluation

The experts of the ASD Unit elaborated an observational instrument for qualitative evaluation in order to evaluate the impact of the game on maladaptive behaviors such as repetitive actions and stereotypes. Specifically, the instrument was oriented at identifying the presence or absence of the following behaviors (binomial selection): sensorial stimulation, hypersensitivity, stereotypes, repetitive actions and interests, echolalia, inflexibility, rituals and negativism.

The designed observational instrument was used for qualitative evaluation during the whole session. Three researchers performed analyses independently and afterwards, evaluations were discussed in order to reach a common agreement.

c) Pre and Post questionnaires for parents

The following questionnaires were administered to parents as pre- and post-test evaluation and measure of transfer of addressed variables:

- ASEBA: Achenbach System of Empirically Based Assessment (Achenbach and Rescorla 2001): The Child Behavior Checklist is a parent questionnaire that aims at evaluating maladaptive functioning and psychiatric symptoms. Measures are based on the following variables: affective issues, anxiety problems, somatic problems, development problems, attention deficit / hyperactivity, oppositional defiant problems,

behavioral problems. Internal consistency (Cronbach's alpha) ranges from good to excellent, depending on the scale (i.e.: Anxiety Problems: 0.72; Total Problems Score: 0.97). Test-retest reliability is adequate (0.90).

- ATEC: Autism Treatment Evaluation Checklist (Rimlan and Edelson 1999). The ATEC was designed to measure the effectiveness of treatments. It consists of 4 subtests: Speech/Language Communication, Sociability, Sensory/ Cognitive Awareness, and Health/Physical/Behavior. The internal consistency reliability is high (0.94 for the Total score). Moreover, research has shown association between ATEC scores, a parent-rated measure, and the Childhood Autism Rating Scale (CARS; Schopler, Reichler & Renner, 1994), a professionally completed instrument (Geier, Kern & Geier, 2013).
- SSRS: The Social Skills Rating System (Gresham and Elliot, 1990). The SSRS evaluates social behaviors of children and adolescents. We used the parent questionnaire form and the following scales: (a) Social Skills Scale (subscales: Cooperation, Assertion, Responsibility, Empathy, Self-Control); (b) Problem Behaviors Scale (subscales: Externalizing Problems, Internalizing Problems, Hyperactivity).
- ABC: The Aberrant Behavior Checklist (Aman and Singh 1994). The following variables were evaluated from the ABC: Irritability, Lethargy, Stereotypes, Hyperactivity, and Inappropriate Discourse. The internal consistency and test-retest reliability of the ABC are very good. Interrater reliability varies across raters and subscales, ranging from mediocre to good.

d) Survey for the children to evaluate the suitability of the game

In order to evaluate the suitability and the likeness of the game, a questionnaire for the children based on the ″Smileyometer″ (Read, 2007) was initially intended to be administered to children.

However, after using the instrument during the first two sessions, we detected significant lack of reliability (children tended to give higher marks independently of the addressed questions).

Due to the lack of reliability of the instrument its usage was suppressed and data was not considered for further analysis.

Procedures

All procedures were in accordance with the ethical standards of the institutional research committee and with the 2000 Helsinki declaration. Parents provided signed consent and informed assent was obtained from each child. Included children were invited to participate in a total of 4 sessions, scheduled on a weekly basis. These sessions took place in a large dedicated room at the Hospital Sant Joan de Déu (Barcelona) and had a length of one hour. During each session, parents and two researchers accompanied the child, while three other researchers observed the sessions from an adjacent room through a one-way mirror. Finally, pre- and post-test questionnaires were administered to parents at the beginning and at the end of the experimental procedure in order to evaluate an eventual transfer of the addressed skills in everyday life.

Sessions were structured according to a treatment plan proposed by the psychologists, following a progressive level of difficulty. According to this defined plan, during each session the child would play a different chapter of the Kinect-based game Pico´s Adventure, which, as aforementioned, had been developed using a participatory design during the first phase of this project (Malinverni et al. 2016). As described at Maliverni et al. (2016), the game is based on the story of Pico, a friendly alien who landed on Earth. At the beginning of the story Pico is shy and the child has to show Pico that they can be friends and that he can help Pico in different missions. Each mission is designed to address a targeted behavior related to social initiation.

The game is structured into four levels that follow a four-sessions treatment plan aimed at providing a progressive scaffolding of the social interaction skills defined by the experts.

Each session is represented by a different chapter in the game, following a progressive order. The structure of the sessions was (Malinverni et al. 2016):

- First session: The child plays in single-user mode, although the game presents socialization opportunities with the protagonist virtual character agent, Pico. In this chapter, the child meets Pico in a forest and can feed Pico to become friends. The goal of this session is to introduce the child to the virtual world and foster his interaction with the character. During this session children have to use gestures to get food for the characterand protect the food from an antagonist bird through gestures and vocalizations. This procedure also allows them to customize the character, which is done through the food they give to the character. To this end, this session is broken down into four distinct stages. In the first stage, depending on the type of food, the character will change the color of its skin. In the second stage, food changes the pattern on the character's outfit. In the third stage different food makes different hats appear on the character. Finally, the fourth stage allows the children to alter the complexion of the body of the character. It is important to note that during the third and the fourth stages (second part of session 1) the antagonist bird appears preventing Pico to eat the fruit and the child must scare it.
- Second session: The child starts playing alone but, at a given point, needs help from an adult; typically one of the parents. In this chapter, the child must help Pico to fix its spaceship. In order to success, the child has to ask for help to the adult and give him instructions.
- Third session: The child plays with an adult from the beginning of the session. In this session the child and the adult travel to Pico's planet and their goal is to liberate spaceships that belong to Pico's friends, which are trapped in colored clouds. The child must give instructions to the adult on how to use a laser ray.
- Fourth session: The child plays the full session together with another ASD child from the experimental group whom the child has not met before. During this session, the two

children collaborate in order to achieve that the inhabitants of Pico's planet offer to them.

Since one of the goals of the study was to compare behaviors in the game with a baseline measurement of behavioral tendency of the child, a free play activity with toys was included in each session. Therefore, each session lasted for one hour and included two activities: free play with toys and playing with the Pico's Adventure game. The free play activity was designed to correspond to the situation presented by each play session. For example, during the first session (child playing alone with the videogame), the child would play alone during the free play, but during the next sessions he would play with an adult or another child, following the same videogame configuration. Free play and videogame were alternated according to a counterbalanced measure design in order to avoid biases related to the timing procedure. Children were randomly assigned to two conditions in each session: condition AB (free play-videogame) or condition BA (videogame-free play), as described in table 3:

(TABLE 3)

Analysis

The main purpose of this study was to compare the amount of social initiation conducts during the video game versus the free play situation. The analysis was carried out using quantitative systematic video coding to quantify the number of occurrences of targeted behaviors during the game and during the free play time with a set of toys. The number of target behaviors was quantified using the instrument for quantitative systematic observation (see section *Observational instrument for quantitative video coding* for a detailed description of the instrument and the video coding procedure) and the software Lince was used to perform the video coding.

Each video had a duration of 5 minutes. For each child, Pico's Adventure and free play videos were paired according to equivalent conditions of play, as described in Table 4 (i.e. playing alone, playing with parents, playing with another ASD child). Due to a technical problem

with the camera to record free play activity, five videos of free play were missed. Therefore, Session 3 videogame was compared to Session 2 free play. We used paired t-test to compare the amount of targeted behaviors elicited by the game with a baseline assessment performed through a free play activity.

(TABLE 4)

All statistical tests were performed by a bilateral contrast and the level of significance was judged at a level of 0.05. The statistical software used was the Statistical Package for the Social Sciences (SPSS®).

RESULTS

Descriptive results obtained through questionnaires are shown in Table 5 and Table 6..

(TABLE 5)

(TABLE 6)

a) Comparison of overall Social Initiation

In order to evaluate the overall Social Initiation, we used the sum of the quantity of behaviors related to: *Integrated request, Non-Integrated request, Integrated Social Commentary* and *Non-Integrated social Commentary* (Table 1). Paired sample t-tests were conducted for each pair (Table 3) to compare the number of occurrence of target behaviors in "Pico's Adventure" condition and in "Free Play" condition.

During the situation where the child was playing alone (pair B), children showed significantly more overall social initiation during the videogame (M= 9.33, SD= 9.61) than during free Play (M= 4.08, SD= 3.82) ; t(11)= 2.438, p= 0.033. Furthermore, Cohen's effect size value (d = 0,704) suggested a moderate to high practical significance.

Similarly, during the situation where two ASD children were playing together (pair F) a significant difference was found in overall social initiation between Picos's Adventure (M= 10.93, SD= 5.54) and Free Play (M= 6.50, SD= 5.11); t(13)= 3.60, p=0,003. Furthermore, Cohen's effect size value (d = 0.962) suggested a high practical significance. Instead no significant difference was reported for the other pairs (for a summary see Table 7).

(TABLE 7)

b) Comparison of Specific Social Initiations

In order to provide a deeper understanding of the previously reported results, we performed a detailed analysis considering each category separately (*Integrated request, Non-Integrated request, Integrated Social Commentary, Non -Integrated social Commentary*). Results from the specific categories are reported in the following sections.

b.1) Requests

Paired sample t-tests were conducted for each pair (Table 4) to compare the number of occurrences of behaviors related to *integrated requests*, understood as *social initiation with eye contact with the interlocutor and aimed at requesting something to the other, such as asking the other to perform an action, or asking for help or information*. A statistically significant difference was reported only in the situation where the child was playing with a parent (pair C), where children showed a higher amount of integrated requests in Picos's Adventure (M= 2.331, SD= 2.097) than in Free Play (M= 0.46, SD=0.519); t(11)= 2.839, p= 0.014. Furthermore, Cohen's effect size value (d = 0.80) suggested a high practical significance. Instead no significant difference was reported for the other situations (see Table 8).

(TABLE 8)

b.2) Integrated Social Commentaries

Paired sample t-tests were conducted for each pair (Table 4) to compare the number of occurrences of behaviors related to *integrated social commentary* with the interlocutor aimed at *drawing the attention to something or sharing experience or making a social commentary*. No significant difference was found between any pair (for a summary see Table 7). However, it is relevant to notice that two different tendencies were present. Pico's Adventure tended to favor a higher number of social commentaries than Free play in situations where the child was either playing alone (pairs A and B) or with another child (pair F). Instead Free Play tended to favor more social behaviors when the child was playing with his parents (pairs C, D and E).

b.3) Non-Integrated Social Commentaries

Such tendencies were confirmed by the analysis of *Non-Integrated social commentary*. In this case significant difference was found in the situation where the child was playing with a parent (pair C), in favor of the Free Play activity; $t(12) = -2.202$, $p = 0.048$. Instead no significant difference was found between the other pairs (for a summary see Table 8).

c) Comparison of gestures

Along with social initiation we calculated the number of spontaneous gestures performed by the children in both the game Pico's Adventure and in Free Play. Specifically, the following gestures were considered:

- Conventional gestures: Gesture with an explicit and acknowledged culturally established meaning (e.g. clapping).
- Emotional gestures: Expressive gestures aimed toward expressing and communicating feelings.
- Pointing gestures: Point gesture to indicate something.

Paired sample t-tests were performed for each session to compare the amount of specific gestures between Pico's Adventure and free play. As reported in Table 9, a higher amount of emotional gestures was reported in Pico's Adventure than in free play in the following

situations: child playing with a parent during the second part of the second session (pair D), child playing with a parent during the third session (pair E) and child playing with a peer during the fourth session (pair F). Similarly, a higher amount of pointing gestures was found in the situation of a child playing with a parent during the third session (pair E) and when the child was playing with a peer during the fourth session (pair F).

(TABLE 9)

d) *Evaluation of the impact of the game on maladaptive behaviours*

The qualitative evaluation of the presence of maladaptive behaviors (i.e.: sensorial stimulation, hypersensitivity, stereotypes, repetitive actions and interests, echolalia, inflexibility, rituals, negativism) was performed through direct field observation, using the instrument described in section "*Observational instrument for qualitative evaluation*". Defined variables were evaluated on a nominal scale that rated the presence or absence of the maladaptive behaviors. Results show that the game Pico's Adventure elicited a wider variety of maladaptive behaviors with respect to free play activity. Most of the maladaptive behaviours were related to stereotypes and eventual disconnections. However, no significant difference was reported between Pico's Adventure and free play for the following behaviors: partial disconnection, echolalia, stereotypes, auditory reactions, and stimulations. Instead it is relevant to notice the significant difference reported between the item "repetitive actions" between free play and Pico's Adventure. A Wilcoxon Signed-ranks test was performed to compare the total amount of identified repetitive action behavior during the three sessions for free play and Pico's Adventure. Results indicate that "repetitive actions" were more frequent in Free Play (Mdn = 2) than in Pico (Mdn = 0), Z = 2.05, p = 0.040.

The analysis of the distribution of maladaptive behaviors among the different sessions (reported in Table 10) showed that in Pico's Adventure maladaptive behaviors tend to be concentrated in the first session (child playing alone) and are not present in the fourth session (two ASD children playing together). Conversely, during free play maladaptive behaviors tend to be concentrated in the fourth session (the two peers playing together).

(TABLE 8)

e) Pre- and post-test comparisons with questionnaires

In order to evaluate the transfer of the addressed skills in everyday life and possible improvements in comorbid symptoms, questionnaires were administered to parents at the beginning and at the end of the experimental procedure. Statistical analyses showed no significant difference on any of the administered questionnaire before and after the intervention.

DISCUSSION

The main purpose of this study was to conduct a feasibility study to test whether a full-body interaction videogame could be proposed as a tool to promote social initiation skills in children with Autism Spectrum Disorder. Results show that the videogame Pico's Adventure elicited more social initiation conducts than free play when children were playing alone or playing with a newly met peer. Furthermore, it showed to elicit as many social initiation conducts as free play while playing with parents.

A possible explanation of this result can be related to the fact that, when playing alone or with another child, the child is not provided with the structure and familiarity that is offered by parents. Such results thus suggest that Pico's Adventure could be considered an effective tool to facilitate conditions for social interaction with unfamiliar people. This aspect is extremely relevant in autism since major difficulties are present when having to communicate and start a social interaction with an unknown person (Kasari et al. 1993).

The increase in social initiation skills when playing alone was observed in the second part of session 1. The goal of this session is to introduce the child to the virtual world and foster his interaction with the character.

It is important to note that during the second part of session 1,the antagonist bird appears preventing Pico to eat the fruit and the child must scare it. During the first session children showed several behaviors associated to social skills such as commentaries, responses to the conventional and instrumental gestures of the character and use of conventional gestures (e.g. using the hand to say "bye-bye"). Social initiation, in the form of commentaries, was

especially triggered by changes in the character's outfit or by the appearance of unexpected

foods (e.g. a donut on a tree). These surprising elements motivated children to either call the attention of the parent on the element or comment on it to share their experience.

Our results are coherent with other studies that show that virtual environments could be useful to promote social skills in adolescents (Parsons et al. 2004) and children with ASD (Fengfeng and Tami 2013). Deeper analysis of the types of social initiations suggests the efficacy of the game in promoting social requests (e.g. asking for help or giving instructions). As reported in Table 8, the game Pico's Adventure elicits a significant higher number of social requests than free play in several of the analyzed pairwise comparisons. Training oriented toward fostering spontaneous requests in children with autism represents a life-long learning task since it facilitates social interaction and improves quality of life. From this perspective, the game can be considered an effective instrument to promote these target behaviors in a playful and engaging manner. For example, the videogame performed better than free play in eliciting requests in the context of child playing with a parent (pair C). In this context it is relevant to notice that pair C (playing with a parent) includes the first part of the second level of the game Pico's Adventure (see Table 4). In this part of the game, the child starts playing alone and is then faced with a situation that requires him to ask for help to parents, since he cannot reach some of the objects in the game. It is therefore possible that this situation could have facilitated the elicitation of integrated requests behaviors. On the other hand, results related to social commentaries (Table 8) show that the game was not more effective than free play in eliciting children's spontaneous expressions such as sharing emotion and experience. Such shortcoming requires further research on adequate game stimuli that are capable of promoting

a higher willingness of producing spontaneous commentaries in children. In the context of the child playing with a parent (pair C), the amount of social commentaries was higher during free play. A possible explanation of this result could be related to the level of parent intervention during Free Play. Despite parents were instructed to "remain passive and wait for children initiations", this instruction was not always completely respected. To address this issue, four raters evaluated the level of parent intervention using a 1 to 5 scale. A Wilcoxon Signed-ranks test was performed to compare the level of parent intervention in Free Play and Pico. Results indicate that parent intervention was higher in Free Play (Mdn = 3) than in Pico (Mdn = 2) during the second session (pairs C and D), $Z = 2.01$, $p = 0.044$. Instead no difference was reported for the third session (pair E), $Z = 0.67$, $p = 0.5$. However, no significant correlation was found between the level of parent intervention and the number of children social initiation, suggesting that this variable may not have played a major role.

The analysis of maladaptive behaviors highlights how most maladaptive behaviors concentrate in the first session of Pico's Adventure; they were mainly related to self-stimulatory behaviors, which are generally associated with arousal states. It would be therefore necessary to properly evaluate whether these maladaptive behaviors are the result of a novelty factor, or whether they are associated with the use of gaming technologies. However, on the other hand, given the significant difference between Pico's Adventure and free play, results associated with repetitive actions suggest the potential of this game to reduce repetitive behaviors. At the same time, longitudinal studies could be beneficial to evaluate the effectiveness of the game in long-lasting behavioral changes.

In our study pre- and post-treatment questionnaires showed no significant improvement. Such results were expected due to the short duration of the treatment and by considering that most questionnaires evaluated a broad spectrum of conduct and symptoms, whereas our intervention was mainly focused on social initiation abilities. Moreover, although questionnaires are the most commonly used assessment method to measure effectiveness, they have limitations, such as being based on subjective responses from respondents who are not usually blind (Rao, Beidel, & Murray 2008). Another limitation is that, in order to detect changes,

questionnaires require that the child generalizes improvements to real situations. This generalization is not often achieved after short interventions. Thus, a longitudinal study of the use of the game would be necessary to properly track whether it could facilitate learning the targeted skills. Nevertheless, considering limitations of questionnaires, more accurate assessment methods to evaluate changes in social skills are needed. Observational measures and behavioral coding have been proposed as promising approaches in the social skills training literature (McMahon, Vismara, & Solomon 2013).

As limitations from our study, it is important to note that raters who coded the observational scale were not blind to the state of the intervention. Therefore, codes might have been influenced by subjective perceptions. Another limitation is that we chose a within-group design due to the small size of the study population. However, a between-group design would be more appropriate when designing future studies with larger samples. Other limitations that have already been pointed out are the short duration of the intervention and the lack of appropriate measures to rate changes after interventions with children with ASD.

Implications

Despite these limitations, it is important to highlight the potential use of full-body interactive videogames as tools to foster social initiation conducts in children with ASD. Further research is needed to determine whether this type of intervention could be included as a complementary tool in clinical protocols, as children with ASD seem to benefit from safe enjoyable contexts where they can train their skills.

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